University of Massachusetts - Amherst
ScholarWorks@UMass Amherst

Open Access Dissertations | Dissertations and Theses

5-1-2009

Women in Engineering: Tell Me What You Need to Succeed

Susan Catherine Lyon
University of Massachusetts Amherst, sue.lyon@roadrunner.com

Follow this and additional works at: http://scholarworks.umass.edu/open_access_dissertations

Part of the Educational Assessment, Evaluation, and Research Commons

Recommended Citation
Lyon, Susan Catherine, "Women in Engineering: Tell Me What You Need to Succeed" (2009). *Open Access Dissertations.* Paper 69.

This Dissertation is brought to you for free and open access by the Dissertations and Theses at ScholarWorks@UMass Amherst. It has been accepted for inclusion in Open Access Dissertations by an authorized administrator of ScholarWorks@UMass Amherst. For more information, please contact scholarworks@library.umass.edu.

WOMEN IN ENGINEERING: TELL ME WHAT YOU NEED TO SUCCEED

A Dissertation Presented

By

SUSAN C. LYON

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

DOCTOR OF EDUCATION

May 2009

School of Education

© Copyright by Susan C. Lyon 2009

All Rights Reserved

WOMEN IN ENGINEERING: TELL ME WHAT YOU NEED TO SUCCEED

A Dissertation Presented

by

SUSAN C. LYON

Approved as to style and content by:

_____
Joseph B. Berger, Chair

_____
Ana Muriel, Member

_____
Gretchen Rossman, Member

_____
Vanessa Rivera, Member

_____
Christine B. McCormick, Dean
School of Education

DEDICATION

To my mother and father the late Hon. Thomas V. and Lillian E. Mallon.
This accomplishment is in your honor; for instilling in me the courage to follow my heart.

And, to my daughter Carly
I hope you always dance. You are my dream come true.

B2
I love you.

ACKNOWLEDGMENTS

Thank you to my family and most especially to my husband, Bill, for allowing me the freedom to reinvent myself later in life. Your support and encouragement gave me the guts to embark on this remarkable journey. To my step-sons, Channing and Morgan, thanks for believing I could do this. To my daughter Carly, your joyous arrival allowed me to slow down and concentrate more completely on both you and this work. I love you all.

Dr. Joseph Berger, thank you for accepting me into the doctoral program and advising me over all these years! It has been a memorable adventure. Your patience, insight, intellect and sense of humor inspired me on many occasions. You are a remarkable person. I look forward to future collaborations.

To Dr. Vanessa Rivera, thank you for convincing me to pursue my doctorate. The continued mentoring, unwavering support and love you provide will forever be appreciated. To Leo, thank you for the data analysis suggestions and most especially for sharing good food and music.

I thank Dr. Gretchen Rossman for being an integral part of my team and sharing her expertise in qualitative research. Your enthusiasm gave me the courage to carry out this case study. Thank you to Dr. Ana Muriel for your keen insight and the opportunity to present this paper. My sample would not have been as robust without your advice and suggestions.

Thank you to the administration, faculty and staff at the College of Engineering for allowing me to conduct this study.

Dr. Rebecca Fiske, I guess I can't say, "I'm going to meet Joe" any longer! Thank you for allowing me space to finish my work. I'm looking forward to joining the ranks of administrative faculty. Annie Martin our walks and talks kept the "momentum" going, thank you.

To Carol, my sister and best friend, I can't say enough. Your unending support and encouragement means the world. To my brothers, Tom and Rob, I'm really done! To my in-laws and all of my nieces and nephews, I love you. To my friends who endured this journey with me, I'm looking forward to joining a book club.

Thanks to Dr. Alan Bloomgarden, Dr. Kate Douglas and Dr. Ray McCarthy for accompanying me on the often lonely quest for the doctorate. I'm glad we persisted.

Thank you to the participants in this study. You are amazing women, already transforming the profession. Your openness and commitment to this study was remarkable. I will never forget your stories and am honored to have had the opportunity to share this adventure with you. You made this study a success!

ABSTRACT

WOMEN IN ENGINEERING: TELL ME WHAT YOU NEED TO SUCCEED

SUSAN C. LYON, B.S., STATE UNIVERSITY OF NEW YORK OSWEGO

M.B.A., UNIVERSITY OF MASSACHUSETTS AMHERST

Ed.D., UNIVERSITY OF MASSACHUSETTS AMHERST

Directed by: Professor Joseph B. Berger

The purpose of this qualitative study is to understand how women enrolled in undergraduate engineering programs perceive their undergraduate experience in relation to their anticipatory socialization into the engineering profession. The significance of this study rests in the fact that although over the past few decades millions of dollars have been invested to combat the shortage of women entering and persisting in engineering undergraduate programs, very little improvement has yet been achieved. More importantly, although many factors have been determined to perhaps influence the under representation of women in engineering, a clear understanding of why this phenomenon continues has not yet been established. The findings from this study are intended to provide insight into what women in engineering need to succeed and provide clear recommendations for practice and policy to address the issue.

TABLE OF CONTENTS

Page

ACKNOWLEDGMENTS v

ABSTRACT vii

LIST OF TABLES xii

LIST OF FIGURES xiii

CHAPTER

1. A CRISIS IN THE PROFESSION 1

Statement of the Problem 1
Purpose of the Study 4
Research Questions 4
Significance of the Study 5
Assumptions 8
Definitions 10
Overview 11

2. REVIEW OF RELATED LITERATURE 15

Introduction 15
Anticipating the College Experience 18
Theoretical Approaches 19
The "Freshwoman" Year 25
Universities as Communities 27
A Wo(man)'s Perspective 29
The Differences in Knowing 31
The Chilly Climate 34
The Importance of Role Models 36
Exploring the Impact of WEP Programs 38
The Need for Future Research 40

3. DESIGN AND METHODS 42

Conceptual Framework 42
Research Questions 46
Research Design 48

Observations 49
Personal Journals 49

In-Depth Interviews 50
Focus Group Discussions.....51

Participants/Data Sources 51
Data Collection 52
Analysis.....53
Limitations 54
Conclusions.....55

4. FINDINGS OF THE STUDY.....57

Introduction.....57
College Entrance.....60

The Role of Family 61
Academic Expectations.....63
Social Expectations.....65
Academic Self-efficacy.....67
Social Self-efficacy.....69
Personal Motivation.....70

The College Experience.....72

Excitement – Freshman Year.....73
Questioning – The Sophomore Year.....76
Despair – The Junior Year 79
Realization – The Senior Year.....82

Challenges and Supports.....84

Academic Challenges.....84

Commitment 84
Confidence 86
Mastering Material.....87
Grade Shock.....89
Academic Competition among Women.....90
Stress 91

Academic Support.....93

Faculty.....93
Internships/Research Experience for Undergraduates (REU) 95
End Goals.....97

Social Challenges 99

Too Few Women 99
Social Competition among Women 102
Isolation 104
Limited Social Life 106

Social Supports 108

Living Learning Communities (LLCs) 108
Involvement in Engineering Societies 109

Persistence 111

Immediate Success 112

Understanding Hard Material 112
Getting Good Grades 113
Developing Personal Relationships 113
Happiness 114

Overall Success 115

Graduating 115
Having a Meaningful Job 115
Being Happy 116

Conclusion 117

5. SUMMARY AND CONCLUSIONS 120

Overview of Study 120
Review of Research Questions 121

Overarching Research Question 121
Research Question 1 125
Research Question 2 126
Research Question 3 127
Research Question 4 128
Research Question 5 129

Implications for Practice and Policy 131

Practice 131
Policy 137

Implications for Further Research 140
Conclusion 143

APPENDICES 146

A: INITIAL JOURNAL QUESTIONS 147
B: GUIDING QUESTIONS 148
C: MODERATOR OUTLINES 149

BIBLIOGRAPHY 150

LIST OF TABLES

Table Page

1.2 Percent of freshman women intending to major in engineering 1995 – 2000 1

1.2 Percent of bachelor's degrees conferred to females, by selected fields of study: Various years, 1969 to 2000-01 2

4.1 Demographic Profile of Participants.....58

LIST OF FIGURES

Figure Page

3.1 Conceptual Framework 44

3.2 Quasi-concurrent Triangulation Design 49

4.1 Conceptual Model 60

CHAPTER 1

A CRISIS IN THE PROFESSION

Statement of the Problem

For over a decade in the United States, the number of women entering colleges and universities has been equal or greater than men (Pascarella, Whitt, Terenzini, et.al, 1997), however the number of women graduating with degrees in engineering continues to lag well behind men. Although women earn 57% of all bachelors' degrees awarded (Freeman, 2004) they account for less than 20% of all engineering degrees awarded (Heyman, Bryn, & Bhatia, 2002). The number of women enrolled in engineering programs did not begin to grow until the 1960s when the Civil Rights Act and other affirmative action movements permitted equal access to employment. In 1972, equal access to public educational resources for women was granted through Title IX. As shown in Table 1.2, even with changes in federal policy, the ability to increase the number of female students graduating with engineering degrees continued to elude institutions of higher education. This is further evidenced by the fact that the number of freshmen women intending to major in engineering has made no significant gains since 1995:

Table 1.1: Percent of freshman women intending to major in engineering 1995-2000

1995	**1996**	**1997**	**1998**	**1999**	**2000**
2.0%	2.6%	3.0%	2.2%	2.4%	2.9%

(Source: Higher Education Research Institute, 1995, 1996, 1997, 1998, 1999, 2000).

Shockingly, the actual number of engineering degrees awarded to women in engineering appears to have reached a plateau in 2000 at 20.4% and has experienced a decline in the number conferred since (Freeman, 2004).

Table 1.2: Percent of bachelor's degrees conferred to females, by selected fields of study: Various years, 1969 to 2000-01

Field of Study	1969-70	1974-75	1979-80	1984-85	1989-90	1994-95	1999-2000	2000-01
Total	43.1	45.3	49	50.7	53.2	54.6	57.2	57.3
Agriculture and natural resource	4.1	14.1	29.6	31.1	31.6	36	42.9	45.1
Accounting	8.7	17.7	36.1	49.1	53.3	56.2	60.4	60.5
Biological sciences/life sciences	29.7	33.1	42.1	47.8	50.8	52.3	58.3	59.5
Business management and administrative services	9	16.2	33.1	44.9	46.5	47.7	49.5	49.4
Computer and information sciences	12.9	18.9	30.2	36.8	29.9	28.4	28.1	27.7
Education	75.3	73.3	73.8	75.9	78.1	75.8	75.8	76.7
Engineering	**0.7**	**2.2**	**9.3**	**13.1**	**13.8**	**15.6**	**20.4**	**19.9**
Health professions and related sciences	68.6	77.7	82.2	84.9	84.4	81.9	83.8	83.8
Mathematics	37.4	41.2	41.5	46.2	45.7	46.8	47.1	47.7
Physical sciences and science technologies	13.6	18.2	23.7	28	31.3	34.8	40.3	41.2
Psychology	43.4	52.6	63.3	68.2	71.5	72.9	76.5	77.5
Social sciences and history	35.9	37.3	43.6	44.1	44.2	46.8	51.2	51.8

Source: U.S. Department of Education, National Center for Education Statistics, Higher Education General Information Survey (HEGIS), "Degrees and Other Formal Awards Conferred Survey"; and Integrated Postsecondary Education Data System, "Completions Survey" (IPEDS-C;90-01), various years, 1989-90 through 2000-01. In Freeman, C. Trends in Educational Equity of Girls & Women: 2004.

The shortage of women applying to engineering programs and the low rates of persistence for women enrolled in engineering programs are two areas of focus that researchers have been studying for decades (National Center for Education Statistics, 2000; Blaisdell, 2000; NSF, 2002). Both of these issues continue to be explored by researchers, scholars, policy makers and administrators in an effort to increase the number of women matriculating with engineering degrees.

More specifically, since the 1970s the number of women entering engineering majors continued to rise, until most recently when numbers have appeared to plateau, and actually drop slightly. Retention rates of women, however, have continued to decrease significantly over the same time period. Between 1972 and 1976 retention of women in

engineering was recorded at roughly 90% (Brainard & Carlin, 1991). That number continued to decrease and by 1987 the national retention rate for women in engineering programs was recorded at just under 60% (Brainard & Carlin, 1991). Most recently, the retention figures for women in engineering programs are reported down to nearly 40% (Adelman, 1998). Interestingly, grades are not the reason women are choosing to leave engineering. NSF (2002) reports that women who are leaving engineering have "A or B averages" in their engineering courses. Similarly, a study by the Elizabeth S. Johnson College & University (1993) found no difference in the mean GPA between women and men in engineering who completed their bachelor's degree requirements. These statistics reinforce the need for a deeper understanding of why competent women are choosing to leave engineering.

The attrition trend must be reversed if the US is to fill engineering demands over the next decade. The fact that studies have shown that persistence at an institution, or program, is related more to what occurs when a student becomes part of the campus environment rather than what may take place prior to entry (Terenzine & Pascarella, 1977, 1997) has put the onus back on institutions of higher education to eradicate the attrition of women from engineering programs. In efforts to improve retention of women in engineering, many interventions have been developed to offer support for these women.

These interventions strive to foster academic and social integration among students and include programs such as first year seminars (Tinto, 1993; 1998; Fidler, 1991; Starke, Harth & Sirianni, 2001; Schnell & Doetkott, 2003) and learning communities (Tinto, 1998;Stassen, 2003; Hobbs, Millett, & Minkley, 1999) . While these

programs offer social and academic support to women in engineering, the overall impact on a woman's academic satisfaction, aspirations and persistence has not yet been fully understood or explored.

Although these interventions have helped to improve retention a closer examination needs to be conducted in relation to what women entering engineering program anticipate their experience to be and how these interventions relate to those expectations. A discussion needs to take place regarding the relevance of these interventions in relation to women in engineering programs (Brainard & Carlin, 1991; NSF, 2002).

Purpose of the Study

The purpose of this study is to enhance the current knowledge base regarding how women enrolled in undergraduate engineering programs perceive their undergraduate experience in relation to their anticipatory socialization into the engineering profession.

Research Questions

The ultimate goal of this study is to understand what women enrolled in engineering programs need to succeed. The study began by generating an understanding of what women need, and specifically how anticipatory socialization plays a role in their success. The overarching research question of this study was:

> How do female engineering students perceive their undergraduate experience as anticipatory socialization into the engineering profession?

Preliminary probing questions that were fluid and flexible based on the interviews with female students included:

- How do background characteristics of students influence their perceptions?
- How do these perceptions change from freshman to senior year
- What are the critical decision points?
- What is the role of faculty shaping these perceptions?
- What are the perceptions of the classroom and lab climate?

Significance of the Study

The significance of this study rests in the fact that although over the past few decades millions of dollars have been invested to combat the shortage of women in engineering undergraduate programs, very little improvement has yet to be achieved. More importantly, although many factors have been determined to perhaps influence the under representation of women in engineering, a clear understanding of why this phenomenon continues has not yet been established.

One potential reason for the continued ambiguity surrounding this topic is that very little research has been conducted that focuses exclusively on women's experiences in college engineering programs (NSF, 2002). Much of the research surrounding this topic is conducted under the umbrella of STEM (Leslie, McLure & Oaxaca, 1998; Brainard & Carlin, 1991; Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development, 2000; Clewell & Campbell, 2002) which assumes that these very different disciplines pose the same challenges to women. Research targeted specifically toward women enrolled in

engineering programs is clearly needed to understand from their perspective what they really need to succeed.

While increases in the total number of women matriculating with engineering degrees have been recorded since the 1970s, these numbers continue to remain very low. In recent years, the increases appear to have reached a plateau and during the 2000-2001 academic year, a slight decrease in the number of women matriculating with engineering was recorded, down 0.5% over 1999-2000 data (Freeman, 2004). Less than 20% of all engineering degrees are awarded to women, although they comprise almost 60% of the total undergraduate student body (NSF, 2002). In addition women are both less likely to select engineering as a major and are more likely to switch out of engineering, compared to men (NSF, 2002). The combination of these two facts has caused institutions of higher education to develop interventions targeted expressly at this student population.

Since 1969, WEP programs have been used extensively to provide support services to combat this issue. Although significant funding continues to be provided for WEP support activities and programs, the actual scope of impact of these programs is difficult to fully understand. Research on WEP programs tends to look primarily at retention numbers within the institution (Brainard & Carlin, 1991; Hartman & Hartman, 2003). While this data is important for the institution, the full impact the WEP program on a woman's academic satisfaction, aspirations and overall persistence in engineering have not been fully explored.

In 2002 the National Science Foundation (NSF) and the Alfred P. Sloan Foundation funded the Women's Experiences in College Engineering (WECE) study as a response to the lack of multi-institutional data on WEP programs. This study was

commissioned to understand if the increased funding for support activities for women in engineering programs was effective. This study, the first of its kind, provided a longitudinal, cross-institutional look at women's experiences and retention in engineering programs. The study's intent was to be the first multi-site study to assess the contribution of undergraduate WEP programs. The purpose of the study was to be able to quantitatively explore the relationship between retention and participation in support programs among women in engineering programs. Its ultimate goal was to "identify aspects of women's educational experiences that are critical to their retention in engineering" (NSF, 2002).

The study gathered data over a three year period (1999 – 2001) from 53 institutions with undergraduate engineering programs. Twenty six of the participating institutions had formal WEP programs and 27 did not have formal WEP programs. The data was collected from a variety of sources (students, WEP Program Directors, Engineering Deans, Engineering Faculty) utilizing on-line questionnaires. The research team also conducted site visits to 11 schools who reported high levels of "contentment in engineering, confidence in engineering and commitment to their major" (NSF, 2002). During these visits, focus groups were conducted among the female students (21 in total) and interviews were conducted with other key administrators. One of the most surprising findings from this study was that there were "no statistically significant differences in retention between women at schools with WEP programs and women at institutions without formal WEP programs." An anecdotal explanation for this finding suggested that those schools without formal WEP programs offered similar services through other

avenues (NSF, 2002). This finding reinforces my assumption that the impacts of WEP programs on its members are still not fully understood.

Further results of the study provided quantitative evidence of the importance of a woman's background and pre-college experiences, reasons for entering engineering, decisions to stay or leave the major, grades, sources of encouragement and discouragement, being female in engineering, perceptions and persistence, and participation in support activities from a pre-scripted menu. However, this study failed to produce knowledge relevant to the overall impact WEP programs have on the academic satisfaction, aspirations and persistence of women in engineering. More importantly, the study never asks women to define, in their own words, what they need to succeed in engineering.

The significance of this study is to build a more complete knowledge base off of the foundation of the WECE study. I do this by conducting a case study, at a large research institution located in the Northeast, across multiple cohorts to gather an in-depth understanding from women enrolled in the engineering program, what they really need to succeed and what role how their socialization process changes across time. The results of the study provide Engineering Deans, administration and faculty data to create or revise programs that empower women to succeed in engineering. It also provides researchers and scholars with a new lens from which to continue exploring the issue.

Assumptions

My interest and desire to understand why women continue to be under represented in engineering is a direct outgrowth of my former graduate assistantship working in the Office of Student Affairs for the College of Engineering at the University.

In my role, I supported the Assistant Dean and Director of the Women in Engineering Program as well as the student chapter of the Society of Women Engineers (SWE). In my daily interactions with students, the gender disparity in engineering became quite evident. This first hand experience with engineering students enhanced my curiosity. Through my work experience and doctoral studies I was able to explore the issue at both a macro and micro level. My exploration into the issue led me to create my own set of assumptions about this issue which include:

- Women who have reached the point of admittance to an engineering program are likely to be interested in math and science, creative, determined and interested in making a difference in the world.
- Women who enroll in engineering programs have pre-conceived perceptions relating to what their college experience, both academically and socially.
- While millions have been spent on research relating to the topic, the results are not easily accessible, shared or implemented as best practices across all engineering programs.
- Current interventions such as WEP programs may not foster the proper balance of academic and social involvement, focusing more heavily on the academic side.
- Women may perceive the existence of negative consequences associated with participating in programs set up to help women in engineering.
- A gap in literature exists that listens to the voices of women enrolled in engineering programs about what they perceive they need to succeed in engineering.

- The issue is not unsolvable; perhaps not enough attention has been paid to understanding the needs of women, as they define them.
- It will be difficult to solve the problem if faculty and administration do not admit a dire issue exists.
- The issue isn't that men are superior to women in engineering.
- Participants for this study are available and interested in advancing the knowledge relating to the subject.

Definitions

Throughout this paper I refer to terms that have specific meanings. Below is a listing of the terms and how they are intended to be understood throughout the context of this paper:

Anticipatory Socialization*:* How non-group members take on the behavior characteristics of the group to which they seek membership (Tierney & Rhoads, 1993).

WEP*:* Acronym for Women in Engineering Program.

REU: Acronym for Research Experience for Undergraduates.

TAP: Acronym for Talent Advancement Program.

Formal *WEP*- WEP programs which meet the following criteria: the WEP program receives institutional funding, with an administrator whose position is paid; the WEP administrator is devoted at least 25% to the program; the WEP program focuses on recruitment and retention of students; and, the WEP program has been in existence for more than three years (NSF, 2002).

STEM*:* Acronym for the combination of studying science, technology, engineering and math disciplines.

Persistence*:* refers to the desire and action of a student to stay within the system of higher education from beginning year through degree completion (Berger & Lyon, 2005)

Retention*:* refers to the ability of an institution to retain a student from admission to the university through graduation (Berger & Lyon, 2005).

Involvement: refers to the amount of physical and psychological energy that a student devotes to the academic experience (Astin, 1984).

Overview

In the following chapter, I provide an introduction that reviews literature and statistics relevant to the current state of women in undergraduate engineering programs (Title IX, 1972; Higher Education Research Institute, 1995, 1996, 1997, 1998, 1999, 2000; Freeman, 2004; Jackson, 2004; Heyman, Bryn, & Bhatia, 2002; National Science Board, 2002; NSF, 1995; Drake, Clewell, & Sevo, 2002; Wadsworth, LeBold, & Daniels, 1992; Brainard, Kelley, & Wadsworth, 1993; Hewitt & Seymour, 1991). In this introduction, I explore the importance of continued attention to the under representation of women in engineering. I then explain how WEP programs have been created and utilized as an intervention to tackle the issue of retaining women in engineering programs but has done so with mixed results.

Throughout the second section of Chapter 2, I discuss anticipatory socialization (Van Maanen & Schein, 1979; Tierny & Rhodes, 1993). Utilizing this concept I explore

how a woman's pre college perceptions influence their overall socialization into the engineering profession.

In the third section of the chapter, I review literature relevant to retention theory (Spady, 1971; Astin 1975, 1984, 1996; Tinto, 1975, 1993; Braxton,1998; Milem & Berger, 1997;Berger & Milem,1999). This section explores the underpinnings for retention strategies at institutions of higher education. It also highlights why these theories many not be appropriate for examining the specific context of women in engineering programs.

In the fourth section of the chapter, I review specific interventions that have been created to aid in the retention of all students on college campuses. These interventions strive to foster academic and social integration among students and include programs such as first year seminars (Tinto, 1993; 1998; Fidler, 1991; Starke, Harth & Sirianni, 2001; Schnell & Doetkott, 2003) and learning communities (Tinto, 1998;Stassen, 2003; Hobbs, Millett, & Minkley, 1999) . I describe the importance of these interventions and discuss the relevance of these interventions in terms of women in engineering programs (Brainard & Carlin, 1991; NSF, 2002).

In the fifth section of Chapter 2, I discuss some of the complex issues faced by women on college campuses that have been identified as potential factors contributing to attrition of women from engineering. I specifically examine the effects of gender socialization (Gallagher & Pearson, 2000; Haines, Wallace & Cannon, 2001; Haines & Wallace, 2002), a women's way of knowing (Perry, 1970; Belenky, Clinchy, Goldberger & Tarule, 1986; Gallos, 1995; Zuga, 1999; Ryan & David, 2003), the campus climate (Crombie, Pyke, Silverthourn, Jones & Piccinin, 2003; Sandler & Hall, 1986; Pascarella,

Whitt, Edison, Nora, Hagedorn, Yeager and Terenzini, 1997) and conclude with a discussion about the lack of role models for women in engineering (Canes & Rosen, 1995; Solnick, 1995; Turner & Bowen, 1999, Rask & Bailey, 2002; Crombie, Pyke, Silverthourn, Jones & Piccinin, 2003).

In the sixth section of the chapter, I explore how WEP programs have been structured as an intervention to help improve the retention of women in engineering.

I conclude Chapter 2 by building a case for why more research is needed build a complete knowledge base relevant to helping women in engineering succeed. This justification will lead us into Chapter 3 which includes an overview of how I structured the research proposal to study this issue.

In Chapter 3 of this paper I identify the research protocol I implemented to understand how anticipatory socialization impacts the academic satisfaction, aspirations, and persistence of female college students enrolled in these programs. This qualitative case study (Rossman & Rallis, 2003) builds on the NSF 2002 quantitative, cross-institutional study of WEP programs. The purpose of my case study is to hear from women enrolled in the College of Engineering, through their own voices, how their values, beliefs and behaviors impacted their on-campus engineering experiences and desire to persist in the discipline. The results of the study provide Engineering Deans, administration and faculty with data to create or revise programs that empower women to succeed in engineering. It also provides researchers and scholars with a new lens from which to continue exploring the issue.

Previous research confirms that the true needs of women in engineering programs remain unclear by program administrators and researchers. The continued result of this

uncertainty is the high attrition of women in engineering programs. I suggest that there has not been enough research conducted specific to women enrolled in engineering programs. In conclusion, I believe that to fully understand how anticipatory socialization impacts academic satisfaction, aspirations and ultimately persistence rates of women enrolled in these programs, an in-depth understanding from women, in their own words, is of paramount importance.

CHAPTER 2

REVIEW OF RELATED LITERATURE

Introduction

In 1876 Elizabeth Bragg, a student at the University of California, was the first American woman to receive an engineering degree. She received her degree in Civil Engineering (Iowa State University Library, 2005). Over a hundred and twenty five years later, the United States is struggling to graduate women into the engineering profession.

The under-representation of women in engineering has been a topic of intense focus by the federal government, academia and researchers since the 1970s. The problem is of particular importance in the United States where young women and minority youth are now the demographic majority (Jackson, 2004). Compared to women, four times as many white males plan to major in engineering, physics, computer science or technical disciplines (Higher Education Research Institute, 2000). Currently, in the United States women earn 57% of all bachelors' degrees awarded (Freeman, 2004) yet account for less than 20% of all engineering degrees and only 9% of the engineering jobs (Heyman, Bryn, & Bhatia, 2002).

Over the next ten years, the United States will need to educate an additional 1.9 million workers to fill expected employment demand in engineering and the sciences (National Science Board, 2002). In order for the United States to fulfill this demand, an increased involvement of women in engineering is critical. For these reasons researchers and scholars in addition to the federal government have invested significant time and energy searching for answers.

The federal government has invested millions of dollars sponsoring research and programs to address the lack of women matriculating in engineering majors. A primary reason for the government's attention to the issue is due to the influx of women into colleges and the job market. A lack of technical education and experience in this growing proportion of the workforce will be detrimental to an increasingly technology-based society (NSF, 1995).

In 1980, The Science and Engineering Equal Opportunities Act gave the NSF authority to support activities to improve participation of women in science and engineering. Between 1993 and 2002, NSF's Program for Women and Girls, now called the Program for Gender Equity in Science, Mathematics, Engineering, and Technology, invested over $85 million dollars sponsoring some 250 projects (Drake, Clewell, & Sevo, 2002). At the graduate level, NSF sponsors the Professional Opportunities for Women in Research and Education (POWRE) initiative which supports the research of individual female scientists at critical junctures during their careers (Rosser & Lane, 2002). NSF continues to be the major source of funding for research on this topic; however, the current focus on national security has impacted its ability to provide the resources necessary to effectively address the problem (Clewell & Campbell, 2002). Decreased federal funding coupled with an increase in demand for workers in the engineering and science fields, means that it is critical for colleges and universities to understand how to best retain women in engineering, and begin to reduce the gender inequalities prevalent in this major.

Institutions of higher education are trying to address this dilemma through continued research and by offering special programs in recruitment and retention of

women in engineering. In 1969, Purdue University launched the first Women in Engineering Program (WEP) in the country designed to combat attrition of women in their engineering programs. During the first ten years of this program, retention rates improved and today, more young women have earned engineering degrees from Purdue University than from any other institution of higher education in the country (Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development, 2000). Since the inception of the first WEP, hundreds of WEP programs have been implemented on campuses across the country. The purpose of these programs is to provide women in engineering with academic support services, hands-on experiences, role models, and career guidance. They are designed to help women navigate a predominantly male dominated system and create a sense of community for female engineering students, ultimately resulting in higher retention rates. To date, the goals of WEP programs have been met with varying degrees of success.

Throughout this chapter I begin to examine the impact of college socialization on the academic satisfaction, aspirations and persistence of female college students enrolled in engineering. I start with an introduction to anticipatory socialization and how a woman's ability to anticipate what lies ahead in engineering may help her succeed. I then have a brief discussion of retention theory and how these theories influenced the types of interventions implemented on college campuses. Next, I explore two specific types of interventions that were developed based on retention theory, first year seminars and learning communities and discuss the implications for women in engineering. I then explore barriers to retention unique to women in engineering including gender socialization, the way women learn, the campus climate and lack of role models. After, I

focus on efforts made by institutions of higher education to increase retention rates of women in engineering through services and programs, including WEP programs. Finally, I identify a need for future research that should be conducted to understand the role anticipatory socialization plays, both positively and negatively towards helping women in engineering succeed.

Anticipating the College Experience

Group socialization can be thought of as the way a person develops the beliefs, attitudes, behaviors and knowledge needed to function as a group member (Van Maanen & Schein, 1979). It is this basic concept that I use to elaborate on how a woman's ability and willingness to become assimilated into the world of college engineering may impact her ability to succeed. Specifically, I explore how anticipatory socialization and the actual experiences faced by women enrolled in engineering might impact how women are socialized into the engineering profession.

Tierney and Rhoads (1993), looking at faculty socialization examined how an individual is socialized into a new role. They broke the process down into two stages: anticipatory socialization and organizational socialization, this paper focuses specifically on anticipatory socialization only. "Anticipatory socialization pertains to how non-members take on the attitudes, actions, and values of the group to which they aspire" (Tierny & Rhodes, 1993). In other words anticipatory socialization is how a person might imagine themselves in a future situation, such as when a female student is preparing to attend a college of engineering. Utilizing this concept I examine how a woman's pre college perceptions influence their overall assimilation into the engineering profession.

Anticipatory socialization can be used as a building block to understand how a woman perceives and interprets how she will assimilate both academically and socially into the role of an engineering student. Utilizing the work of retention scholars (Spady, 1971; Astin 1975, 1984, 1996; Tinto, 1975, 1993; Braxton,1998; Milem & Berger, 1997;Berger & Milem,1999) I build an understanding of how a student needs to be assimilated in order to best succeed. I then explore how these retention theories have been incorporated into the development of specific programs, such as first year seminars (Tinto, 1993; 1998; Fidler, 1991; Starke, Harth & Sirianni, 2001; Schnell & Doetkott, 2003) and learning communities (Tinto, 1998; Stassen, 2003; Hobbs, Millett, & Minkley, 1999) to aid in the retention of students on college campuses. These interventions strive to foster academic and social integration among students and I discuss the specific attributes of these interventions below. I then turn my attention specifically to women issues faced by women on campus and how these unique issues can play a major role in the academic satisfaction, aspirations, and persistence of women in engineering. Finally I conclude this chapter with a look at the origins of WEP programs as interventions to foster the retention of women in engineering programs and identify a need for further research.

Theoretical Approaches

Retention of college students to graduation continues to be an important issue facing most institutions of higher education. On average in the United States 25.9% of all freshman students at four-year institutions do not return the following year (Dervarics & Roach, 2000). In engineering majors retention rates average 40% (Tobias, 1990); however the gap between women and men who complete their engineering degrees

reveals a 20 percentage point swing. Studies show that only 42% of women on the engineering path actually complete their engineering programs, compared to 62% of men (Adelman, 1998). This statistic, coupled with the changing demographic composition of the college student population, as well as workforce demand, reinforces the need for institutions of higher education to understand what women in engineering need to succeed. A logical starting point is to understand what researchers have found to be the necessary ingredients for increasing retention on college campuses, the next step is to uncover if the underpinnings of these current theories are applicable to women in engineering. In the following section I provide a brief overview of the more contemporary thought regarding college student retention. I then explore the possibility that these theories may need to be revisited when exploring the specific context of women in engineering.

Traditional theories of college student retention have provided institutions of higher education with various frames from which to explore why the number of female students leaving engineering programs remains high. Most of the early work examining college student retention was conducted using psychological methodologies (Summerskill, 1962; Waterman & Waterman, 1972) that focus primarily on personality attributes (maturity, motivation, disposition). This lens remains popular when researching attrition in engineering as many faculty support a "top-tier" mentality that implies only the strong and dedicated survive (Tobias, 1990). More contemporary scholars incorporated sociological, environmental, organizational and economic attributes into their theories to help explain reasons for college student departure. It wasn't until 1971 that William Spady transformed how retention was studied by conducting an examination

of existing empirical work on the subject. Through this synthesis of existing empirical work, he was able to create a conceptual framework for studying the issue; an emphasis on the interaction between individual student characteristics and the campus environment (Spady, 1971). Over the next thirty years many researchers including Alexander Astin (1975, 1984, 1996), Vincent Tinto (1975, 1993), John Braxton (1998), Joseph Berger and Jeffrey Milem (1997, 1999) built upon Spady's early work and created more comprehensive models of student departure that examine how students and institutions, together, influence student departure decisions.

After years of studying institutional policy and programs, Astin (1975, 1984) continued to be concerned about the lack of attention paid to the individual student's interactions with the institution. This skepticism led him to develop his own theory of student involvement. Astin's (1975, 1984) theory of student involvement postulates that the more physical and psychological energy (involvement) a student invests in the academic experience (social and academic); the more engaged the student becomes with the institution. An important component of his theory is the relationship between the "quality and quantity" of student involvement. Astin (1984) theorized that increases in the quality and quantity of student involvement ultimately lead to reduced attrition rates at institutions. His theory allows institutions of higher education with to examine and create institutional policy and programs that provide student's with the opportunity to become involved with the institution. Astin's (1984) theory of involvement was also instrumental in serving as a stepping stone for future researchers to expand upon.

Tinto, building off of the work of Astin, created his own theory of college student departure (1975, 1997). This theory, even today, continues to be heavily relied upon by

researchers in the field. Tinto's theory incorporates components of the psychological and organizational lenses, and incorporates Astin's theory of involvement. Utilizing the findings of multiple empirical studies he conducted, Tinto created an interactional theory of student departure which identified thirteen primary propositions that impacted student retention. These propositions connect a strong relationship between student entry characteristics (family background, skills, resources, pre-college experiences), initial institutional commitment and the goal of graduation (Tinto, 1993). Further on campus interactions with faculty and peers (social and academic) would either increase or decrease a student's continued commitment to the institution and the goal of graduation, resulting in the student either staying at or leaving an institution.

Tinto's theory has been used extensively when researchers and scholars examine retention issues, however it was discovered that very little empirical evidence supported the internal consistency of each of the propositions outlined by Tinto. In 1997, Braxton, Sullivan and Johnson set out to test the validity of Tinto's propositions. Utilizing results of single-institution studies, four of Tinto's propositions were found to be "logically interconnected" (Braxton, 2000). These propositions state that students bring to college different entry characteristics which impacts their initial commitment to the institution; a student's initial commitment to the institution will impact their future commitment to the institution; their continued commitment to the institution is enhanced by the level of social integration they realize early on; and the greater the level of commitment to the institution, the higher the likelihood of the student being retained through graduation. This finding suggested that social integration, not academic integration was the key to understanding student departure. In an attempt to improve upon Tinto's model, Braxton,

Sullivan, and Johnson (1997) recommended that future scholars and researchers integrate Tinto's model with aspects of the psychological, social and organizational lenses that could play an impact on either social integration or commitment. Berger and Milem (1997, 1999) did so by integrating Astin's (1996) and Tinto's (1993) models of student departure.

Berger and Milem (1997, 1999) combined the work of Tinto (1993) and Astin (1984) to develop an integrated model of student departure that connected the relationship between "involvement behaviors and integration perceptions." Results of their research indicated that students' perceptions of their situations can be a strong link to the level of involvement and connectedness the student feels, both socially and academically. If the behaviors and perceptions are positive, the student is more likely to view the institution as a "home", resulting in a greater likelihood for completion of their degree.

Although each of these theoretical approaches provides insight into how an institution can design interventions to increase academic and social involvement and integration within an institution, it is important to keep in mind that as these early theories were being developed, the majority of the participants studied and analyzed were white males. Tinto (1993) was one of the first researchers to suggest that retention could be gender specific and wrote "females are more likely than males to face external pressures which constrain their educational participation" (p.77). In addition, most of these theories look at overall college student departure, not discipline specific departure. Finally these theories are examining institutional retention, what an institution can do to retain a student at their institution through graduation. Obviously this is a main concern

for individual institutions, however for women in engineering, the issue is more global and the focus needs to be shifted towards persistence to degree as the main area of focus.

Although classic retention models are not explicitly designed to measure persistence to degree, the underpinnings of these theories can serve as a starting point for institutions to understand the factors that could contribute to the persistence of women in engineering. The focus can be changed slightly to understand how to get women involved and integrated within the discipline, regardless of the specific institution. This paradigm shift will allow engineering staff to utilize these constructs to evaluate how their programs are structured to increase academic and social involvement and integration of their female students among faculty, staff, and peers.

The results and recommendations of these retention scholars have been incorporated into the development of specific programs, such as first year seminars (Tinto, 1993; 1998; Fidler, 1991; Starke, Harth & Sirianni, 2001; Schnell & Doetkott, 2003) and learning communities (Tinto, 1998; Stassen, 2003; Hobbs, Millett, & Minkley, 1999) to aid in the retention of students on college campuses. These interventions strive to foster academic and social integration among students and I discuss the specific attributes of these interventions below. I then turn my attention specifically to women issues faced by women on campus and how these unique issues can play a major role in the academic satisfaction, aspirations, and persistence of women in engineering. Finally, I conclude this chapter with a look at the origins of WEP programs as interventions in to foster the retention of women in engineering programs and identify a need for further research.

The "Freshwoman" Year

Research suggests that an institution can impact the retention process at various stages of a college career beginning with recruitment and admissions policies by providing accurate information relative to the social and academic communities of the campus (Tinto, 1993). Once on campus institutions play an equally important role in developing strategies to retain admitted students. The immediate transition of students to the institution is critical for overall student retention. Integration and involvement is critical during the first ten weeks (Tinto, 1998) on campus. For this reason colleges and universities have implemented freshman orientation and freshman seminars or courses.

Student departure is highest during the first and second year of college and the incorporation of early intervention programs have proven successful in reducing student departure (Tinto, 1993). The use of student affairs offices to offer programs to first year students focusing on adjustment to the academic and social culture of an institution have proven effective in the student retention equation (Braxton & McClendon, 2002). Integrated first year seminars or courses that serve to immediately assimilate students into the academic and social cultures of the institution (Tinto, 1993) have seen long term, positive results. These programs help to build a foundation on which the remainder of a student's college experience is based.

Paul Fidler (1991) conducted a comprehensive study relating to the long term impact of first year seminars. Fiedler (1991) studied sophomore return rates for students at the University of South Carolina from 1973 to 1988. He compared sophomore year retention rates among students who had enrolled in a first year seminar to those who did

not. He found that sophomore year retention rates were higher for students who had participated in the first year seminar for all 16 years.

A more recent study (Starke, Harth & Sirianni, 2001) explored retention of students in eight cohorts who participated in a first year seminar from 1986 to 1993 and compared rates to those students who did not participate. Once again, Starke et al (2001) found that those students who participated in the first year seminar had much higher retention rates over four years than those students who were not involved with the seminar.

In 2003, Carolyn Schnell and Curt Doetkott conducted another longitudinal study looking at the effectiveness of first year seminars on retention over a four year period (1991, 1992, 1993, 1994 academic cohorts). Their study matched 927 students who participated in a first year seminar with 927 students who did not participate. Their findings once again clearly support the value of first year seminars as those students who participated in the first year seminar were consistently retained across four years at significantly greater numbers than those who did not enroll in the seminar.

Retention studies focusing specifically on women in science and engineering also identify the freshman and sophomore years as the critical period when women disproportionately abandon plans to major in these disciplines (Tobias, 1990; Atkin, Green & McLauglin, 2002; NSF, 2002). Therefore, the need to provide women with the opportunity for a smooth transition into engineering could be an important step in the retention process. Research into the effectiveness of first year seminars specific to women in engineering has not been an intense focus of researchers. In fact, an ERIC database search for journal articles devoted specifically to this topic returned only one

journal article and eight documents. Although previous research, discussed above, suggests first year seminars would benefit women in engineering, this is clearly a topic that can use additional research.

Another topic that has been thoroughly researched and proven to aid in retention efforts is the building of community on college campus. In the next section I explore how the research findings on community building can be used to help support women in engineering.

Universities as Communities

The more academically and socially involved students are with peers and faculty the more likely they are to persist (Astin, 1984; Tinto, 1998; Berger & Milem, 1999; Terenzini & Pascarella, 1980). Involvement occurs both inside and outside of the classroom, across the campus community. The ability for an institution to create a campus community for its students can help improve retention rates.

Learning communities (LCs) have been used as tools to aid in improving retention rates at colleges and universities for decades (Stassen, 2003). LCs can be structured in a variety of ways, each with the purpose of allowing students to have some affiliation with other students, whether through course taking as a group to living together on the same floor. The positive impacts of LCs have been well documented. Studies show that whether a LC is highly or loosely structured, community members tend to have higher first semester GPAs, better overall first year experiences and they tend to persist. The existence of community that provides minimal access to faculty and peers, also proved to be effective in impacting retention (Stassen, 2003; Tinto, 1998). Tinto, Love, and Russo (1994) found that first-year students involved in LCs felt these communities were key

sources of academic and social support, necessary components for positive involvement and integration. The importance of community building can not be overlooked when trying to develop programs to improve retention.

Studies show that women are more likely to persist in programs that foster a sense of community building among peers and faculty (Hobbs, Millett, & Minkley, 1999). A recent longitudinal, cross-institutional study of women in engineering programs, the first of its kind, conducted by NSF and the Alfred P. Sloan Foundation (2002) found that a sense of community allowed these women to "build networks and to feel that their presence in engineering is important to others. Networking can counteract the isolation that women experience- providing them with information, support and the knowledge that they're not alone it the challenges they face." These results reinforce previous findings (Brainard & Carlin, 1991) supporting the necessity of community building and putting a sense of meaning to what women in engineering are accomplishing. These data are important in the evaluation of university programs and curriculum. If engineering programs can provide a sense of community for women, retention rates may be impacted. This will take a concerted effort as women are faced with many barriers to success on college campuses. The need to offer these women a sense of community may be the linchpin in improving persistence of women in engineering.

In the next section, I describe some of the complex issues faced by women on college campuses that have been identified as potential factors that contribute to attrition of women from engineering. I examine the effects of gender socialization, a women's way of knowing, and the chilly campus climate and conclude with a discussion about the lack of role models for women in engineering. I then explore how WEP programs have

been structured as an intervention to help improve the retention of women in engineering. Finally I outline a case for why more research is necessary to understand how to best help women in engineering succeed.

A Wo(man)'s Perspective

Gender socialization theory has long been used by researchers to study gender differences among those selecting engineering as their major. The assumption behind gender socialization is that a set of attitudes, behaviors and aspirations are defined as socially and culturally appropriate and deemed acceptable for men and women. These constructs are then continually reinforced throughout society. It has been shown that the socialization of women strongly influences their self perception, their relationships with others, their learning styles, and their choice of career (Gallagher & Pearson, 2000). Through gender socialization, early childhood messages are reinforced. Boys are encouraged and expected to learn about machines and how things work, not so for girls. Gender-specific social expectations may play a role in limiting the likelihood that girls will become engineers (Girl Scout Research Institute, 2001).

Engineering has always been viewed as a man's occupation. This notion has been reinforced continually over time and throughout society. This stereotype may influence the choice of college major for women as a college major is often selected utilizing an "outsider" perspective. Students are often influenced by the image portrayed of the discipline (Barber, 1995). The overwhelmingly male portrayal of engineering coupled with the strong pressure women feel to follow traditional female defined norms (Gallagher & Pearson, 2000) could play a part in the why women choose to not major in engineering or switch out of engineering at such high rates. Once enrolled in the major,

however, the decision to remain rests largely on the day-to-day experience of the student (Barber, 1995).

Haines, Wallace & Cannon (2001) explored how gender roles and gender stereotypes impact decisions to major in engineering. In 2001, they utilized a hypothesis of cumulative advantages and disadvantages to test this theory. Cumulative advantage and disadvantage theory purports that the accumulation of small advantages for men and small disadvantages for women contributes to the gender gap in engineering. Results of their survey showed that men and women accumulated different advantages and disadvantages as they move throughout the college pipe-line. These findings support the need for research to be conducted looking at the micro-inequities that could impact retention. In a follow-up study, Haines and Wallace (2002) tested the hypothesis that being female reduced the likelihood of majoring in science and engineering based on traditional gender roles, self-efficacy and encouragement. Results from their survey supported this hypothesis. It is evident that gender socialization can have an impact on the success of women in engineering.

Since the general population continues to view engineering as a masculine discipline, the impact of societal rules and norms must be considered when analyzing this issue. The media has a significant impact on shaping beliefs and attitudes of young men and women (Muuss & Porton, 1999). The media has traditionally portrayed the engineering discipline as white man's work. Dilbert, the most well-known engineer in the United States is a white, male cartoon character who hates his job and is surrounded by dysfunctional co-workers (Tietjen, 2004). This negative portrayal of engineering reinforces the notion that engineering is not for women. Institutions of higher education

must rethink and try to influence how the media and society views and socializes women towards engineering. Once a woman elects to major in engineering, it is vital that institutions of higher education recognize their own college gendered socialization patterns.

Learning styles is a reflection of gender socialization. Differences in learning styles between men and women have been recognized and researched (Belenky, Clinchy, Goldberger, & Tarule, 1986). Throughout the next section I discuss contemporary thinking concerning learning styles and the relevance of this topic specific to women in engineering.

The Differences in Knowing

It comes as no surprise to most people that men and women are different. Although differences should be embraced, often times these differences between the genders are highlighted and barriers to gender equality are created. This notion of gender difference has recently been reinforced with comments made by Lawrence Summers, President of Harvard University, at a conference discussing how to diversify the science and engineering workforce. His controversial comments specifically state that "innate differences exist that prevent women from succeeding in science and engineering" (Fogg, 2005). While these comments continue to cause intense debate on the subject they provide institutions of higher education with the opportunity to explore what these differences really are and how they can embrace these differences for the common good of not only the university, but society. One way to do this is to re-examine the differences in how men and women learn.

Over 300 years ago, American universities were created by men, for men (Rudolph, 1990). The engineering discipline and curriculum was also created by men for men. Today, engineering continues to be a heavily male dominated field, even as other typically male-oriented disciplines such as medicine, law and business have made significant strides in attracting women. There could be many reasons for the continued shortage of women in engineering, but perhaps one way of eradicating this trend is to develop a thorough understanding of the differences in how men and women learn.

Mary Field Belenky, Blythe McVicker Clinchy, Nancy Rule Goldberger and Jill Mattuck Tarule (1986) identified a gap in cognitive development research that had previously been conducted among college students. The gap in the literature showed that the majority of the cognitive development research that had been conducted relied on responses from predominantly white males (Perry, 1970). Their individual passion for understanding how female college students developed cognitively drove them to collaborate to provide insight into a women's way of knowing. Utilizing in-depth interviews and focus group discussions with 135 rural and urban women ranging in age from 18 to 60 with various occupational backgrounds, Belenky, et. al (1986) set out to understand how a woman comes to know. Through the interviews with these women, they identified five cognitive developmental perspectives: *silence* where women did not have a self and did not speak out; *received knowledge* where women learned by listening to others, but were not confident in their ability to participate in the conversation; *subjective knowledge* where women begin to trust their instincts and intuition and desire to find their own identity; *procedural knowledge* where women begin to look for reason and become aware of separate and connected knowledge; and *constructed knowledge*

where women are able to integrate the self, voice and mind. Each of these perspectives was a reflection of how these women perceived the evolution of their identity (self); the development of relationships with others (voice); and how they come to understand truth and knowledge (mind). Their results provided evidence that differences exist in how women experience and think about the world, compared to their male counterparts.

Belenky et al. (1986) found that women typically need to understand the context of the idea and to have a thorough explanation. These and subsequent studies (Gallos, 1995; Zuga, 1999; Ryan & David, 2003) provide evidence that women do think and learn differently then men. Perhaps the time has come for institutions of higher education to address these differences in engineering education where extremely low number of women continue to persist. It is possible that engineering educators have not paid close enough attention to the ways women learn and think. A better understanding of different learning styles could help engineering educators to develop a curriculum that is more inclusive of women. By incorporating simple ideas such as providing a more thorough explanation and providing legitimate context for the work of engineers perform would benefit all students (Zuga, 1999) and perhaps changing the relationships between the men and women in the classroom. As discussed earlier the importance of being involved and integrated both socially and academically inside and outside of the classroom fosters retention. Teaching to students in a way that fosters connected learning would be beneficial to all students and is perhaps a way to transform the discipline.

Besides learning styles, the climate in the classroom is also a factor that might impact retention rates. It is important for engineering faculty to be cognizant of the classroom climate that women face. In the next section I describe research that reveals

women and men are treated differently in the classroom. Again, if a student does not feel involved and integrated inside and outside of the campus, a greater likelihood for attrition exists.

The Chilly Climate

Hall and Sandler's (1982) seminal work, *The Classroom Climate: A Chilly One for Women?* launched the term "chilly climate" to the forefront of college campuses. This report, a synthesis of existing research studying the perceptions of both male and female students regarding their classroom experiences revealed that certain practices on coeducational college campuses and in classrooms existed that result in a woman's marginalization. Specifically, Hall and Sandler (1982) found that faculty members tend to call on male students more often then female students, give more feedback to men than to women, and ask less difficult questions of female students. Subsequent studies found sexist use of language, stereotypic views of women, different faculty/student interactions based on gender, and a lack of women faculty as mentors exists on campuses nationwide resulting in negative impacts on a woman's cognitive and social well being (Crombie, Pyke, Silverthourn, Jones & Piccinin, 2003; Sandler & Hall, 1986).

Pascarella, Whitt, Edison, Nora, Hagedorn, Yeager and Terenzini (1997) examined the effect of a perceived chilly climate on women's cognitive development during the first year of college. Analysis of data collected from 1,636 women attending 23 two and four year colleges across the US hinted that there was a slight correlation between the perception of a chilly climate and negative cognitive development. In 1999 Pascarella, Whitt, et al expanded the study and examined climate effects through the junior year. Evidence from this study confirmed earlier results.

Although studies have been conducted to refute the notion that a chilly climate impacts cognitive and social outcomes for women, it seems intuitive that the existence or even perception of a chilly climate would most likely result in negative consequences for the student. In the engineering discipline where five out of six engineering students and nine out of ten engineering professors are male (Black Issues in Higher Education, 2005) the climate on college campuses could be critical for the retention of women. The absence of female peers and faculty both in and out of the engineering classroom inhibits women from forming support networks which can lead to a perceived chilly climate (Washburn, 2004). In order to retain women in engineering, a discipline taught and studied predominantly by white males, institutions of higher education need to examine and potentially change the climate women face today on campus.

Women in engineering literature, from 1980 to the present, has examined gender bias in the classroom and in the laboratory. Much has been written about women's voices not being heard in the classroom (AAUW, 1998), their status as note-takers in labs and the undervaluing of their work by male peers in group projects (Tonso, 1996). As women continue to grow in number on college campuses, currently accounting for 51 to 56 percent of all students in higher education (Krunkel, 1994), it is important to have an understanding if women still perceive and actually face these types of gender bias in the classroom.

One potential way to change the climate on campus and in the classroom for women in engineering is to provide female faculty and role models for them to emulate. Unfortunately until undergraduate educators can figure out a way to retain women in engineering, it becomes even more difficult to have a women progress to the doctoral

level. Therein lies the vicious cycle that must be addressed. The next section explores research that has been conducted into the importance of role models for women in engineering programs.

The Importance of Role Models

The importance of female role models to attract women into specific majors has been a widely held belief in academia. Many researchers (Canes & Rosen, 1995; Solnick, 1995; Turner & Bowen, 1999, Rask & Bailey, 2002; Crombie, Pyke, Silverthourn, Jones & Piccinin, 2003) have studied the link between female faculty and female major selection, but have reached various conclusions, leaving room for further exploration on this topic.

Rask and Bailey (2002) explored the impact of faculty role models in relation to major selection by analyzing student pre-college, college transcript and demographic data among samples of female, minority and male students. They then identified the specific courses that were taken and attached race and gender of the faculty member to that data. They examined data on 8,167 undergraduates between 1988 and 2000 from one private university. Their data suggested that faculty role models did influence major selection for female and minority students. A major shortcoming of this research is that it was conducted at a single, liberal arts, private institution where the ratio of faculty to students is smaller.

A student's perception of their classroom experience and interaction with faculty does have dramatic consequences for participation, which has long been linked to successful learning and overall satisfaction. In a study to measure a student's perception of their own participation, researchers (Crombie, Pyke, Silverthourn, Jones & Piccinin,

2003) examined features of the classroom environment. They explored contextual aspects of the classroom (size, gender balance, instructor gender, discipline) on perceptions of their own participation as well as the influence of student gender, student self-perceived activity level and student age. Their findings supported previous studies that found female students perceived themselves as participating less overall, using less assertive modes of participation, participating more in classes taught by female faculty, and having more positive perceptions of female professors (Crombie, Pyke, Silverthourn, Jones & Piccinin, 2003). These findings support the need for institutions of higher education to provide access to female faculty as role models for female students.

Although this particular study was not focused on any specific discipline, it can be hypothesized that in courses such as engineering where women are outnumbered significantly by male students and typically taught by male professors, women may become silenced and not fully participate. Since women account for less than 10% of all faculty positions in engineering (Huband, 2002) females may not feel as comfortable in the classroom and may loose interest in remaining in an engineering major. As women find fewer faculty members to emulate as role models, they are less likely to perceive themselves as future teachers. This self-fulfilling prophecy may perpetuate the inability to close the gap between men and women in engineering. As this cycle continues to plague the engineering discipline, educators have been trying for years to help women find role models to emulate. The WEP program has been designed to help facilitate a linkage of female students to female role models.

WEP programs are interventions that were created to help women combat the tough issues they faced on campus. In existence since 1969, programs have been

implemented on more than 200 campuses nationwide (Brainard & Carlin, 1991). The success of these programs still remains unclear, as the numbers of women in engineering has not made great strides since its inception. The remainder of this section is devoted to an overview of WEP programs and why there is a need for additional research into how these programs are working to support the academic satisfaction, aspirations and persistence of female college students enrolled in these programs.

Exploring the Impact of WEP Programs

In 1919, over 40 years after the first woman was awarded a degree in engineering, the first evidence of female engineering students trying to organize was recorded. In a letter written by Lou Alta Melton (Daniels, 1995), an engineering student at the University of Colorado, she asked Engineering Deans throughout the United States for help:

> "The women students in the engineering department at the University of Colorado wish to know the names and addresses of the women who are, or have been, registered in your engineering school. We desire this information for the purpose of organizing women students into a society auxiliary to the men's organizations."

Melton's letter received few responses, however one response received from a professor at the Georgia School of Technology hinted at the uncertainty ahead for women in engineering:

> "Dear Lady,
>
> Up to the present, women students have not been admitted to

Ga. Tech. Yesterday, the City of Atlanta conferred suffrage on women in City affairs, so no knowing what may happen!" (Daniels, 1995).

This exchange provides early evidence of the uncertainty waiting for women who desired to pursue engineering. As a response to provide some support for women in engineering programs, the first WEP program was launched at Purdue University in 1969. WEP programs are utilized to attract and retain women in engineering programs. Today there are over 200 WEP programs on campuses across the country (Brainard & Carlin, 1991) providing activities which support women in engineering. These activities include both academic and social support and may include newsletters, mentoring programs, tutoring programs, speakers, social events, and outreach programs (NSF, 2002). WEP programs today are viewed as vital components in attracting and retaining women in engineering programs and have received millions of dollars from governmental agencies to help eliminate the void of women in engineering. As stated throughout this paper, even with dedicated staff, formal programs and millions of dollars allocated to address this issue; significant gains in retention have not yet been achieved. Over the years, individual institutions have done minor program evaluation research, however until recently (NSF, 2002) no comprehensive data existed which measured the effectiveness, defined as increase in retention of women in engineering majors, of WEP programs.

In 2002, NSF released the results of its WECE project, the first cross-institutional, national study of WEP programs. The goal of this study was to "*statistically* assess the relationship between women's persistence in undergraduate engineering programs and

their participation in support activities, as well as the relationship between persistence and departmental, institutional and personal factors" (NSF, 2002).

Findings from this study provide institutions with a laundry list of options to use in efforts to improve persistence, many of which were described above (community, role models, improved climate), however the surprising finding was that the study found "no statistically significant differences in persistence between women at schools with WEP programs and women at non-WEP institutions" (NSF, 2002). A possible explanation could be that additional support services are available to women at non-WEP institutions; however this theory needs to be investigated.

The Need for Further Research

Over the past century, the consistently low representation of women, in undergraduate engineering majors has continued to baffle educators, researchers and policy makers. Currently, in the United States women earn 57% of all bachelors' degrees awarded (Freeman, 2004) yet account for less than 20% of all engineering degrees and only 9% of the engineering jobs (Heyman, Bryn, & Bhatia, 2002).Demographic data and workforce demand have overwhelmingly confirmed that this is an issue that needs continued in-depth attention.

Research is needed to more fully understand what women in engineering truly need to succeed. To generate this body of knowledge, a qualitative study is warranted to explore how a woman's anticipatory socialization impacts her academic satisfaction, aspirations and persistence in engineering programs and how it is changed and influenced over time. This is an area of research that is still in its infancy stages and perhaps the linchpin to solving this issue.

In Chapter 3, I discuss how the research protocol was structured to study this issue. I begin by explaining the conceptual framework that guides this study. This framework is based upon a synthesis of the literature reviewed above. I then present the blueprint utilized to conduct this study which results in producing data which builds upon the current knowledge base of why there are so few women in engineering.

CHAPTER 3

DESIGN AND METHODS

Women are now part of the demographic majority on college campuses yet they continue to represent a very small percentage of engineers. Millions of dollars have been invested to understand why women are leaving engineering majors at alarming rates. The purpose of this study is to understand what women in undergraduate engineering programs need in order to be successfully socialized into the engineering profession.

Throughout this chapter, I outline the research methodology used for examining how anticipatory socialization impacts the academic satisfaction, aspirations and persistence of female college students. First, I discuss the conceptual framework I utilized to build my methodology. I then discuss the research questions that were explored throughout the study and the research strategies I employed to answer these questions. I then define the resources employed to identify participants and discuss the instruments used to gather the data. Next, I outline how the data was analyzed. I conclude this chapter with a summary of why this study enhances the existing knowledge base.

Conceptual Framework

The research outlined in this chapter was conducted as a case study of women enrolled in the College of Engineering at a large research university in the northeast. The case study was used to improve understanding of the under representation of women in undergraduate engineering programs through a detailed investigation of one engineering program (Rossman & Rallis, 2003). Through listening and reading about the expectations these women had regarding their college experience in comparison to their actual experiences, I began to understand the policy implications that could help women

succeed in engineering and how these women perceive anticipatory socialization impacted their academic satisfaction, aspirations and persistence. These results clearly add to existing literature relating to persistence of women in engineering.

The underpinnings for my conceptual framework are constructs derived from contemporary retention models, including Tinto (1993), Astin (1984) and Berger and Milem's (1997, 1999) integrated model of student persistence. The Berger and Milem model combines the work of Tinto (1993) and Astin (1984) and connects the relationship between "involvement behaviors and integration perceptions." These previous theoretical models view the relationship between involvement and integration as linear progressions. I elaborate on these theories of persistence by incorporating "helper" constructs from other theories that relate to the complexities of the topic and propose that the persistence equations is more of an on-going, evolving process rather than a more formal linear progression. I draw from existing literature in the areas of anticipatory socialization, gender socialization, learning styles, community building and the chilly climate discussed in Chapter 2.

As Figure 3.1 depicts, students enter college with their own personal attributes and attitudes about how they succeed, as well as an initial commitment to college. Once on campus, their involvement and integration in both academics and social activities plays a major role in their persistence to graduation (Milem & Berger, 1997; Berger & Milem, 1999). This study explored the effects of pre-college and continued college anticipatory socialization attributes/experiences impacted perceptions, involvement, and overall satisfaction with their college academic and social experiences.

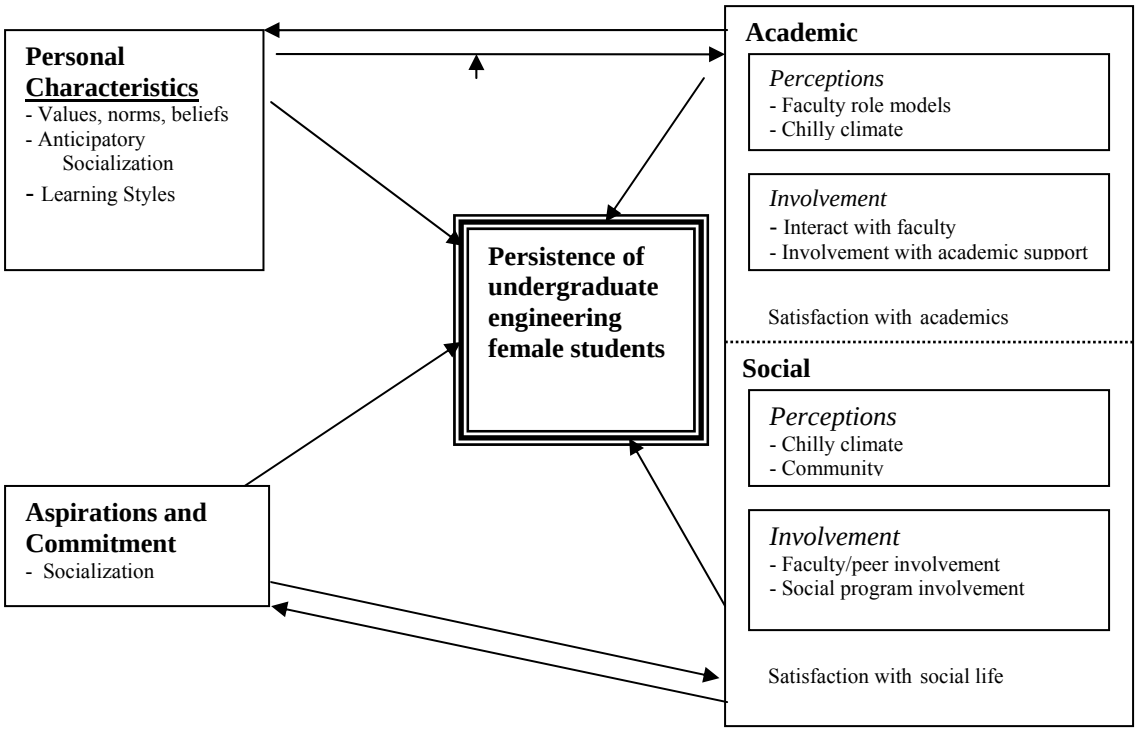

FIGURE 3.1. Conceptual Framework.

My specific research questions informed "helper" constructs drawn from the literature and outlined in Chapter 2. These theories include the effects of anticipatory socialization (Tierney & Rhoads, 1993), gender socialization (Gallagher & Pearson, 2000; Haines, Wallace & Cannon, 2001; Haines & Wallace, 2002), learning styles (Perry, 1970; Belenky, Clinchy, Goldberger & Tarule, 1986; Gallos, 1995; Zuga, 1999; Ryan & David, 2003), the chilly climate (Crombie, Pyke, Silverthourn, Jones & Piccinin, 2003; Sandler & Hall, 1986; Pascarella, Whitt, Edison, Nora, Hagedorn, Yeager and Terenzini, 1997) and the lack of role models for women in engineering (Canes & Rosen, 1995; Solnick, 1995; Turner & Bowen, 1999, Rask & Bailey, 2002; Crombie, Pyke, Silverthourn, Jones & Piccinin, 2003). Additionally, I explored how women perceive interventions such as first-year seminars (Tinto, 1993; 1998; Fidler, 1991; Starke, Harth

& Sirianni, 2001; Schnell & Doetkott, 2003) and learning communities (Tinto, 1998; Stassen, 2003; Hobbs, Millett, & Minkley, 1999) as factors in persistence.

Also worth noting is the role faculty pedagogy plays in the academic satisfaction, aspirations and persistence of women in engineering programs. Retention theorists (Astin, 1984; Tinto, 1975, 1993; Milem & Berger, 1997; Berger & Milem, 1999) clearly articulate the importance of both formal and informal faculty/student interaction. Researchers have cited engineering pedagogy issues such as a lack of diversity of ideas as well as positioning engineering as a rigorous and competitive environment (NSF, 2002) as deterrents for women to persist in engineering. Engineering courses continue to be taught in a subject driven manner, with little attention paid to societal implications. Research suggests that women persist in courses where a connection can be made between subject and real life application (Seymour, 1992). Recently (NSB, 2002) recommendations have been made for revisions to the engineering curriculum to include "more investigative learning, technology, laboratory experience and collaborative work". Throughout this study, pedagogy issues were explored through discussions of the classroom climate (Crombie, Pyke, Silverthourn, Jones & Piccinin, 2003; Sandler & Hall, 1986), differences in learning styles between men and women (Belenky et al., 1986) as well as the importance of female faculty as role models (Canes & Rosen, 1995; Solnick, 1995; Turner & Bowen, 1999, Rask & Bailey, 2002; Crombie, Pyke, Silverthourn, Jones & Piccinin, 2003).

These issues were explored as potential sources of influence on the socialization perceptions that were likely to impact the persistence of undergraduate women enrolled in the engineering program. This conceptual framework provided a map of initial areas to

explore with participants and evolve in response as narrative data was collected and analyzed throughout the study.

Utilizing observations, personal journals, in-depth interviews and focus group methodologies I was able to probe specifically how women interpreted their anticipatory socialization and how it impacted their academic satisfaction, aspirations and persistence. To fully understand the influence anticipatory socialization had on their decision to remain in engineering, an in-depth understanding from women, in their own words, was of paramount importance. The result was a research strategy designed with specific questions in mind. The next section of this chapter details the specific research to be explored throughout the study.

Research Questions

The logical point to begin this study was to examine what happens to women as they arrive on campus and enter the engineering program. Factors explored included their perceptions and expectations compared to the reality they faced. The comparison helped reveal the factors that contributed to becoming successful engineers. The qualitative nature of this study required flexibility and willingness to embrace findings as they presented themselves.

The goal of this study is to understand what women enrolled in the engineering program needed to succeed. The starting point for the study was in gathering an understanding of what women anticipated they needed, and specifically how this program was aligned to meet their needs. The overarching research question of this study is:

How do female engineering students perceive their undergraduate experience as anticipatory socialization into the engineering profession?

Probing questions that provided evidence to answer the overarching question included:

- How do background characteristics of students influence their perceptions?
- How do these perceptions change from freshman to senior year?
- What are the critical decision points?
- What is the role of faculty shaping these perceptions?
- What are the perceptions of the classroom and lab climate?

In order to generate usable results, I conducted a trustworthy and rigorous case study. Rossman and Rallis (2003) define the term trustworthy by asking researchers to consider two important questions when conducting qualitative research: is the study competently conducted and is the study ethically conducted. To accomplish this, throughout the study I explained both the methodological as well as the ethical choices that I employed to guide this study. The building of credible and trustworthy results will enable administrators, Engineering Deans and faculty to make informed decisions regarding their own program development or modification. It is also hoped that this study might serve as a launching pad for additional research on this important topic.

In the next section of this chapter, I outline the methodology utilized to answer the questions outlined above.

Research Design

> *Qualitative research is a situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that make the world visible. These practices transform the world. They turn the world into a series of representations including field notes, interviews, conversations, photographs, recordings and memos. To the self…qualitative researchers study things in their natural settings, attempting to make sense of, or to interpret, phenomena in terms of the meanings people bring to them* (Denzin & Lincoln, 2000).

A qualitative, case study research methodology was employed to gather data on female students enrolled in the college of engineering at a large research institution in the northeast. The case study was designed to generate a thorough understanding of how a woman's anticipatory socialization impacts her academic satisfaction, aspirations, and overall persistence. Specifically, the study focused on their expectations and experiences while they are on campus and to understand how anticipatory socialization impacted these expectations and experiences. Factors identified in previous research studies and discussed in Chapter 2 was used as a starting point and evaluated throughout the study. These factors included; anticipatory socialization, gender socialization, the campus climate, role models and specific interventions designed to foster retention (first-year seminars, learning communities and WEP programs). Approaching this study utilizing a case study approach allowed me to understand what women experience on campus through stories and words of their own. These stories identified clear barriers for women in engineering, in the 21st century.

This purely qualitative study was conducted utilizing a quasi-concurrent triangulation design (Creswell, Clark, Gutmann, & Hanson, 2003) as depicted below:

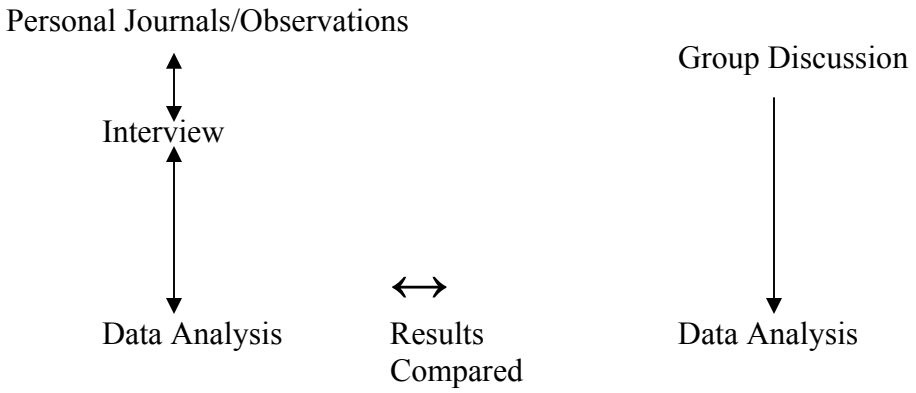

FIGURE 3.2. Quasi-concurrent Triangulation Design

In this study, data sources included: observations of participants in the classroom and at social events; personal journals of participant's experiences; in-depth interviews with female students enrolled in the engineering program; and focus group discussions with participants.

Observations

Participant observation is a form of qualitative research used to study communities or groups in a natural setting. According to Rossman and Rallis (2003), "observations take you inside the setting; it helps you discover complexity in social settings by being there". Seventeen participants were observed in a setting of their choice including: the classroom, WEP meetings, laboratories and society meetings. These observations allowed me to observe both the social and academic experiences of women in the engineering program.

Personal Journals

Participants were asked to keep personal journals of their social and academic experiences on campus during each semester. An initial set of questions, included in Appendix A, were given to the participants to answer. After the initial set of questions

were answered, the women were told to use the journals as a free writing exercise with no specific instructions. A majority of the women (fourteen of nineteen) wrote on a daily basis. The average total journal length was 15 pages. The journal served as the daily memory for the participants. It captured their experiences and feelings in real time. The journals were personal and provided the study with honest feedback relating to their undergraduate experience. Through content analysis, the journals were used to augment data collected through observations, interviews and focus groups.

In-Depth Interviews

Two individual interviews were conducted with each participant. The first interview occurred within the first few weeks of their arrival on or back to campus. The purpose of the initial interview was to create a profile of their expectations and actual experiences on campus. A list of guiding questions was developed, but modified based on the conversation. A copy of the guiding questions is included in Appendix B. The interview was used to collect data regarding influences on their decision as well as their perceptions of the engineering program. Participants also discussed their expectations regarding the engineering program. Data regarding how perceptions and expectations changed over time was collected from upper class women. The interviews were conducted as personal life history discussions which allowed the participants to narrate their individual experiences (Rossman & Rallis, 2003) and expectations. The second interview was conducted during the spring semester. This follow-up interview was conducted to gather data on their actual experiences and to identify any changes in their expectations throughout the academic year. This interview was also conducted to generate a complete understanding of how anticipatory socialization impacted their

experiences Interviews lasted approximately 1 hour each and were conducted in a private conference room in the engineering quad. Interviews were audio taped and transcribed verbatim.

Focus-Group Discussions

Two focus group discussions were conducted with participants. The discussions were conducted toward the end of each semester after each semester's in-depth interviews had been conducted and analyzed. Nineteen women participated in the fall, and seventeen women participated in the spring. The focus groups were used to explore, clarify and confirm particular ideas generated in the personal interviews. The second discussion was structured to define what the term success meant to these women. The moderator outline from group 2 is included in Appendix C.

These discussions also served as a means of member checking. The group format permitted a more in depth exploration of the ideas with all participants present. The groups also provided a safe space for dialogue about experiences among freshman and upper class female engineering students.

Participants/Data Sources

This case study was conducted at a large, co-educational, ABET accredited research institution with approximately 13% or 132 female undergraduate engineering students. In the following section I outline the rationale for my sample selection.

This research study is designed to enhance the understanding of how women are socialized into the engineering profession. To enhance the current knowledge base, my case study was conducted at a large, a co-ed, ABET accredited research university with a formal engineering program. At the time of this study, I was working as a graduate

assistant for the College of Engineering in the Office of Student Affairs. In my role, I supported the Assistant Dean and Director of WEP as well as the student chapter of the Society of Women Engineers. My role presented both opportunities and potential obstacles for me as I had a pre-existing relationship with some of the participants in the study. Throughout the study I was diligent in honestly and clearly representing the views of my participants as I saw and heard them unfold.

The scope of this study was to understand the role anticipatory socialization has on academic satisfaction, aspirations and overall persistence of the women enrolled in the engineering program. To develop a clear understanding of how socialization changes across their academic careers a sample was recruited consisting of women from each of the four cohorts (freshman, sophomore, junior and senior). An incentive of fifty dollars was used to increase participation rates. A total of nineteen women agreed to participate in the study. Participants were not paid until successful completion of the study. The self-selected sample consisted of primarily white female students with a diverse engineering discipline mix. Two of the nineteen students did not complete the entire study.

Data Collection

Initial contact was made with potential participants shortly after they arrived on campus in early September. The first notification was an email letter from the Dean of Students and the WEP Director informing them of the research study. I followed up with an email letter to all women enrolled in the engineering program inviting them to participate. An incentive of fifty dollars was offered for their participation at the conclusion of the study. I was clear that their decision, either way to participate or not, would have no impact on their career at the institution. A reply mechanism was included

for the students to inform me of their decision. Follow-up phone calls and emails were used to confirm participation. Once participants were identified, I invited them to an information session.

At the information session, I introduced myself to the participants and gave them an overview of this study. I informed them of the importance of the study and assured them that their involvement was not only in the giving of information but in the ultimate product, the research report. I reminded them of their commitment: allowing me to observe them in various settings, keeping a daily journal, participation in two personal interviews and two focus group discussions with all members. Participants were provided with a journal, and the first of two interviews was scheduled.

As the study proceeded, the participants were asked to review my notes to be sure I had a correct understanding of what I heard. This process occurred throughout the analysis stage of the study, which I describe next.

Analysis

Data analysis was conducted utilizing a combination of analytical methods. A constant comparative model was used to generate categories of data, while a holistic approach was employed to generate portraits of these women (Rossman & Rallis, 2003). These methods are interwoven in the findings chapter to tell the complete story of how women perceived anticipatory socialization has impacted their academic satisfaction, aspirations and persistence.

As observations were recorded, field notes were generated and analyzed. Attention was paid to the observer comments from which to draw potential interviewing topics.

Interview transcripts were compiled at the completion of each interview. The interviews were tape-recorded and manually transcribed. Transcripts were formatted leaving large margins to the right of the transcription so that I was able to highlight and pull out points of interest mentioned by the participants. I synthesized the data, identified themes and coded the data. At the completion of these steps, I presented my findings back to interested participants for their review and comment (Rossman & Rallis, 2003). The analysis of the data collected in the in-depth interviews served as the foundation from which the moderator outline was generated for use in the focus group discussion. The process for data analysis of the focus group discussion was similar to that of the interviews described above, with the inclusion of video taping to be used if clarification was necessary.

The personal journals were collected at the end of each semester in an effort to get a complete picture of their experiences and thoughts across the entire semester. The journals were analyzed and coded, and the data were used to augment the data collected via observations, interviews and focus group discussions. Although this qualitative study was designed to be comprehensive, and in depth, there are limitations inherent in the design. In the following section, I outline the limitations of the study.

Limitations

The goal of this study was to explore how anticipatory socialization impacts the academic satisfaction, aspirations and persistence of female college engineering students, therefore the thrust of this study was focused on these issues. As anticipated, ancillary topics surfaced and were recorded as potential areas for future study.

The study was an examination of one engineering program, at one point in time. I was intentional in my description of the case study and present the findings based on those women, at this institution, at that point in time. It is left to the reader of the study to decide whether the findings apply to their own situation and institution (Kennedy, 1979).

My reason for focusing exclusively on the impact of anticipatory socialization is to understand how an institution can best structure and implement programs that are instrumental to helping women become involved and integrated, ultimately helping them to persist and succeed in engineering. This focus will provide researchers, scholars, program directors and administrators with a body of knowledge that is currently limited.

Conclusions

The importance of this study is evidenced by the fact that, although over the past few decades millions of dollars have been invested to combat the shortage of women in undergraduate engineering programs, very little improvement in numbers has been made and no clear understanding of why this phenomenon continues has been identified. One reason for this continued trend is that very little research focuses exclusively on women's experiences in college engineering programs (NSF, 2002). Research is needed to understand from women enrolled in engineering programs what they really need to succeed.

The overall importance of this study was to build on previous research relating to women in undergraduate engineering programs. Conducting a case study to gather an in-depth understanding from women enrolled in an engineering program enables practitioners to understand what women really need to succeed and how anticipatory socialization impacts their success. The results of the study will provide policy makers,

engineering administration, faculty, researchers and institutions of higher education with data to create or revise strategies and programs to empower women to succeed in engineering. They also provide future researchers with information, from a woman's perspective, on which to build future studies.

CHAPTER 4

FINDINGS OF THE STUDY

Introduction

In the fall of 2005 and the spring of 2006, nineteen women enrolled in the college of engineering at a large research institution in New England participated in a qualitative study to identify how their undergraduate experience prepared them for anticipatory socialization into the profession. If I relied only on the work of top retention scholars (Spady, 1971; Astin 1975, 1984, 1996; Tinto, 1975, 1993; Braxton, 1998; Milem & Berger, 1997; Berger & Milem, 1999) and my knowledge about the chilly climate for women in engineering, to make predictions about the fate of the women in this study, I would hypothesize that the majority of my sample would not be successful in completing their degrees in engineering. In fact, the data in this study provide evidence from these women that many of the negative predictors associated with failure to persist do in fact hinder their academic and social experiences in the college of engineering. Yet, it is noteworthy that these women are still persisting to degree and more importantly are able to identify why they are succeeding. Through the journals, interviews and focus groups with these women, we have the data that help us understand the challenges and support systems that influence their academic careers in engineering. Through thoughtful and heartfelt stories, often filled with frustration and more often, inspiration, one comes to understand how these women succeed in a male dominated major.

The participants in the study were a very motivated group. Throughout elementary and secondary school they excelled in math and science. They self-selected into a discipline that they understood would be highly competitive and rigorous. The

participants represented the five disciplines of engineering (Civil, Chemical, Electrical and Computer Systems, Industrial and Mechanical) offered at this University. The women ranged in year of study from freshman to Post Graduate. Three women were transfer students who entered during their sophomore or junior years. Table 4.1 below provides some additional information about these women and their overall academic performance.

Table 4.1 Demographic Profile of Participants

Name	Major	Overall GPA	Year	Race	Residence
Lisa	ChE	3.13	Soph	Indian	In-State
Sue	EE	3.31	Senior	Cape Verdean	In-State
Allison	Pre-CE	3.90	Fresh	Caucasian	In-State
Claudia	EE	3.59	Senior	Caucasian	Out-State
Cindy	IE	3.78	Soph	Caucasian	In-State
Carol	IE	2.54	Junior	Caucasian	In-State
Emily	Pre-Chem	3.76	Fresh	Caucasian	In-State
Maren	CHE/Biochem	3.88	Senior	Caucasian	In-State
Valerie	Transfer - CE	3.07	Junior	Caucasian	In-State
Annie	IE	3.72	Soph	Caucasian	In-State
Carly	EE	3.56	Junior	Caucasian	In-State
Lil	EE	3.06	Senior	Caucasian	In-State
Janet	Pre-CE	3.61	Fresh	Caucasian	In-State
Rebecca	CHE	3.93	Junior	Caucasian	In-State
Karen	CE	1.98	Soph	Caucasian	Out-State
Rochelle	ME	3.40	Soph	Indian	In-State
Moira	Transfer - CE	2.99	Soph	Caucasian	In-State
Marcy	Transfer - EE	3.01	Senior	Caucasian	In-State
Emma	PG-CE	3.37	Junior	Caucasian	In-State

Throughout this chapter, I utilize the participants' words to reveal the experiences they face inside and outside of the classroom. Immediately, I heard the importance of striking a balance between time spent on social and academic activities; or what I refer to as "equilibrium" throughout the study as a key factor for success. The need for

equilibrium was constant from college entrance through exit and is the overarching theme throughout this chapter.

I begin by examining pre-college expectations and experiences. Family support along with personal motivators will be discussed. Next, the focus shifts to the college experience and, I explore the factors and influences that impacted their success. The final analysis focuses on how the college experience influenced their socialization into the profession.

The temporal framework below (FIG. 4.1) illustrates the equilibrium these women were trying to achieve throughout their undergraduate studies. The horizontal arrow represents equilibrium across time. The ovals in the college experience section identify the academic and social challenges and supports which impacted their ability to find equilibrium. The vertical line on which these ovals lie is drawn to suggest at various points during the college experience these challenges and supports move a student closer to or further away from equilibrium. The final section of the diagram details persistence, and how over time the women are able to move closer to equilibrium. The final part of the diagram depicts how success is defined in the short term and overall by the women.

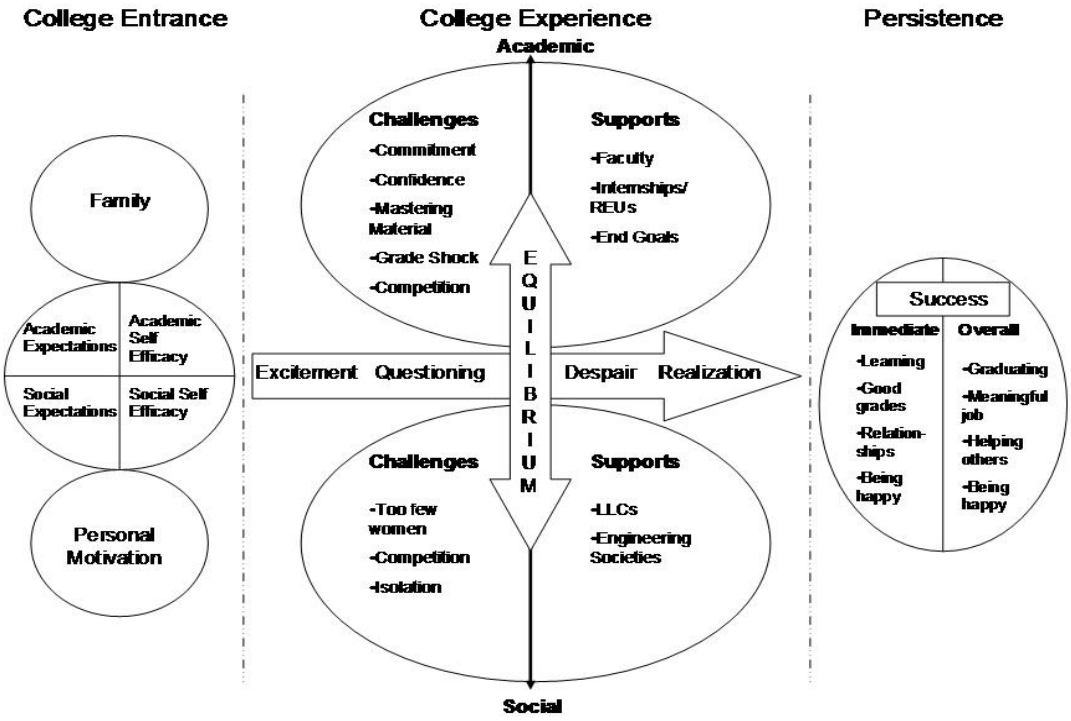

FIGURE 4.1 Conceptual Model

College Entrance

The Role of Family

The women in this study come from many different backgrounds and are currently in many different stages of their lives. Three women are first-generation college students; one woman is Cape Verdean and raised her brother in the US on her own; and two women are raising children of their own while working on their degree. By listening to why they decided to explore engineering as a college major, their pre-college experiences and the influence of their immediate family became evident. This is illustrated by Emily, a freshman who notes:

> "Well part of it [the reason for going into engineering] is that I come from a really sciency and mathy background like all the way to my grandparents…both of my grandmothers were math teachers…and my dad is a high school science teacher

> and one sister is a botany major and she is getting her PhD…then my other sister is a chemistry major so it's just like I'm so use to over the dinner table conversations about science and math and this problem and that aspect of elements and chemicals…so it would be nearly impossible to ever really leave it…and it's also like now I can participate in the conversations so that has always been an inspiration" .

Positive familial influence was mentioned by all but two participants as a main reason why they decided to pursue engineering as a college major. One of the two women who did not mention positive familial influence, Sue, a Cape Verdean senior majoring in Computer Systems Engineering, mentioned a different type of familial influence. She told an intriguing story of being brought over to Boston by her father at an early age. Her parents later divorced and, due to her father's remarriage, she was forced to live in difficult circumstances and ultimately left to raise her younger brother primarily on her own. She credits this adversity with providing her the needed courage and commitment to succeed in engineering, "It really motivated me…I wanted to give my brother someone to look up to, and I am doing it."

Reference was made in each interview to how growing up in their particular family exposed them to a world of science and how ultimately these experiences piqued their interest in engineering. The women recounted early childhood stories and memories of loving to use their hands to "build things" and the joy they had playing with blocks or exploring the land around their homes, "I've always been interested in the sciences since I was little…my mom always bought me insect or human body stuff...all sorts of science topics…she really pushed it," recalled Carol.

Although mothers and other siblings were mentioned as playing a role in the decision to pursue engineering, it was clearly the father who had the strongest influence on these women's decision to enroll in engineering. A clear pattern of positive paternal

encouragement was evident for these women from a young age through their decision to major in engineering. Cindy remembers, "my dad always encouraged me when I was little I was always the little girl who played with rockets…I won the rocket competition in fourth grade…my dad encouraged me all throughout school and he was the one who asked me to try engineering because I was so good in math and science, so here I am." Claudia specifically remembers her dad as being the major influencer beginning in eighth grade, "In middle school my dad actually mentioned the idea [of engineering] to me…I started to think about what I wanted to do in eighth grade….at that time my criteria was I'd have to be the smartest and I'd make the most money…I was looking into being a doctor or a lawyer when my dad told me that electrical engineers are smarter than doctors and he said that as an engineer I would earn money earlier in my career…that's when I started to think seriously about engineering."

Three women in the study had fathers who were involved in engineering. Each of these women mentioned that being exposed to what engineers do was important in their decision to pursue engineering. There was consensus that their father inspired them to pursue engineering, however the inspiration came in different forms. Lisa views her reason for entering engineering as a competition with her father,

> "My dad is a chemical engineer and I think it kind of plays into it as well [decision to pursue engineering] because we have this strong rivalry, well it's more of a competition…like he was always number one in everything he ever did and he aced all his tests…but he didn't really have a life so I want to be able to do both and kind of show him up."

Allison's dad worked closely with engineers and suggested she look into it, "I thought since I was good in math and science, engineering made sense." Karen's father had a tremendous influence on her decision to follow engineering, even helping to define

which discipline she should study, “my dad was an engineer for 20 years so he’s been pushing me to get the degree and he talked about engineering all the time growing up and I knew I wanted engineering because I was good in math and science…I was still deciding what kind of engineer I wanted to be but my dad explained everything to me so I’m in civil.” It is clear that from a very young age these women felt the influence of their fathers in shaping their educational future.

The importance of positive familial influence, and more specifically paternal influence, related to a significant role in the college major decision for most of these women. The academic and social pre-college experiences and expectations held by these women allowed them to enter engineering with a very optimistic outlook, knowing that they would be able to persist and succeed in engineering. In the next section, I explore the academic and social expectations these women had for their undergraduate experience. Along with these expectations, each woman entered college with varying degrees of academic self confidence and social self-efficacy.

Academic Expectations

> “When you tell someone you are going to college for engineering you often get an intense response, something like ‘WOW’, followed by a pause then an overly enthusiastic ‘GOOD FOR YOU’ followed by another ‘OH WOW.’ All I expected from the college of engineering was for it to be hard,” Carol, Junior, IE.

Upon entering college these women expected the work to be challenging, they were all uncertain about how their academic experience would unfold yet they were all determined to persist. Hard work is the consistent descriptor of academic expectations upon arrival into the college of engineering. The women all felt that they were ready and while most had no idea what to really expect academically, they were willing to try and

hope to have it all at the end. Annie recalled, “I didn’t know what to expect when I started as an engineering student. I picked the major because I knew if I could get through the program I’d have a great chance of getting a good job upon graduation. But at the same time, I was expecting it to be hard.” The optimism felt by these women also came with some reservations about being a woman in engineering. Carol summarized her incoming academic and social expectations by saying, “My expectations were to have great professors, learn a lot, work harder than the average student and be a minority for the first time in my life.” Maren, a junior in ChE, came to the college of engineering “knowing that I would need to work hard.” She was also hoping to receive some recognition and validation for her hard work, “In high school, I feel I worked hard and never got appreciated for the things I did. I was hoping that in the college of engineering I would finally be appreciated.”

The women in this study expected the academics to be hard, but they were uncertain regarding what they might actually experience. All of these women were looking for a challenge and felt they were prepared academically to conquer what was ahead of them. Lisa recalled that choosing to apply to a rigorous program was an appealing and a motivating factor, “I wanted to do something challenging because I like math and I like science...I may not be amazing at it, but I do like it so I wanted to do engineering plus the College of Engineering was the hardest college to get into here and I always like to do the most difficult things, so I picked it.” Sue had advice from friends at a CISCO program she participated in, “everyone talked about how engineering is like so hard, so I knew it was going to be hard (laugh), but I was willing to take that chance.”

Lil, a senior in EE, had time to reflect on her time in engineering and offer some insight into her academic expectations versus her reality,

> "When I came into the college of engineering, I thought that the learning would be more hands-on and, that we would be in the lab a lot more testing of ideas rather than just working them out on paper. I knew coming into this major that it would be a lot of work, but I had no clue that it would be THIS much work."

The women came to college with uncertain academic expectations. They knew the work would be hard; however, coupled with their determination to make it in a male dominated environment, they were certain they could succeed. This uncertainty was mirrored in the stories they told of their social expectations. In the next section, the women talk about their incoming college social expectations.

Social Expectations

Throughout high school, many of these women struggled socially because of their interests in math and science and their overall dedication to their academics. When asked what they hoped to find socially in college, these women talked of the excitement of meeting new people, but they also expressed uncertainty and, admitted to being nervous about what they would actually experience. "Socially, I was kind of worried because I have a hearing problem and I was afraid that I was not going to be able to communicate," explained Carly as she reflected on her experience. Emily spoke of being excited but admitted that she had a hard time assimilating into a group, "I'm a person who has a really hard time transitioning…I can be good at meeting people and being friendly, but I've always had a tougher time saying this is my group of friends." Most of these women are in-state residents and had a perception that the institution was a "party school" and that they might not fit in. Rebecca recalled, "When I came here I lived on the engineering

floor and they were all in the same position that I was in that they couldn't afford to go to other schools and I actually found that there are people here who actually want to study…I was able to find people like me and it really helped me." Rochelle confirmed the importance of meeting people with the same academic goals, "The people I have met in my major have greatly influenced my wanting to stay in ME. I have met so many people with the same goals as me and having the same problems in classes as me."

Excitement about meeting new people was cited by all of the participants in the study. "I like to meet new people so I was looking forward to that," explained Karen. "I was excited to meet a lot of new people," offered Allison. Most felt attending a larger institution would allow them the opportunity to meet a diverse group of students and to become involved in campus clubs and activities. "Just meeting new people and the diversity of the people," are the social aspects that Allison was looking to find at college. Maren came to the university hoping "to be involved in many campus activities, including kayaking, tae kwon do and theater."

Most of the women understood that they would be entering a field of study predominantly male. Once again, they expected it to be "different" but they were not sure of what to really expect. For Claudia, the prospect of being one of a few girls was enticing, "In high school, I was the only girl on the math team that competed in competitions. I really loved it because I had gotten tired of listening to girls' conversations and found it quite refreshing to be in a predominantly male environment for a change. When I came to summer orientation, I was actually glad that engineering was male-dominated." For others, the thought of being a minority motivated them for the

challenge. Cindy remembers feeling, “I knew engineering was dominated by men, but that wasn’t going to stop me from succeeding.”

It is clear that the women in this study came into engineering with mixed expectations: it would be hard academically and socially, but also exciting and rewarding. Each woman came to college with a set of academic and social self-efficacy beliefs, thoughts and ideas about their abilities to perform tasks necessary to succeed (Bandura, 1986). In the following section I discuss how these beliefs influenced the women throughout their undergraduate college years.

Academic Self-efficacy

Intuitively, it makes sense that strong academic self-efficacy is important if women are to persist to graduation. Although efficacy is sometimes compared to confidence, efficacy encompasses confidence and also weighs the actual strength of the belief to succeed (Hutchison, Follman, Sumpter, & Bodner, 2006). Upon entering college, these women all came with a strong conviction that they would have it all. The journey to get to that point came from a strong familial and particularly paternal influence coupled by an internal passion to succeed.

Academically, these women were strong students. Across elementary, middle and high school, the women found math and science to be interesting, although for two of the women, math and science were not their strongest subjects. All of the women were enrolled in some honors classes in high school. Two participants were the valedictorians of their class, and the post-doctorate student had a master’s degree in biology with a stellar GPA. Emily was always the youngest in her high school class and proud of being able to do better academically than her class mates, “In high school, I was the youngest in

my class and I enjoyed getting better grades, in addition to being the youngest in my class. Now, I can be a female, one of the youngest students, and get good grades. I take pride in being a female engineer. It makes me happy to work hard and do as well as I can."

These women were inspired by supportive conversations with family members and sometimes teachers at school. While some of their peers were reading People Magazine, these women were looking for stimulation in other sources. Throughout high school, Karen continually searched for ways to satisfy her academic hunger, "I love the ideas of engineering. Popular Science is my favorite magazine, and I am a full-fledged computer dork. In high school, I took every single computer class they offered, by senior year there was nothing else for me to take so I ended up TAing in a few classes." Cindy's determination started at home through encouragement from her family, "I can do it just as well as they can [boys] if not better…my parents were always encouraging and I never had people tell me you can't. I was brought up to know that I can do anything I want."

The thought of being able to "make an impact" reinforced their academic drive to pursue a field of study where they felt they could make a difference, or just simply make something that interests them. "It was weird… I'm in love with roller coasters. I love riding them and, I thought I would be able to design them, so here I am," admitted Annie. Janet found inspiration in the ability to help others, "…I was showed how they analyze things like where to put a light and I think that's cool because once you decide where to put up a stop light you can be saving people…I want to do things for a cause and that make an impact on life."

Consistently, these women mentioned their clear sense of determination and dedication to their decision to major in engineering. Carly wrote,

> "I'm the kind of person to stick with something to the end. I also don't like to throw money down the drain, and don't want to get into debt so I want to graduate on time. I like learning, I like technology, I want to invent things, I want to work for companies that treat employees great, and I want to make money so I can travel and live nicely and have fun at my job. I see that in Electrical Engineering."

The academic self-efficacy beliefs shared by the women in this study were strong. They spoke of their determination and the academic drive to accomplish their goals. These women prepared and conditioned themselves, academically, prior to college and brought with them the beliefs in their power to produce their goal…the ability to succeed in engineering. Socially, as discussed earlier, these women came to college with mixed expectations; their efficacy remained strong as discussed in the next section.

Social Self-efficacy

Prior to entering college, the benefits of entering a predominantly male field were viewed favorably by all of the women in the study. The ability to make a social, or gendered, impact on the field, by bringing a woman's point of view was inspirational to many including Carol, "being a female in engineering is positive because you are bringing a different view to all kinds of designs and ideas that have been mostly male dominated for a long time." However, Rochelle took gender out of the equation, "I don't think there's very much about being a female engineer that is different from being a male engineer. The only big thing is that 75% of all your classes are filled with males…I'm very comfortable around men."

For three participants, the ability to relate better to males was the motivation behind their decision. Annie enthusiastically spoke of her convictions, “I love it; it started in high school when I took AP Physics and I was the only girl in a class of eleven and the teacher was a male too…I found that guys are just more relaxed. They talk about what is going on and don’t really judge people. They just laugh and make jokes and stuff and I really enjoyed that experience so I decided I wanted to be an engineer.” Janet also felt that there are many positive aspects to being a woman in engineering, “Because of the man to woman ratio [in engineering] many women want to show that they are equal to men and can do whatever they do. I like being a female engineer because I find that men are easier to work with and somewhat more laid back than many women I know, so there being fewer women is somewhat to my advantage.” Claudia wrote about how “refreshing” it was to be a part of a predominantly male group, “I was the only girl on the math team...I loved it because I had gotten tired of listening to girls’ conversations…I enjoyed a wonderful camaraderie.”

Although the social expectations were uncertain coming into college, the efficacy each woman brought was clear as Moira expressed in her journal, “I know once I got to know everyone and figure out who I would be good friends with, it will all be great.”

In the next section, I explore the college experience to validate if the expectations and the experiences correlate and how these women’s self-efficacy influenced the goal of persistence to graduation.

Personal Motivation

Ambition, drive and the desire to succeed in engineering were characteristics described during the college entrance stage. Their personal motivation to succeed ranged

from their desire to make their families proud to being the best student. Rochelle explained how her family provides her with personal motivation, “My parents expect me to do well and they want me to succeed…it’s how I was brought up and I don’t want my family to be upset.”

In all cases, these motivations provided positive influence for the women. This high level of personal strength and determination made them want to succeed from the onset. One woman, Cindy, expressed reservations about entering engineering because of stories she had heard, “I was so scared to be a girl in engineering because I always heard horror stories how professors are like she’s a girl and doesn’t know what she is doing.” Her desire for a challenge and her determination to succeed outweighed this uncertainty. Emily, a freshman, wanted to defy the odds, “I was not entirely sure what I wanted to do in college, so I thought that engineering might be fun. I like science and math, and I work really hard. Just because I wasn’t originally positive about what I wanted to do, doesn’t mean that I’m not serious. I have a tendency to be stubborn and now that I have started and engineering is notorious for dropouts, I’m that much more determined NOT to quit.” Carly talked openly about her tenacity, “I knew I wouldn’t change my mind about engineering. I’m the kind of person to stick with something to the end.”

Claudia’s ambition and motivation stemmed from out-performing boys, “another thing that excites me is dong better than boys at things that they are supposed to be better at…engineering included.”

The personal motivation and determination these women brought into engineering would be tested throughout their college experience. In the next section I explore the academic and social challenges faced over their undergraduate experience. The support

available to these women is also be examined, and it becomes clear how personal motivation impacts success.

The College Experience

Group socialization can be thought of as the way a person develops the beliefs, attitudes, behaviors and knowledge needed to function as a group member (Van Maanen & Schein, 1979). Women in engineering are faced with the struggle of transitioning into college, socializing into the discipline as well as socializing into a minority group. Interestingly, over the course of the college career, the women who persisted in this study were socialized into the discipline with varying degrees of socialization into the "women of engineering" group. Nevertheless, they all entered the college of engineering with the belief that they would be socialized into the discipline and ultimately the profession.

As they move from freshman year through their senior year, a consistent point mentioned by the women was their constant struggle to find a balance between their academic and social lives. The inability to balance these two worlds was cited most frequently as the reason many considered leaving the major.

Through the journal entries, interviews and focus group discussions it is clear that these women are striving for equilibrium in their academic and social lives. In the next section the women talk about the four phases of their college career: excitement (freshman year), questioning (sophomore year), despair (junior year), pragmatic (senior year). It is important to realize that the women are in a constant state of motion, moving in and out of equilibrium. The women able to find an acceptable balance emerged as most successful in this study.

Excitement – Freshman Year

The immediate transition of students to the institution is critical for overall student retention. Integration and involvement is critical during the first ten weeks (Tinto, 1998) on a campus. It's important to remember that women in engineering are typically at the top of their high school class academically, but oftentimes socially they are lacking confidence and experience being socialized into a particular group. As presented earlier in the chapter, all of the women in the study remarked that they believed academically the program would be rigorous, but manageable. From a social perspective, many of the women were excited about meeting new people, yet some had reservations about how the social experience would unfold.

The first semester in the college of engineering presented differing degrees of transition issues for all nineteen women in the study, transfer and post graduate students included. The natural uncertainty surrounding leaving home and/or beginning a new chapter in their adulthood was apparent in all of the stories. The transition from high school to the college of engineering was especially hard on three freshwomen: Allison, Emily and Janet.

In our first interview, Allison told me of her struggles to transition from home to college, "I was excited to meet a lot of new people…in the beginning I was like really stressed out and stuff I think I was home sick and I just felt less secure with myself not being at home." Janet left the comfort of her family and equally as important her own room, "I was excited about coming to college but at the same time I have a really good relationship with my family…it was hard leaving…and I've never shared a room…I'm really laid back and my room mate is kind of high maintenance…it's been kind of hard

living with her at least for the first couple of months it was very very difficult living with her because our personalities clash so much." The transition struggles for Allison during the first semester were in part social in terms of her ability to compromise with her room mate, as she describes, "I have found that it is a lot easier to do my homework in the library before going back to my room because it is hard for me to concentrate in the room. Between my roommate talking or listening to music, people coming in and not really having a good place to study in my room it's hard to be efficient."

Emily's low social expectations were realized, and she struggled throughout her first semester to connect with a peer group, "I had very low (social) expectations because I know for me I'm a person who has a really hard time transitioning…it's not been the easiest thing this first semester at all." That sentiment was echoed by several of the women in the study, including Carly, who reminisced that during her freshman year she was "kind of worried that I wouldn't make any friends…it just took a while."

Academically, the transition was initially quite smooth for all of the women. The expectation that the coursework would be rigorous, but manageable seemed to mirror the actual experience. Lisa recalled, "Oh I thought classes were easy, I loved coming to classes." Cindy, a second semester freshman, had the same academic experience, "First semester I was like I can handle this." Karen, too, was full of excitement to be heading off to college, "I thought college was going to be a lot easier than high school because people told me that you only take 3 or 4 classes so I thought I could handle that but I didn't know how different they [classes] were going to be I basically thought college was an extension of high school so I was excited to come…and I like to meet new people so I was looking forward to that."

As the first year progressed, the realization of the challenges of transitioning into the college of engineering and into a male dominated major began to resonate. Looking back on her first year, Carol recalled in her journal, "Engineering was definitely hard academically and it became hard in other ways too…I never thought about how it would feel to be the minority until I got my housing notice…..There were four girls including myself on my floor 20 boys and 4 girls." Maren, a junior in Chemical Engineering, wrote, "I came to the college of engineering in 2003 knowing that I would need to work hard. I was hoping to be involved in many campus activities…I quickly found out that I wouldn't be able to be as involved as I had hoped." During the second semester of her first year, Allison agonized in her journal entry, "This semester is way more difficult than last. It's really frustrating because last semester I got all As and now I find myself working very hard just to get Cs."

Academic and social challenges were experienced by all students during their first year, including transfer students. Moira transferred in as a sophomore in the program, but was still required to take some freshman classes. During her first semester in the COE, she was more concerned about her social, rather than her academic, transition, "I knew it would be a slow start socially because that's just the way I am, as far as academics I kind of came in here with this take charge attitude." By the second semester of her first year, Moira was struggling academically, as she details in a journal entry, "I have come to the conclusion that I am going to have to take an incomplete in one of my classes. The truth is that it is so hard for me to admit that I can't do something and so while I'm sitting here trying to find a way to make it work I just can't help realizing that it just isn't possible….I'm barely staying above water ." She goes on to say, "I am having some

difficulty balancing work and school. I guess I can see why a lot of engineering students have trouble finding time for extracurriculars."

As the women I spoke with corroborated, it didn't take long for the initial enthusiasm and excitement to waiver. Although they realized early on that challenges were ahead, only Cindy mentioned thinking of leaving the major during the first year due to a bad experience with her introductory engineering course. To the contrary, most retained the excitement and commitment they brought with them to the major. Despite Janet's confession in an early journal entry that "it was a relief to go home and relax in my own bed and room," she remained extremely optimistic about her future in the college of engineering: "I expect to get more engaged in engineering rather than the basic classes and knowing what I definitely want to do or at least getting an idea of what I want to do …I expect to learn I expect to go to classes and it will be getting better as the years go on."

These data confirm that for these women, the sophomore year became a pivotal year in which they faced many decision points regarding their future in engineering. Next you will hear how these women faced the reality of the engineering discipline and questioned their decision to pursue the major.

Questioning – The Sophomore Year

Research has demonstrated that student departure is highest during the first and second years of college (Tinto, 1993). During the first year of college, these women remained positive about their ability to succeed in engineering. It was during the sophomore year when the women began to question their decision and ultimately their abilities to persist. Almost half (nine) of the women who participated admitted to

considering dropping the major during their sophomore year. For these nine women, the main issues identified were academic. Lisa wrote of her sophomore struggles, "This school year so far has been pretty tough, well mostly cuz it's more difficult classes…I'm considering dropping out of engineering because this semester does not seem to be going as well as I had been doing in the past…I don't really seem to care much anymore."

As the workload increased during the sophomore year, most of the women began to wonder question their commitment. Lisa reflected on other engineers perspectives about the program and told me, "Apparently the school work gets much, much harder and everyone keeps telling me to drop out now like there is this one guy who is a senior and … every day he is like drop out, drop out now." I wondered why he would say this and she replied, "because he is a senior and he wishes he dropped out his sophomore year or freshman year because there is so much work involved." All of the women in the study mentioned that, at some point, another engineering student had recommended that they drop out before the junior year. This input from older students was targeted at both men and women.

The fear of failure, questioning of commitment, and a lack of confidence in overall ability to find a social and academic balance became more prevalent concerns during this time frame. Annie had seen a tremendous difference from her freshman to sophomore year. She began questioning her academic abilities as well as her decision to major in engineering,

> "Freshman year was pretty good. I finished with a 3.86 overall GPA. Most of the classes were repeats of senior year in high school, only with a little more depth. I expected to do just as well in the following years because of the confidence I had after last year. This year that changed. I understand most of the material in all my classes, but tests have me much more stressed than before and my grades have suffered a little. I'm still

> trying to adapt and I'm questioning my ability to do well in this major. I don't want to give up because I don't want to feel like I couldn't do it…. I 'm so used to being super Annie from high school who could handle everything and now I feel like everything is falling apart at the seams."

Rochelle, a sophomore in ME, recalled in a journal, "I expected the COE to be hard, but it is actually more difficult than I thought! The schedule is very crammed for engineers and leaves very little space for any kind of choice in classes."

The lack of time to complete the work assigned became more and more the pattern during the sophomore year. The women were forced to sacrifice their "free" time in order to succeed in the major. This academic pressure made the women begin to question whether or not they actually were enjoying the work of the major. Cindy, feeling a bit overwhelmed with the workload, wrote, "First semester I was like I can handle this. This year it is more work and next semester it will probably be even more work and next year even more. It's just going to get worse and worse."

It was also during the sophomore year where the term "weed out" was mentioned by two students; one commented, "at first it seemed as if it would be fun like I wouldn't have too much trouble I mean sophomore classes are sort of weed out classes anyway. They are not really challenging as much as they require a lot of time especially with homework….well I wanted all As but I'll settle for ABs now." The increasingly harder curriculum was evident to everyone, as Carly articulated, "sophomore year was academically tougher because it was all new stuff that I'd never had before….it just keeps getting newer and tougher."

Many of them received grades during their sophomore year lower than they had ever imagined. Grade shock, increasing work load, and the total lack of a social life were all important flash points during the sophomore year. These factors were all

considerations for leaving the major. Lil, a senior, recalled her sophomore year, "When I was a sophomore during the spring semester, I was very close to switching to mathematics. I was very frustrated with the major…there are a few reasons I decided to stay, one was because I thought that it was the easy way out in the end to just give up."

The sophomore year was a definitive decision point time for the women in this study. This was also a realization point for the women that, in order to persist, they would need to forgo many of the activities that brought them enjoyment and allowed them to fully integrate into the engineering society. For many of these women, it was a time they watched fellow engineers, both male and female, get their withdrawal slips signed and move on to other majors. What began as a sophomore slump, continued and magnified throughout the junior year.

Despair – The Junior Year

The journals and interviews made it clear that the junior year could be described as torture for women in all engineering disciplines. At this point, the women reported feeling trapped in the major. There was little joy, academically or socially, for these women at this time. In fact, the women were working nearly all the time, forgoing food and sleep while trying to complete the assignments and solve the seemingly unsolvable engineering problems. The journal entries from the women provide especially honest assessments about their experiences. Sue wrote,

> "Wow! It's 5:00AM and I'm still here at the lab. This is my second all nighter. I am still trying to finish up my electronics lab. I just finished writing my report. I have been here since 4pm. I woke up, ate breakfast and went to the science library to read for my other classes. I was hoping to be able to catch up with one class at least but I don't think I will, ever. There's always some lab or paper due that takes all of my time. Like this one, took my whole afternoon and night. I feel really tired right now and I don't think my body will stay up for all my classes. I need to sleep."

In her journal entry, Maren explained the impact a typical week in her life had on her personal life, "Well, this was my hell week. I had three exams in three days on top of two homework sets, a research poster and a paper. I spent the entire three day weekend studying for my exams. I barely even ate at all this week I was actually disappointed I missed "apple Week" in the DC [Dining Commons]. Whenever it is exam time, I never go to the DC. I usually have frozen dinners in my fridge or order food in my dorm. It takes so much time to walk down the hill to the DC, I just can't bother with it." In another journal entry, she reinforces the lack of time by writing, "I crashed last night. I was so tired. I had to finish a 30 page homework assignment due on Thursday, and I only got two hours of sleep that night [Wednesday]. Thursday night I had to stay up to finish more work, so on Friday night I was dead asleep by 10:30. Isn't it sad that I go to bed earlier on a weekend than I do on a weeknight?"

It's during the junior year that the pressure of the discipline reaches a high point and everything seems to go out of control for these women. The efficacy each woman brought to college was tested and nearly destroyed. Rebecca, a junior in ChE, wrote candidly in her journal:

> "It has been a very tough semester. There have been many times that I have seriously contemplated dropping Chemical Engineering. I just don't know if I'm smart enough to do it. I've had to stop doing research with Professor XYZ and I've cut down on a lot of my extracurricular activities and I still feel that I can't do well in my classes. In the beginning of the semester I cried for an entire Saturday because I felt so overwhelmed with everything. I go in and out. My confidence to be able to do the work waivers a lot. Last Thursday I got my Thermo grade back. I got a 69 and I was devastated."

In a November entry, Carly wrote of her experiences during her junior year, "My self-confidence in engineering classes is like a roller coaster right now. More so than any other year. Things seem pretty overwhelming, it's hard to schedule in eating and sleeping. But it makes me feel better to know that I'm not the only one in this boat."

These feelings were confirmed by all through the journals, interviews, and focus group discussions throughout the year. During our first interview Sue talked about the inability to find balance during her junior year:

> "…everyone talked about how engineering is like so hard so I knew it was going to be hard (laughs) but I thought that no matter how hard it is I would still have time it would just be a matter of studying…now I'm finding out that you really don't have that time to study…I think that's one of the hardest things…finding that time which is almost an impossible thing."

Maren confirmed the difference between being a junior and earlier years, "This semester is much worse (work wise) than it has ever been." Carly admitted that it's impossible to get the work done on your own, "academically it is horrible (laughs) yeah I don't think the work is something I can do on my own no matter what…I can't do my homework on my own from any class…I need help from other students."

A feeling of hopelessness also describes the junior year experience of these women. Rebecca, the valedictorian of her high school and a 4.0 student freshman and sophomore year told me what everyone else had conveyed about this year:

> "I really don't enjoy my classes this semester….Perhaps I don't enjoy the classes because I am not really understanding the material. I find that there is just so much work to do that I don't even have time to sit down and try to understand things I don't get when I am first presented with the material…I get discouraged very easily but I've come so far in Chemical Engineering that I feel it's pointless to drop out now…I'm really wondering if I'll be able to handle and get through chemical engineering. The senior's say that next semester [2nd semester junior year] is even worse than this semester. I really don't know how much more I can take."

The women quoted above are strong, smart and, even though their confidence and commitment is shaken, somehow they persist. Part of the reason is that they have come so far they don't want to give up, but there is more to their stories. In a later section I discuss the support systems in place at the university that allow these women to find a reason to remain engaged with the engineering community.

Realization – The Senior Year

The experience during the senior year for Lil, Claudia, and Marcy continued to be more of the same: work and more hard work. Along the course to this point, they mature and adjust to the pace of the engineering lifestyle. The women know they will reach their goal of graduation and are now able to reflect back at their college experience with a sense of humor. They can finally see the light at the end of the tunnel!

Lil, coming back from a tumultuous junior year wrote in her first journal entry, "So, my senior year is going all right so far. It's a bunch of work. I spend more time doing school work than I do sleeping in a week…." When she was home for December break she added to her journal, "Whoever claims that senior year is easier than junior year is lying. I have never worked so much in all my life."

Claudia, found the work in her senior year enjoyable, but still difficult. She commented in her journal that, "this year I like my classes more than I did last year…I am interested in all of my classes to some degree, but I have not been getting the grades that I had been hoping to get so far." It is during the senior year that the women realize they have made some sacrifices during their school years, but remain hopeful that the best is yet to come.

The senior year is also the time when these women began to explicitly consider socialization into the engineering profession. During a summer research project in Puerto Rico, Marcy had a conversation with a female professor working on the project who told her, “As a woman in engineering it is not just enough to be smart. You have to be a strong woman as well.” This comment stuck with Marcy, and she was preparing to begin her career in the field. Marcy was exposed to another example of future challenges as she and a male counterpart were offered jobs at a large engineering company. Marcy had a higher GPA and more work experience, but was offered $900 less than her male peer. When she asked the recruiter what the salary was based on, he answered, “grades and experience.” Marcy told me, “I think that I will have to work harder to prove myself.”

The undergraduate experience of these nineteen women in engineering can be described as rigorous and draining. Each woman exhibited a profound dedication and determination to succeed. These women found strength to persevere.

The preceding sections provide an overview of the temporal process outlined by these women. With each of the four stages are common themes related to the specific aspects of the academic and social experience that influenced the challenges and successes of these women. In the next sections I discuss the specific academic and social challenges encountered by these women as they moved through their college career. I also examine how these women felt supported and how this support ultimately influenced their desire to persist in engineering.

Challenges and Supports

Academic Challenges

It is clear that, as these women progressed through their college experience, the ability to find a balance between their academic and social lives became impossible. Academics quickly became the focus and although initially these women felt prepared, they were forced to focus almost all of their time on their academics. As we talked and they wrote in their journals, a clear identification of six academic challenges they faced emerged: wavering commitment to engineering, questioning their abilities, an unsatisfying curriculum, grade shock, competition with peers, and overall stress.

It's important to remember that the women in the study were all succeeding. The stories of their tribulations are revealing, and one can only imagine the experiences of the women who don't succeed.

Commitment

Upon entering the COE each woman spoke of their commitment to earning an engineering degree. There was enthusiasm surrounding learning and excitement about engaging in a major that allowed them to do make a difference in society. As the amount of school work continued to grow and the material was found less than inspiring, all of the women experienced second thoughts.

Emily, a freshman in ChE, chose to study engineering because she thought it might be fun. She expected the program to be challenging, but not anything that she could not handle. When she first arrived, she was determined, "not to quit." Two months into the program, her determination began to falter, "When I have been debating about

leaving the engineering program it is because I have not enjoyed that class at all [introduction to engineering]."

In the first two months of Lisa's sophomore year, she encountered many obstacles. Faced with personal and health issues, she needed to work feverously to get her academics back on track. During our second interview she discussed how she was taking charge of her circumstance, but spoke of the challenges to stay committed to her academics, "I'd be going to a review session or going to classes but then I'd be on my way there and someone would be like 'why are you going and come hang out with me' and I'd say oh I don't need to go to the review session I'll go hang out with them and well I don't think that was a very good decision." She also revealed her uncertainty about the major and her interest in her classes: "… like who really wants to go to classes, like honestly I don't know…I sometimes just wonder if it's really what I want to do." This was a clear departure from her freshman year when she boasted that she entered engineering because she "likes a challenge."

Cindy entered the COE to pursue a career in Industrial Engineering. At the start of her sophomore year, the commitment to the profession changed, "I'm nervous that I'm not going to like it eventually and then I'm going to be like wait maybe I made the wrong decision…I'm nervous I'm going to hit a point and be like why did I choose this"?

Maren and Rebecca, both juniors in ChE, told me of how they seriously considered leaving engineering to pursue other majors. Maren, a double major in biochemistry, knew she would be happier if she did switch, "I know that I would be a happier person overall if I were in that major [biochemistry]." Rebecca contemplated her

decision and commitment to the field, “This semester I have also contemplated whether ChE was the right choice for me.”

At many points during their undergraduate experience, these women were faced with a wavering commitment to engineering. This fluctuation was caused by other challenges they experienced through the course of their college career including a loss of confidence in their ability to succeed.

Confidence

“My self-confidence in engineering classes is like a roller-coaster right now. More so than any other year (freshman and sophomore year). Things seem pretty overwhelming,” Annie told me on the verge of tears during an interview. Her feeling was echoed by all of the women at some point during their college career. Again, it is important to remember that all of the women who participated in the study were top students and academically felt prepared to tackle engineering. Their confidence was strong entering the major, but as early as freshman year, these women began to question their abilities.

Emily had strong beliefs in her ability to succeed as she entered the COE as a freshman, “I am confident that I can manage, maybe not to my ideal standards, but I can actually do it.” Toward the end of her second semester, her confidence has begun to waiver, “Overall, this year has been a rather difficult one for me. Although I tried, most everything did not go half as well as I had hoped.”

The intensity of the blow to confidence became more pronounced through the sophomore and junior years. In November of her sophomore year, Annie wrote in her journal about a test she had just taken, “As much as I studied, I still did badly. I haven’t

even gotten the paper back yet and I know I did badly. I had a nervous breakdown halfway through and forgot how to do an entire problem. I'm still REALLY upset about it and I'm having thoughts on switching majors again." During her junior year, Maren wrote, "I had another mental breakdown today. I cried for three hours. I can't do this anymore. I'm just not smart enough to be an Engineer."

Due to the small number of women in the discipline, when a woman decides to leave the major, it is felt by all of the women remaining in the major. Cindy remembered feeling uneasy as she heard of her friends dropping engineering after receiving poor grades on an exam, "it was really hard to watch my fellow female engineers to get their withdrawal slips signed after our first exam." It is clear, that although the women in the study did stay in engineering, there was an impact on their confidence and commitment when their peers would leave the major. Lisa was questioning her abilities as she watched some of her friends leave the major, "my best friend dropped out of engineering and that has affected me and now my room mate isn't sure if engineering is for her."

The roller coaster of emotions surrounding their ability to succeed intensified throughout the four years. To compound the issue, the structure of the engineering curriculum and overall interest in the material presented forced these women to reach deep inside in order to succeed.

Mastering Material

The structure of the academic calendar and the course content across all disciplines were mentioned by the women as significant challenges for them at some point. The women felt a false sense of security was developed during the freshman year as they were only required to take one engineering course and the workload was

manageable. During her sophomore year, Annie recalled, "I expected to do just as well in following years because of the confidence I had after last year…this year that changed." That sentiment was confirmed by all nineteen women in the study.

To address this problem, the EE major created an advisory board consisting of faculty, undergraduate, and graduate students. This fact finding task force was exploring alternative curricular options. Carly and Sue were student representatives on this committee. Sue explained the goal of this committee, " we try to discuss subjects like moving some of the courses to earlier in the years so that we're not so packed during our junior year…that way we will have time to do other things."

In addition to the amount of work, the content of the courses was a big concern for these women. Carol reflected in her journal,

> "I just hate how all classes seem to be about building mechanical things like cars or they're about making factories that make cars. Not all engineers want to work in fields like that. I want to work for a company that makes something I can understand. I'd love to work for a company that produces make up and run their factory lines for them. Or something girly like that…I feel that because there are a lot more men than women in the COE the courses follows with topics that appeal to men."

The inability to relate to the engineering classes rang true for others as well, Emily wrote, "When I have debated leaving the engineering program it is really just because I have not enjoyed that [engineering] class at all."

Emily, struggling through her freshman year, wrote in an April journal entry, "Most days have been the same, work, work, and more work. I am actually getting really tired of this monotonous schedule. It's getting harder and harder to work efficiently and effectively. I just keep trying to tell myself that I can do this." Although these women

keep reinforcing that they can do it, with a weakening confidence and an impossible work load, it is easy to understand why there is attrition from the major.

Grade Shock

Grades matter to these women. During high school they were in the top of their class and they continued to work hard in college. Many of these women had never seen a grade below a B and for some As were the norm. For all of the women, the grades they were receiving in their engineering classes were devastating. In addition to the grade itself, these women had to learn to rely on a curve, something they certainly were not used to. Janet recalled, "On my first Calculus test I got a 75 which is a C but here it is a B but I'm like that is not a B it's really a C and I can't believe I got a C."

Even as a senior, Lil continued to struggle with grades, "I've had two tests this semester. The one in Comm went so-so. I was hoping to do better on it, but it was really tough. The average was a 55 and I got a 48 which the teacher said is around a B- or C+." She was beside herself, again, a few weeks later, "I got my second Comm test back today and it had two numbers on it, a 7 and a 3 and not in that order...it's not like I haven't been studying the material either. On the contrary, I spend most of my time studying for this class…I just can't do it."

Grade shock was experienced by all of the participants continually through their undergraduate years and confirmed by Cindy, Maren, Rebecca, and Rochelle. Although Cindy did comparatively well on a recent test, she was still disappointed by the results, "I want to get As and I'm not seeing myself get them like I think I should. I mean I study a lot and then I don't do as well as I think I should like on my statics test I got an 80 and a lot of kids got 30s so my 80 looks really good but not to me."

Feelings of despair and disbelief can be heard in their voices. Upon getting an exam back, Maren explained, "I studied SO hard for that exam – and I got a 71. I just feel so worthless." After two years with a 4.0, Rebecca was pondering C's, "I got my Heat Transfer exam back today. I'm really starting to wonder if I can actually do engineering. I got a 76.6. This semester is going horrible, I'm feeling so overwhelmed. I really think for the first time I am going to get Cs in all my classes." Rochelle's internal motivation and drive gave her angst when she contemplated the grades she was receiving, "I got a 75 on the first exam and a 65 on the second. This is way lower than I usually get and it's definitely much lower than I want to get."

As stated earlier, grades matter to all of these women and, because they are not seeing the results they expect based on the amount of work they put in, the rewards of the engineering discipline are not apparent to these women. These women came to engineering with a strong academic self-efficacy in their abilities. They also came to engineering looking to connect with a select group of women like themselves. Although they did find people like them, they also encountered competition from women which they were not expecting to encounter.

Academic Competition among Women

Coming into engineering, these women were aware that they would be in the minority, but all of them looked at it as a positive challenge. When they entered engineering, they were happy to find women with the same interests and academic commitment. I was fascinated to hear from these women that, although there were very few women in each discipline, it did not create an immediate and natural bond between the women. In fact, many women commented on their inability to relate to the women in

their discipline and an easier connection with the men in the program. Several women, including Maren, spoke of the high degree of competitiveness among the women and how it impacted the academic experience:

> "I also feel very very competitive with some of my classmates, enough so that I cannot continue a friendship with them. It's terrible. I have to say one thing though, it's all females. I do not feel competition with any of the males in the class...it's actually really funny. There's supposed to be this whole camaraderie for women in engineering. This is absolutely not true. I feel more camaraderie with the males in the program."

Annie reiterated, "…when I'm just with her in class there is just this endless tension and feeling of competition between us…but it's like we're always trying to one up each other and I very much dislike it."

Another challenging aspect of being part of this small group is that it is very easy for classmates and professors to remember very specific details, especially of the women. A few girls mentioned the difficulty of seeing some of their female classmates doing very well, even if it was a perception, and the internal stress they placed on themselves to be able to compete with their female cohort. Janet recalled, "I put too much pressure on me sometimes because some of my friends do well and I'm happy they do well but I'm like why can't I do that well so I put a lot of pressure on myself…"

The pressures, mainly internal pressures experienced by these women increased their stress levels across the board. In the next section I highlight the specific triggers for stress described by these women.

Stress

These women were living in state of constant anxiety, worry, and stress surrounding their academic progress. This stress manifested itself with differing effects. Mental meltdowns, becoming physically ill, not sleeping, eating too much or not at all,

and often just internalizing nervous energy leading to headache or exhaustion were mentioned as common results for dealing with the stress. In all cases, these reactions to stress were new to these women and began in their freshman year and lasted through their senior year. Being that all of these women came into engineering with very strong academic backgrounds, they had never had to deal with this level of academic pressure. Allison began to feel the pressure early in her freshman year and it began with studying and would get worse as an exam or large project was due, "When I study a lot it makes me really sick, I think because of anxiety." Maren wrote in her journal in early October, "I had an anxiety attack on Wednesday before my first exam. I cried for about an hour and vomited in the bathroom."

Annie was using food as a release for her stress, but was finding that solution was only adding to her pressure. In her journal she wrote, "I keep eating too much. It's affecting how much work I can do. I get cravings for sugar, eat too much of it and then feel all light-headed so I can't concentrate. I need to stop."

Cindy detailed her mental exhaustion surrounding her workload and exam schedule, "Midterms have been stressing me out recently. I have been so run down and tired that I cannot even imagine taking another one, but I have to." By the end of the semester, she was still lamenting in her journal, "The semester is ending and I am overwhelmed with work. While most students are enjoying a down week before finals I have to continue to do homework sets as well as prepare for a presentation."

The desire to do well and the determination to succeed were articulated through the stories of these women, no matter what the cost. Many spoke of a vicious cycle of forgoing sleep due to their desire to do well. Although they intuitively know they can't

function with any sleep, they feel there is no alternative. Sue told me the story of how getting stuck on one homework problem starts the cycle:

> "You spend hours doing something and if you can't figure it out I need to learn to let it go and then go back to it some time instead I could work all week 24 hours a day and that's how the stress builds like you keep trying to do something that you can't really do and then you start thinking about your other classes that your are falling behind in…and then you can't even sleep because the problems are running through your head and you're thinking I've got to do this and that and then you feel you'll never catch up (laughs)."

The constant barrage of academic challenges faced by these women makes it easy to see why attrition of women from engineering exists. The efficacy they begin with is continually challenged resulting in a loss of confidence and commitment to the discipline, alienation and severe reactions to stress. Somehow, these nineteen women were continuing to succeed throughout the study. In the next section I discuss the support these women found and how it influenced their desire to succeed.

Academic Support

Through the words of the nineteen women participating in this study, it is clear that the academic challenges they experienced were greater than anticipated when they came to campus. Although each of these women entered expecting the work to be hard, they did not realize the full scope of how the work would impact their daily lives. Still, they continued to hold on to their goals and, with support of faculty, internships, and research experiences, they were able to face their academic challenges.

Faculty

For almost thirty years, literature on women in engineering has examined gender bias in the classroom and in the laboratory. Much has been written about women's voices not being heard in the classroom (AAUW, 1998), their status as note-takers in labs, and

the undervaluing of their work by male peers in group projects (Tonso, 1996). The women in this study did not report any incident or perception of gender bias in the classroom or laboratories. Instead, the women commented on the accessibility and fairness of all professors, both male and female. Annie wrote, "I find them [faculty] very involved with students, and very willing to meet up with you at any time, always encouraging you to go to office hours and get help."

Research also suggests that female faculty can inspire women to continue in engineering (Crombie, Pyke, Silverthourn, Jones & Piccinin, 2003). This hypothesis was supported by the women I interviewed. Cindy spoke enthusiastically about the impact female engineering faculty had on her studies:

> "it's awesome having two female professors this semester. It just makes you realize there are women making it in engineering…it's almost like you walk through the door and feel like you see a friendly face even though you don't know them even if they're going to be the hardest professor ever you know that they survived as engineers and they are girls and look at them teaching at a great university…it makes me feel good like I can make it…" The ability to connect on a deeper level with a female faculty was mentioned by three participants. Carol reflected on her faculty experiences and wrote, "I know gender does not make a professor good or bad but sometimes having a women professor just makes me feel more at ease."

The importance of connecting with faculty or someone in an advisory role was reinforced by all of the women. Although engineering faculty played a key role in supporting these women, some, including Lisa, found support from faculty outside of the discipline and from other administrative staff, "I had an amazing math teacher. I still go over and talk to her during her office hours and I have people in the COE , the Director of Multicultural Engineering Program he's such a nice guy and the Director of Transfer Programs he's pretty cool and faculty members too and my advisor." The important

finding is that women need to find a connection at the academic level to be able to turn to for help and guidance along the way. In each case during this study, these women could identify at least one person who supported them academically.

The next section explores how experiences outside of the classroom provide an important practical application to the class room learning.

Internships/Research Experience for Undergraduates (REU)

Internships and research experiences are common components of a traditional engineering undergraduate program. These experiences are developed so that students can get some hands-on experience and apply what they learned in the classroom. These experiences are not often realized until either the summer between sophomore and junior year or between the junior and senior years. Another option for practical application is for undergraduate engineering students to work with a faculty member on research while they are attending the institution. Twelve of the nineteen women in the study had participated in either an internship, research experience or both during their time at the COE. These experiences were transformative for each woman. It gave them the opportunity to see how their hard work in school will be applied when they graduate.

Eleven of the women held summer internship positions. Eight began interning between their sophomore and junior year. One woman, Lisa, was lucky to be selected for an internship between her freshman and sophomore years, "I had one at the Massachusetts department of environmental protection. I worked with graphing and storing data of the air toxic pollutants on the AP1 form. It was very interesting and I learned so much." These experiences opened their eyes to what life after college could be like as Sue articulated,

> "I realized [at internship] that we don't use most of the things we learn in school you use the basics but the high level stuff forget it (laughs) all the details and stuff is just to challenge your mind…I see that the purpose of school is to challenge your mind and to teach you the basics that you will improve upon once you are there [in your job]."

These experiences sometimes were the inspiration to stick with the major, as Rebecca told me, "I've had doubts this semester but the internship showed me this is really what I want to do so it was a great experience for me." Lil was also able to solidify her commitment to engineering after a summer internship, "I really enjoyed my internship and knew that I wanted to work in the utility industry when I graduated and to get the job I wanted I needed to stay in Electrical Engineering."

For others, the internship allowed them the opportunity to evaluate the stress of their school work by comparing the benefits of the "real world" work and knowing it'd be meaningful and fun. Sue was able to put the school work into perspective by remembering her internship experience, "I worked at Raytheon this summer and…it made me excited about the work…I know what it is like (laugh) out there (laugh) and I guess that's one of the reasons that keeps me going I know these 3 months are going to pass and then the other 3 months will be gone (laughs) and then I'll go back to Raytheon this summer and it will all be OK."

Marcy worked for two summers doing research for an organization called the Collaborative Adaptive Sensing of the Atmosphere (CASA). She felt that the two summers she spent working kept her focused on what she wanted to accomplish and prepared her for life in industry, "I feel that I am prepared really well for my future mostly because I have worked with CASA for the past two years and have experience doing what I am most interested in." Cindy applied and was accepted into an REU

program between her sophomore and junior year. She was going to use this experience to help her solidify her post graduate plans, "I was accepted to an REU program in Nanotechnology and manufacturing nanotech structures. It's something I am excited about. I may want to go right to graduate school after earning my BS and this REU will help me decide."

Internships or research experience can play a significant role in providing a needed bridge between academic work and practical world application. These experiences allow women to visualize what their future might entail. Another important reason the women in this study persisted was that they constantly reminded themselves of their end goals and the importance of what graduating means to them. In the next section I explore how the end goals held by these women was a tremendous support in staying with the major.

End Goals

The end goals of the women in this study were clear; they were positioning themselves to be able make a good future for themselves. The definition was different for some; however, the majority of the women were focused on graduating and securing a good job. To accomplish this goal, these women would remind themselves that they were making sacrifices for four years and then, they'd be in a position to enjoy the benefits of their hard work. When Annie became overwhelmed, she would remind herself, "it's going to be over soon and that I'm only here for 4 years and then after that I can just…graduate and get a nice job (laughs)." For others, it was clear that there were no alternatives, as Lil questioned, "what else would I do if I didn't do engineering?"

The majority of the women in the study, 15, were interested in securing a good job or steady income as a result of their hard work. Lisa admitted that "making money is important" and a big reason she would not leave the major. Carol wrote in her journal that she thought engineering offered "the best future like it's a lot of work for 4 years but after, well, you can go to grad school and it's still a lot of work but I'd have a good future I'd have a steady income."

The ability to continue to encourage other women to enter the field of engineering was very important to Carol. Her experiences at the university with female faculty reinforced the importance of role models in engineering, "I would like some day to become a professor because I know how excited I was to have women professors in engineering."

Lisa, a first year student, planned to use her degree to better position herself for law school. She had no intention of ever practicing engineering, but wanted to have a degree in a rigorous disciple to help her larger goal of being accepted into an Ivy League law program, "I'm gong to get this Chemical Engineering degree because I want to go to Yale and get a law degree…so it's basically that I have to get through these four years and then I can do what I want to do and in all of these classes it can be easy to lose sight of that because you are so caught up in it."

Although these women had different end goals in mind when they entered the COE, the goals often inspired them to continue by helping to focus and, often times refocus, their efforts and energy to succeed in the major.

The tough academic challenges faced by these women could give any person many reasons to not persist in engineering; however through academic support these

women were able to put academics into perspective. As discussed in the next section, these women faced several social challenges: the lack of women in the major, competition, isolation and no time for socializing. These challenges working in concert with the academic challenges made the undergraduate experience for these women especially trying at different points along their college career.

Social Challenges

Too Few Women

The women in this study knew they were entering a male-dominated discipline and were confident they would succeed; however, as early as summer registration, the women were faced with the reality of what it meant to be in the minority. Carol talked about the false sense of security she felt when she came to campus for summer orientation, "We were in the dorms for orientation like everyone was together for all majors so there were plenty of girls…..then we did our registration for just engineers and there were only 3 girls and the rest boys probably over 50 boys it was very awkward."

The impact of such a small number of women crossed both the academic and social spheres. Fourteen of the women lived on an all engineering floor during their freshman year. This living community, designed as a support for engineers, also highlighted the disparity between women and men in engineering, "we're the only 2 girls on our side of the floor which was kind of hard for me because in high school most of my friends were girls and now I have to talk to more guys so it's different for me… …it's like 4 [girls] to 30 [guys](laughs)."

The experience with so few women in the dorm carried over into the class room. Carol recalled how she felt walking into her first engineering class, "It was like a class of

70 and I walk in and there are like maybe 2 or 3 girls sitting there and the rest of the faces are all guys and then maybe one more girl came in so there were like 4 girls and 66 guys and you're like hmm wonder if this is how it's always going to be. It was a lot to think about." Cindy remembered how she felt after the introduction to MIE class as a freshman:

> "being a minority was something I expected, but not the extent that I encountered. Of course more than half of my classmates would be men, but to have the ratio be 9 men to 1 woman my freshman year was something I did not expect. It was so hard to watch my fellow female engineers get their withdrawal slip signed after our first exam in MIE 124 [second semester freshman year intro course] after so many had dropped after MIE 113 [intro course]."

A few women were pleasantly surprised to find more women in their classes than they anticipated. "There are actually a few more girls in that class [CE] than I expected well Civil Engineering has the most girls out of all the disciplines there's like maybe 15 out of 60", recalled Allison. Claudia also found more women in her introduction classes than she thought, "I'd say that in a class of 100 there are 10 females." An interesting comment made by some of the upper class women was that, although when they started as freshman there were seemingly few women, as they progressed through the four years that small number became even smaller and it became increasingly harder to find a peer group of female engineers.

The small number of women and the inability to completely connect with a cohort influenced these women in many different ways and on many levels: emotionally, socially, and academically. Carol and Emily recalled how such few women in her classes had an impact on their self-confidence, "half of the difficulty was just mental, walking into a classroom with very few female faces you do not consciously think about it but it's

still somewhere in the back of your mind. Those thoughts creep out at different times. Like when I could not figure out the software program for my Intro Lab and my TA told me if I could not figure it out I should probably quit engineering. I had to question why he said that", reflected Carol. Emily told a story of how women think differently than men and how she needed to remind herself that her perspective was just as relevant as her male counterparts:

> "women and men think differently and when you're in a group that is all boys and one girl it might be hard to convey ideas because your thought process is so different. Often women work differently, focus on different things and put things together in a different process than men. Sometimes it is hard to always be the different one. It's easy to forget that being different does not make you wrong, nor does it make everyone who is similar better. It just takes a lot more confidence in yourself to present something that is different."

Socially, Carly felt the small number of women limited her access to female friends, "another negative aspect would be when it comes to friends. I have only one or two girl friends at the moment and a dozen guy friends."

There were several positive aspects to being a women in a male-dominated field mentioned throughout the interviews and journals. Allison, a relatively shy woman, was hopeful that this new dynamic might bring her out of her shell, "I knew that the number of girls in engineering was a lot less than guys (laughs) I think it was good for me because it helped me to become less shy maybe in some ways (laughs) cause I'm really shy and now I'm trying not to be." Carol thought of the value a women's perspective will bring to society, "…being a female in engineering is positive because you are bringing a different view to all kinds of designs and ideas that have been mostly male dominated for so long."

Cindy spoke eloquently about how the support and encouragement she received from her family and her internal drive would outlast any negatives being in a minority might produce. She said, "it was intimidating [having so few women in her classes]. I knew I could do it and I wasn't going to let that stop me by any means and I had a lot of guy friends in high school because guys are usually less drama than girls; yeah, I was intimidated but it wouldn't stop me from succeeding. I mean I can do it just as well as they can if not better. I mean my parents were always encouraging and I never had people tell me you can't."

As discussed above, the small number of women in engineering presented both positive and negative issues for the women in the study. Another interesting topic of discussion was the competiveness between the few women in engineering and how that influenced their ability to succeed. In the next section, I discuss the challenges this competitiveness posed to these women.

Social Competition among Women

Sometimes competition can be healthy and in fact many of the women used the competition with men as a motivator and incentive to do better. Claudia spoke of how she would use the competition between the boys in her class to her advantage, "the fact that I'm one of a few [women in the class] whenever I'd get one of the best scores on an exam I was like yes I'm smarter than the other guys."

Interestingly, even though the women were part of a small group, the competition that began between them, as distinct from competition with men, made it more challenging to succeed. These women told of how intense the competition was and how any congeniality among them was beginning to fade. Maren wrote in her journal early in

the year, “I feel very competitive with some of my classmates, enough so that I cannot continue a friendship with them…it’s terrible. I have to say one thing though, it’s all females. I do not feel competitive with any of the males in the class.” Marcy wrote about a conversation with her dad regarding the stereotype [dominant women] of women in engineering:

> “he agreed that the stereotype is still there. He then told me to think about the women in my classes. I did and then I realized I also probably thought the same way. I really don’t like to work with those women. I like working with the guys. I can honestly say that only one other woman in engineering is worth pairing up with on a project….they are all too cut throat.”

Maren summed her feelings up about this cut-throat mentality, “there’s supposed to be this whole ‘comrade-ship’ for women in engineering. That is absolutely NOT true. I feel more comrade-like to the males in this program. Why is it that women feel the need to step on the shoulders of other women in engineering?”

There were other social consequences related to being part of a small cohort of females including the quality of the females in the program, feeling used by other women and just getting tired of the same old group. Emily wrote, “I was also somewhat disappointed with some of the girls that are in my chemical engineering class. Some seem to lack a focus, and others are not as serious of students as I expected.”

Carly focused a journal entry on having a limited number of females to work with on labs and the hard decision to break away, “I told my girl friend that I thought it would be best if we found different people to be our lab partners. I did this mainly because I felt like she takes advantage of me sometimes and doesn’t put as much work in as me.”

This inability to connect with a group of female students was mentioned consistently as being one of the reasons these women had feelings of isolation. In the next

section, I explore how this feeling of isolation impacted their overall satisfaction with their undergraduate experience.

Isolation

The College of Engineering is part of a large research institution comprised of over 24,000 students. The COE enrolls roughly 1,200 students, of that about 150 are female. The college itself is situated with its engineering buildings all in the same "quad" and aside from any general education requirements, all engineering courses are taught within the confines of this space. Cindy talked about how, even though academically it would be tough, she thought she'd have the opportunity to socially expand her circle of friends, "I expected it to be a lot of work but I didn't think all of my friends would be engineering friends. I mean I figured I'd have some but I hang around with all engineering girls."

Students enrolled in the COE have different housing options. A student can elect to live among the general university population, they can enroll in the engineering TAP program and live with all engineers on designated floors, or if their incoming academic record permits, they can be enrolled in the Commonwealth College Honors program and live with other engineers in this program. All of the women in the study qualified academically and elected to either live on a TAP floor or enroll in the Honors program which allowed them to live on floors with all engineers. Although these dorms provide an instant network and support system, many engineering students feel a sense of isolation from other students as they progressed through their undergraduate studies.

Allison, a member of the TAP program, wrote, "I find that all of my friends are people on my floor, like, I haven't met people outside of my floor; well, I have, but for

the majority my friends all live on my floor and are engineers and we have classes together too so it's like the same people all the time, which is probably the downside of TAP." Cindy, a member of the Honors program, reinforced Allison's point that the ability to branch out socially is difficult, "Almost all of my friends are engineering students because those are the people you see everyday in all of your classes. The majority of my friends are also from my EnginOptions floor. I mainly hang out with female engineers or my boyfriend, who is a chemical engineer." Rebecca explained that the way the housing is arranged limits the ability to really meet others outside of engineering, "Since I lived on the engineering floor all of my friends are engineers."

One student, Karen, had come to the college for engineering, but also to participate in athletics. She was recruited to play for a team. Her initial housing decision was to live with the other athletes in a dorm on the other side of the campus, a good distance from the engineering quad. Between the first and second semester of her freshman, year she decided to switch room mates and move in with an engineering student, "I sort of felt like I switched sides from the team to engineering and that was hard. Now I'm not as close with my friends on the team." The pressure of having to select one group to be the dominant group impacted Karen's ability to integrate effectively into either group, and she was left with feeling isolated in both groups.

The social isolation experienced by these women increased as they progressed through their college years. The initial sense of community the living arrangements provided quickly turned into a further segregation from the larger community. All of the women recalled a desire to interact with others outside of the engineering discipline and the difficulty in socially connecting. Along with the feeling of isolation, these women all

reported having very little time for social activities. These challenges described below contributed to the social stresses that they experienced.

Limited Social Life

Across the four years in the COE, these women struggled to find equilibrium between their academic and social worlds. The curriculum became more and more rigorous each year, eating away at any precious free time. Most admitted that they had given in to the fact that academics must come first at this point in their life, but that realization did not release them from the struggle of it all. Sue talked about her inability to balance these two aspects of her life, "I don't think I can balance it [social and academic life], I've been trying to balance it but of course my priority is academics."

An overwhelming sense of frustration and rationalization in not being able to put their lives in balance was heard through their stories. In one of several tough moments throughout the semester, Rebecca wrote in her journal, "I used to want to go to grad school and get my PhD so that I could become a professor and do research. I really don't know if I want or even am capable of doing that anymore. I'm so burnt out right now. I feel that I'm doing fewer activities and putting in so much more time than I used to, and I'm still not doing well." Allison talked about her decision to focus on her academics over her social life, "I definitely weigh my academic life more heavily than my social life right now (laughs); definitely during the week I mostly concentrate on my academics."

Cindy and Carol both admitted to spending more time on their academics but explained why at this stage of their life they were OK with it. "I think it's more heavily weighted towards academics than having fun and I don't mind; that is I mean I'm not the typical college kid that goes out and drinks on weekends so I don't mind doing a lot of

work for four years of my life," explained Cindy as she reflected on finding a balance. Carol was more pragmatic about her purpose for education, "I think academics definitely takes more weight because I'm at school to be learning and doing my academics and I'm not going to blow it to go to the movies with my boyfriend when I know I have exams to study for."

In addition to the time spent on academic work, these women faced personal struggles throughout college. Marcy and Emma endured family pressures which added to their inability to find a balance in their social life. Emma, a post-graduate, part-time engineering student, had given birth to her second child six months prior to the study. She said, "I've been really tired lately and have had difficulty finding the time to do anything." Marcy, a transfer student, was raising her 9 year old son as she was completing her degree, "my son asked me to play basketball with him today. I didn't have the time and at first I said no. The look on his face was so sad I put down my books and went outside. It's so hard right now to find time for him." Maren was faced with her parents' divorce and Cindy's dad lost his job while they were going through the engineering program. These distractions took time away from their studies and social activities and added more pressure.

The social challenges discussed above caused conflict within these women. They were struggling academically to succeed and were faced with social pressures that made them rethink what they were trying to achieve with their degree. As with academics, socially, these women were able to find refuge through a few programs: the living learning communities and the engineering societies on campus.

Social Supports

The social challenges faced by these women caused pressure and frustration throughout their college careers. At many points during our interviews, I asked them why they chose to continue. Each woman was able to identify a few key support structures that were in place at the COE which enabled them to forge ahead. In this section, I focus on three key areas: living/learning communities, involvement in engineering societies and these women's the end goals.

Living Learning Communities (LLCs)

The Living Learning Community (LLC) structure identified earlier by the women as a challenge also provided some critical structure and support as they initially embarked on their undergraduate careers in engineering. These programs allowed the women to live on a floor with all engineers thereby fostering an immediate connection with the few women who lived on their floor. It made the transition into the discipline easier. The fourteen women who participated in this program each remarked that it provided a network for them to align with in class and outside of class. It gave them access to resources in a close proximity as Allison pointed out, "It's good to be in TAP because everybody has the same classes so if you have a question you can go next door." Rochelle found the TAP program to be supportive of her needs, "I have found it very helpful to be in the TAP program because everyone on my floor is in engineering and so we always check our answers with each other and help each other out."

These programs also provided some reassurance to the women that others like them did exist. Rebecca came to the COE with many reservations about the quality of the students, "when I came here, I lived on the engineering floor, and they were all in the

same position that I was in…I actually found that there are people here who want to study and they are like me." This community allowed her to forge friendships and connect to people she felt had the same core academic values that she held.

This living community allowed the women to transition into the discipline connecting with the small cohort to which they belonged. It provided a strong foundation and a social network that the women could rely on throughout their college careers. Their involvement in engineering societies provided them access to the world outside of the COE and like internships and REUs, allowed them to be exposed to other women who had succeeded in their chosen fields.

Involvement in Engineering Societies

Involvement with engineering societies was the most consistently mentioned positive social support for these women. They talked about how these societies provided the real life connection between their academics and their goals for the future. Some spoke about the increased contact with faculty and the ability to work more closely with them on projects. The connection to industry and experts in the field was also mentioned. The support of the Society of Women Engineers for a variety of reasons was mentioned by all of the women in the study.

Cindy wrote about the importance of the Society of Women Engineers in her education, "Due to SWE, I am fortunate to interact with upper-class women and occasionally the Dean. SWE is one of the best resources to women in the COE. It makes you realize that there are people who can help you and that women do make it to graduation." For others, SWE provided a level of informality and intimacy missing at the college as Janet recalled in her journal, "I like SWE because if I'm walking down the hall

someone will say ‘hi Janet, how are you’ and I’m like how do you remember my name and it makes me happy so I think it is good and that it helped me to meet some of the people in my classes.” Karen had a very similar impression of the impact SWE had on her transition, “The SWE events were the most influential. Having dinner at the Dean’s house was the most memorable and when you put 20 freshman girls together, it’s pretty amusing. The girls I met there and I became instant friends because we had all seen each other in class but were too afraid to talk to each other. The next day in class we all sat next to each other in a huge row.”

For Rebecca, the importance of SWE was in the external connections she was able to find. During our interview she talked about being selected to attend the National Conference. She talked about how important it was for her to gain exposure to women who had made it in engineering. She was also looking forward to attending workshops that would prepare her for entry into the engineering workforce. She wrote enthusiastically about the trip in her journal, “I’m still very excited about the SWE conference. There are a lot of workshops that I’m really interested in. Especially the one about teaching women how to speak up to get what they want in the work force. I feel that I sometimes get pushed around and don’t know how to stand my ground, so hopefully this will help.”

In addition to SWE, the women in the study were involved with many of the discipline-specific societies. The reasons mentioned for involvement in these societies were similar to those mentioned for SWE. In addition, students liked being able to discuss topics with their peers and also network with professionals dedicated to their particular area of interest. Maren, recently back from a society meeting in Boston, wrote,

"WOW! I went into Boston for a conference for The International Society of Pharmaceutical Engineers. It was AWESOME! There were so many great people there—though I have to admit, I saw few women."

The ability to connect and learn from women who are practicing engineers provided additional support to these women. It helped them to regain confidence in their abilities. The speakers, conferences, and meetings inspired the women to reach one of their end goals, persisting to graduation.

Persistence

Earlier research focusing on student departure (Spady, 1971; Astin 1975,1984,1996; Tinto 1975, 1993; Braxton, 1998, Berger & Milem, 1997, 1999) focused on persistence to degree as the measure for success. However, the qualitative nature of this study provides deeper context to this the meaning of "success". For these women, persistence was one measure of success; however, they were able to identify clear milestones along the way that indicated success or failure in more subtle ways. Since the purpose of this research was to understand what women needed to succeed in engineering, it was important to have the women provide a clear definition of the term. Across one academic year, the women kept a journal and spoke to me about their experiences, but the term "success" was not introduced until the final focus group discussion when I asked the women to define success. The group came to consensus that success encompassed two categories: immediate and overall success.

Immediate Success	**Overall Success**
Learning the material	Graduating
Good grades	Meaningful job/ helping others
Relationships	
Happiness	Being happy

These categories reinforced and summarized much of what the women talked freely about over the year.

Immediate Success

Understanding Hard Material

All agreed that, upon entering engineering, they felt confident they could do the work and had demonstrated academic proficiency throughout high school and college. Beginning in the second semester of their freshman year and continuing through graduation, they continued to question their ability to comprehend the material in their engineering classes. As they sat around the table talking with one another about their experiences, they realized that they were succeeding, on many different levels. They discussed the different measures of success and how it changed over time. Emma articulated the group's feelings, "I think success is 'did I learn the material?'…and along the way it's ultimately about the process… the real focus should be on what I didn't do well and figure out why." Lil supported the importance of learning, "as long as I get the course material in the end then I am happy because I really tried."

At the end of her junior year, Rebecca realized that letting go of competition allowed her to learn in a way she enjoyed, "I'm a lot more confident in myself and I interact a lot better because I don't feel like I'm competing with everyone. Now it's just more for myself and I want to learn for me, not because I want to do better than someone else in my class." While learning the material was a measure of success, it was clear that grades would always be regarded as a barometer for success.

Getting Good Grades

Although the process and the result of learning was mentioned as very important in the definition of success, these data suggest that grades remained another important criteria. "Graduate schools look closely at grades, so you have to do well," reminded Lil. The obsession with good grades was echoed consistently as meaningful in defining immediate success throughout the study and especially in the focus group discussions. Valerie mentioned, "for right now success equals getting good grades."

Over time the intensity to which grades defined success changed. As the reality of the curriculum and the workload associated with a degree in engineering, these women were able to put their grades into perspective, Marcy articulated that:

> "I was hoping to have a higher GPA but it's not bad…when you come into engineering you think I'm going to get all As but that just doesn't happen…At first I was disappointed, but I have over a 3.0 which is better than most of the guys so I'm fine with it."

The B average or 3.0 GPA was the definitive statistical point for defining success. Lil concluded, "staying above a 3.0" is the indicator of immediate success.

Grades matter; however, from a social perspective, there was a clear need to develop meaningful relationships with faculty and peers.

Developing Personal Relationships

Engineering encompasses a highly team oriented approach to solving problems. As mentioned earlier, most of the participants remarked about developing relationships with engineering peers and faculty. These relationships had particular significance to the definition of success. Carly spoke of the necessity to consider academic and social

success, “success is also being able to enjoy what you are studying while you are in school and enjoying working with your team mates while you are here.” Carol focused on the need to help others struggling with the academics, “Success is also being able to help other kids in my class to do well.”

Strong faculty relationships were mentioned as a criterion for success. Moira found satisfaction collaborating with faculty. She spoke of the importance this played in her success, “It feels really good to know that the faculty makes a point to help you when you need it. I can’t imagine what would happen to my self esteem and mental stability if I didn’t have them as a resource.”

Carly agreed, “Professors are very helpful and want to be a part of what you are doing. You need to have those relationships in order to be successful.” The degree of influence faculty had on students ranged from support in class and labs to interactions outside of the classroom, in engineering forums, as well as, office hours. Annie described this, “My professors have helped me tremendously. I’m now working on an independent study with one and he has shown me different options in terms of what I can do with my degree. He keeps me focused and moves me along in the curriculum.”

Happiness

Finding happiness along the way was important, “I think being happy with what I’m doing defines success now and in the future,” mentioned Janet. Throughout the college experience, finding equilibrium, the important balance between academic and social demands, impacted their ability to feel fulfilled. The women placed significant importance on being able to understand the material and, get good grades as measurements for their immediate happiness.

Overall Success

The women brought up the term "overall success" to talk about future success in the profession and, more importantly, in life. The discussion of the term was specifically defined as: graduating, finding a meaningful job, and ultimately being happy.

Graduating

"At this point I just want to graduate and when I graduate I will have succeeded…I set out to do what I said I'd do," explained an excited senior, Marcy. Although the women were currently persisting, thoughts of leaving the major had occurred throughout their journey. Keeping the overall goal of graduating in their mind helped to keep them focused.

A reward for their hard efforts was seen as being able to find a good, meaningful job, or the ability to gain entrance into a good graduate program, after graduation.

Having a Meaningful Job

"The main objective of all of this is to get a job that you like and it being a good job," articulated Rochelle. Annie remarked, "Success will be getting a good job when I graduate that makes me feel that the work I put into engineering was worth it." Valerie agreed, "For right now success equals good grades. When I graduate success equals good job and good company."

Success in employment encompassed many different components. Carly mentioned the importance of a good job combined with the ability to help others, "success can be defined as getting a job that you enjoy and that is meaningful to other people." In contrast, Maren placed more emphasis on company culture, "success in a career would be to have a well paying job that I'm happy with, in a good environment."

Carol defined career success as being able to make an impact at the organization, "I want to work for a company where I can input a lot of ideas and help the company to really succeed and grow."

Being Happy

Finding equilibrium was echoed as being the key ingredient to being successful. Rebecca remarked how her outlook had changed dramatically from when she first entered the college of engineering:

> "Today success means doing fairly well with grades but being happy at the same time. Trying to know the mix of when to do work, but also trying to have fun. My definition of success has definitely changed. When I first came in it was all about grades, but now since I've gone to a lot of industry and society functions I've learned that grades are not the most important things. It's more of whether or not you are a well rounded person."

Claudia reinforced the notion of levels of success, "there are different degrees of success. If you set a goal and accomplish it, that is one degree of success. The bigger picture for me would be not only living a happy life, but also contributing to the happiness in other people's lives. We live together in a society for a reason like to make each other happy so that is another degree of success."

Additional factors mentioned as influencing overall success included: the ability to understand their limits, having a clear understanding of the requirements of all the classes, being organized and the ability to work in teams.

The contributing factors detailed by these women reinforce the pre-college support and efficacy that each woman discussed earlier. It is clear that the success of these women was a true combination of the attributes and efficacy these women held

which was transformed, challenged and supported throughout college preparing them for their careers in the engineering profession.

Conclusion

The nineteen women who participated in the study worked with me to identify what women need to succeed in engineering. These women came from very different backgrounds with varied experiences; however they embarked on a similar journey that defined them as pioneers in a male dominated field. As a group, they identified commonalities which help us to understand how changes in practice and policy influence future success.

Of particular significance was paternal support and encouragement. Although mothers and other siblings were mentioned as playing a role in the decision to pursue engineering, it was clearly the father who had the strongest influence on these women's decisions. A clear pattern of positive paternal encouragement was evident for these women from a young age through their decision to major in engineering. Cindy credited her dad for her decision to try engineering, "my dad encouraged me all throughout school and he was the one who asked me to try engineering because I was so good in math and science, so here I am." Claudia specifically remembered her dad as being the major influencer beginning in eighth grade, "In middle school my dad actually mentioned the idea [of engineering] to me." Programs targeted specifically at helping fathers to encourage their daughters involvement with science and math in their formative years could provide more women with a strong foundation and confidence to pursue engineering.

The struggle to reach a state of equilibrium between academic and social experiences was consistently mentioned as the key reason for considering leaving the major. These women entered engineering knowing the academics would be hard, but they were not prepared for how much time they would need to devote to their studies. They also came to college hoping to expand their social networks and experience. As the reality of the work load became evident, the desire to leave the major grew.

A critical component of the undergraduate experience which helped these women to succeed was the integration of the academic curriculum with real life experiences through internships and REUs. An equally important and consistent source of stability was involvement in engineering societies, particularly the Society of Women Engineers and engagement at conferences. These activities offer women a first opportunity at becoming socialized into the profession and provide them with an alternative perspective on what it means to be successful in engineering. The ability to connect with successful women in the field or work for a summer on a real-life project provided incentives to persist. With the exception of joining an engineering society or SWE, most of the internship and REU opportunities are encouraged later in the curriculum, most during the junior year. Attention needs to be placed on fostering attachment to the profession at an earlier juncture in the curriculum, and these activities should become a requirement of the major.

This research highlighted significant opportunities for policy to help bridge the gender gap in engineering. Women do persist, and policy changes will allow for more women to be successful in a traditionally male dominated field. It is the hope that women will come to the realization that Carol articulated, “Slowly over time I’ve learned that it

doesn’t really matter if I’m a girl or not. It’s the work I do and I just need to focus on that and make sure my work is up to par and then nobody can say anything.”

CHAPTER 5

SUMMARY AND CONCLUSIONS

Overview of Study

This study has addressed a gap in previous research by exploring how women enrolled in undergraduate engineering programs perceived their undergraduate experience in relation to their anticipatory socialization into the engineering profession. Chapter 1 made the case that, although millions of dollars have been invested over the past few decades to combat the shortage of women in engineering undergraduate programs, very little improvement has been achieved. More importantly, although many factors have been determined to perhaps influence the under representation of women in engineering, a clear understanding of why this phenomenon continues, particularly from the perspective of female students themselves, had not yet been established.

The literature review in Chapter 2 presented areas of research used to develop the conceptual framework for the study. Supporting evidence was included to reinforce the need for a more thorough understanding of why women are not persisting in engineering. The demographic shift in gender at the university level and the high demand for engineers over the next few decades highlighted an area in need of further investigation. The remainder of the chapter addressed the underpinnings of the study: the impact of college socialization on the academic satisfaction, aspirations, and persistence of female college students enrolled in engineering. A discussion of retention theory and how these theories influenced the types of interventions implemented on college campuses followed. The literature review explored two specific types of interventions developed based on retention theory: first year seminars and learning communities.

Potential barriers identified in existing research and labeled as "unique to women in engineering" including gender socialization, the way women learn, the campus climate and lack of role models were explored. Finally, the review investigated current efforts institutions of higher education utilize in an attempt to increase retention rates of women in engineering through services and programs, including WEP programs.

A conceptual framework was developed based on existing literature and was used as a guide for the methodology. Chapter 3 provided an overview of the research study and the mechanisms employed for data collection. Chapter 4 reported the analysis of the qualitative case study. The answers to the research questions posed are detailed in the following section.

Review of Research Questions

The goal of this research was to understand what women enrolled in engineering programs need to succeed. The thrust of the study focused on how anticipatory socialization might influence their success. The research questions introduced in chapter one formed the basis of the study. The following sections revisit these questions and use the findings from the analysis to present answers.

Overarching Research Question

How do female engineering students perceive their undergraduate experience as anticipatory socialization into the engineering profession?

This study revealed several interesting perceptions surrounding the undergraduate experience. It also provided evidence that previous research findings have changed over time and that some of the stereotypes perpetuated about being a woman in engineering may no longer hold true.

Upon matriculating into college these women knew they were entering a predominantly male field. They expected their experience might be "different" from a traditional major, but they were not sure what to really expect. A few, including Claudia, thought the idea of being in the minority was enticing, "In high school, I was the only girl on the math team that competed in competitions. I really loved it because I had gotten tired of listening to girls' conversations and found it quite refreshing to be in a predominantly male environment for a change. When I came to summer orientation, I was actually glad that engineering was male-dominated." For others, the thought of being part of a minority motivated them for the challenge. Cindy remembers feeling, "I knew engineering was dominated by men, but that wasn't going to stop me from succeeding."

The benefits of entering a predominantly male field were viewed favorably by all of the women in this study. The ability to make a social, or gendered, impact on the field, by bringing a woman's point of view, was inspirational to many including Carol, "being a female in engineering is positive because you are bringing a different view to all kinds of designs and ideas that have been mostly male dominated for a long time." However, while making a gendered impact was important to most of these women, it was not a priority for every one of them. For example, Rochelle took gender out of the equation, "I don't think there's very much about being a female engineer that is different from being a male engineer. The only big thing is that 75% of all your classes are filled with males…I'm very comfortable around men."

The early confidence displayed by the women on the subject of being a minority in engineering provided extra strength and motivation to succeed. After the initial shock on campus and in the classroom regarding the actual disparity in numbers between men

and women in engineering, these women did not dwell on gender as a defining factor in their success.

The rigor of the curriculum was clearly the most significant issue for these women. The women anticipated that they would have to work, but the actual work load was quite a shock to all of them. Although the rigor of the engineering program is experienced by all students, both males and females, the additional challenges faced by women, and discussed in chapter 4, contributed to higher levels of pressure. This pressure caused the women to constantly question if they truly could and, and if they still wanted to pursue engineering as a career.

As the women progressed through their college experience, the ability to reach a state of equilibrium, between the academic and social demands, became nearly impossible. Academics quickly became the sole focus of their lives and, although initially these women felt prepared, they were forced to focus almost all of their time on their academics. Again, this inability to balance academics and social demands was experienced by both males and women, however, this disequilibrium, coupled with the added pressures of being a woman in a male dominated field, made it even more difficulty for these women to persist. As discussed earlier, the number of women who actually persisted across the four years decreased across the first three years, resulting in an even smaller pool of female peers in the cohort. As the number of female students decreased, the competition among the female students increased, causing significant feelings of frustration and isolation for the women. These added pressures of the discipline caused significant internal struggles for these women. Even though the women had self-selected into this competitive field, they were unprepared and unable to find

equilibrium between collaboration and competition, especially among their female counterparts. The inability to find equilibrium between competition and collaboration became an important issue for the women.

In addition, the women were able to a clearly identify six academic challenges they had to overcome, in order to persist, including:

- wavering commitment to engineering
- questioning their abilities
- an unsatisfying curriculum
- grade shock
- competition with female peers
- overall stress

As they worked through each of these challenges, they realized that these experiences, although painful, were actually preparing them for a future filled with great possibilities.

An integral part of the undergraduate experience which prepared them for the profession was participation in an internship or REU. These opportunities opened actualized what life after college could be as Sue articulated:

> "I realized [at internship] that we don't use most of the things we learn in school you use the basics but the high level stuff forget it (laughs) all the details and stuff is just to challenge your mind…I see that the purpose of school is to challenge your mind and to teach you the basics that you will improve upon once you are there [in your job]."

These experiences sometimes were the inspiration to stick with the major as Rebecca told me, "I've had doubts this semester but the internship showed me this is really what I want to do so it was a great experience for me." Lil was also able to solidify

her commitment to engineering after a summer internship, “I really enjoyed my internship and knew that I wanted to work in the utility industry when I graduated and to get the job I wanted I needed to stay in Electrical Engineering.”

The evidence suggests that initial perceptions surrounding being a female in engineering changed dramatically from entrance to exit, and were not helpful in socializing them into the profession.

Research Question 1

How do background characteristics of students influence their perceptions?

Most of the early work examining college student retention was conducted using psychological methodologies (Summerskill, 1962; Waterman & Waterman, 1972) that focused primarily on personality attributes (maturity, motivation, disposition). This lens remains popular when researching attrition in engineering as many faculty support a “top-tier” mentality that implies only the strong and dedicated survive (Tobias, 1990). Looking at these participants through a psychological lens showed that, despite coming from diverse backgrounds, ambition, drive, and the desire to succeed in engineering were key early characteristics and motivations described during the college entrance stage. The personal motivation to succeed ranged from their desire to make their families proud to being the best student. Rochelle explained how her family provided her with personal motivation, “My parents expect me to do well and they want me to succeed…its how I was brought up and I don’t want my family to be upset.” Claudia’s ambition and motivation stemmed from out-performing boys, “another thing that excites me is doing better than boys at things that they are supposed to be better at…engineering included.”

While these early findings supported a traditional model for explaining success, it also highlighted the need to utilize work by more contemporary scholars and explore sociological, environmental, organizational, and economic attributes as possible reasons for college student departure.

Research Question 2

How do these perceptions change from freshman to senior year?

Perceptions of being a woman in engineering changed dramatically over time. As discussed in Chapter 4, the ability to find a balance between academics and social commitments increased across the years. Four distinct categories were created to describe the change in perceptions across the years: excitement (freshman year), questioning (sophomore year), despair (junior year), and pragmatic (senior year).

These findings supported the work of Berger and Milem (1997, 1999), Tinto (1993), and Astin (1984) that connected the relationship between "involvement behaviors and integration perceptions." Their research indicated that students' perceptions of their situations can be a strong link to the level of involvement and connectedness the student feels, both socially and academically. In contrast to the work of these scholars, this study revealed that, although over time the behaviors and perceptions experienced by these women were not continually eroded and became less positive, they were able to succeed and did indeed persist. This finding makes it important to clearly identify why, faced with great challenges, these women held true to their desire to pursue an engineering profession.

Research Question 3

What are the critical decision points?

Early encouragement and support of fathers, or father figures, emerged as a pivotal factor in engaging women in engineering. A clear pattern of positive paternal encouragement was evident from a very young age through their decision to major in engineering. Cindy remembers, "my dad always encouraged me when I was little I was always the little girl who played with rockets…I won the rocket competition in fourth grade…my dad encouraged me all throughout school and he was the one who asked me to try engineering because I was so good in math and science, so here I am." Claudia specifically remembers her dad as being the major influencer beginning in eighth grade, "In middle school my dad actually mentioned the idea [of engineering] to me…I started to think about what I wanted to do in eighth grade." This finding is consistent with recent research conducted by McCarthy and Berger (2008) which supports that positive identification with adult male role models fostered a girl's ability to "slip in and out of the male world" (p. 72). Early involvement of father figures in support of engineering can make the difference in a girl's decision to pursue this career.

Another key critical decision point suggested by these data is the sophomore year of college. Research has demonstrated that student departure is highest during the first and second years of college (Tinto, 1993). For these women, what began as a sophomore slump, magnified across the year and played a major role on the decisions they made.

During the first year of college, the women remained positive about their ability to succeed in engineering. During the sophomore year, they began to question their decision and ultimately their abilities to persist. Throughout this critical year, nine of the

women admitted considering dropping out of engineering. For all of these women, the issues identified were primarily academic and the inability to find a balance between their academics and their social demands. The struggles the women experienced during the "sophomore slump" increased in intensity through the junior year and continued throughout most of the senior year.

Research Question 4

What is the role of faculty shaping these perceptions?

The women's perceptions of faculty changed over time. Early on, many women mentioned concerns regarding their treatment by male professors. One woman, Cindy, expressed reservations about entering engineering because of stories she had heard, "I was so scared to be a girl in engineering because I always heard horror stories how professors are like she's a girl and doesn't know what she is doing." Over time, with positive relationships with both male and female engineering faculty, they realized that gender did not play a role in their success. More importantly, these women found the support, inspiration, and advice received from all faculty helped them prepare for the profession.

The importance of connecting with faculty or someone in an advisory role was suggested by all of the women. Although engineering faculty played a key role in supporting these women, some, including Lisa, found support from faculty outside of the discipline and from other administrative staff, "I had an amazing math teacher. I still go over and talk to her during her office hours and I have people in the COE, the Director of Multicultural Engineering Program he's such a nice guy, and the Director of Transfer Programs he's pretty cool and faculty members too and my advisor."

Research also suggests that female faculty can inspire women to continue in engineering (Crombie, Pyke, Silverthourn, Jones & Piccinin, 2003). This assertion was supported by the women I interviewed. Cindy spoke enthusiastically about the impact female engineering faculty had on her studies:

> "It's awesome having two female professors this semester. It just makes you realize there are women making it in engineering…its almost like you walk through the door and feel like you see a friendly face even though you don't know them, even if they're going to be the hardest professor ever, you know that they survived as engineers and they are girls and look at them teaching at a great university…it makes me feel good like I can make it…"

The ability to connect on a deeper level with a female faculty was mentioned by three participants. Carol reflected on her faculty experiences and wrote, "I know gender does not make a professor good or bad but sometimes having a women professor just makes me feel more at ease."

The important finding is that women need to find a connection at the academic level to be able to turn to for help and guidance along the way. In each case during this study, these women could identify at least one person who supported them academically.

Research Question 5

What are the perceptions of the classroom and lab climate?

As discussed in Chapter 2, Hall and Sandler's (1982) seminal work, *The Classroom Climate: A Chilly One for Women?* launched the term "chilly climate" to the forefront of college campuses. This report, a synthesis of existing research studying the perceptions of both male and female students regarding their classroom experiences, revealed that certain practices on coeducational college campuses and in classrooms

resulted in a woman's marginalization. Specifically, Hall and Sandler (1982) found that faculty members tend to call on male students more often than female students, give more feedback to men than to women, and ask less difficult questions of female students. Subsequent studies found sexist use of language, stereotypic views of women, different faculty/student interactions based on gender, and a lack of women faculty as mentors on campuses nationwide resulting in negative impacts on a woman's cognitive and social well being (Crombie, Pyke, Silverthourn, Jones & Piccinin, 2003; Sandler & Hall, 1986).

Literature focused on women in engineering, from 1980 to the present, examines gender bias in the classroom and in the laboratory. Much has been written about women's voices not being heard in the classroom (AAUW, 1998), their status as note-takers in labs, and the undervaluing of their work by male peers in group projects (Tonso, 1996). As women continue to grow in number on college campuses, currently accounting for 51 to 56 percent of all students in higher education (Krunkel, 1994), it is important to have an understanding if women *still* perceive and *actually* face these types of gender bias in the classroom.

The perceptions documented in this research contradict findings of past literature. Most came into engineering feeling they would need to work harder than their male counterparts and would experience differential treatment from professors. In all cases, the women confirmed that they did not experience differential treatment by faculty due to their gender. In fact, most cited faculty as being supportive of all students in the program. Instead, the women commented on the accessibility and fairness of all professors, both male and female. Annie wrote, "I find them [faculty] very involved with students, and

very willing to meet up with you at any time, always encouraging you to go to office hours and get help."

Implications for Practice and Policy

Practice

The goal of this research was to add to an existing body of literature and to identify clear steps to be taken by administrators, policy makers, and researchers to make an impact in the field. This study identified specific changes that could be implemented by institutions to recruit and retain women in engineering. These suggestions are outlined below.

1. Develop strategies for involving fathers or father figures in the formative educational years to encourage girls' pursuits of engineering. It is clear that from a very young age these women felt the influence of their father in shaping their educational future. Early involvement of men, particularly fathers, in encouraging young women to explore engineering was identified as a key component of success for women in engineering. Although mothers and other siblings were mentioned as playing a role in the decision to pursue engineering, the father had the strongest influence on these women's decision to think about and pursue engineering.

   An easy first step could simply be for practitioners to create programs focused on the early elementary years involving father (male role model)/daughter (young girl) pairings. It could be as easy as homework

assignments exploring how engineering impacts the world to more elaborate programs holding competitions or workshops for this group.

2. Incorporate an engineering track into pre K – 12 curriculums. The women recalled doing hands-on projects as an important means of introducing and exciting them about engineering. There are many existing quality curricular programs, including Lego, which should be included in early elementary education and continued through high school. Consistent exposure to the various disciplines within engineering and their roles in the global world is critical for the recruitment and persistence of women into engineering. School districts might partner with local engineering colleges or engineering organizations to create after school programs for students. These programs could be student/industry administered with the sole purpose of introducing engineering concepts, requirements and hands-on learning.
3. Incorporate an internship, undergraduate research experience or co-op earlier in the engineering curriculum. Internships and research experiences are common components of a traditional college engineering undergraduate program. These experiences are developed so that students can get some hands-on experience and apply what they learned in the classroom to real world applications. These experiences are not often realized until either the summer between sophomore and junior year or between the junior and senior years.

Twelve of the nineteen women in this study participated in either an internship, research experience or both during their time at the COE. These

experiences were transformative for each woman. It gave them the opportunity to see how their hard work in school would be applied when they graduate. In all cases, it inspired them to continue their pursuit of engineering.

These experiences should be a required component of an undergraduate experience as early as possible. Students must be prepared, socially and academically, to succeed in these positions. Career offices can work with industry partners, engineering board and alumni to identify appropriate opportunities, based on the student's academic preparedness, for summer experiences. The ability to connect their undergraduate experience to the profession early in the curriculum will help women persist.

4. Provide increased institutional support and resources to Women in Engineering Programs as well as engineering society chapters. Involvement in Women in Engineering programs and engineering societies was mentioned as another key contributor to success of these women. They talked about how these societies provided the real life connection between their academics and their goals for the future. Some spoke about the increased contact with faculty and the ability to work more closely with them on projects. The connection to industry and experts in the field was also mentioned. The support of the Society of Women Engineers for a variety of reasons was mentioned by each of the women in the study.

   Cindy wrote about the importance of the Society of Women Engineers in her education, "Due to SWE I am fortunate to interact with upper-class women and occasionally the Dean. SWE is one of the best resources to women in the

COE. It makes you realize that there are people who can help you and that women do make it to graduation." For others, SWE provided a level of informality and intimacy missing at the college, as Janet recalled in her journal, "I like SWE because if I'm walking down the hall someone will say 'hi Janet, how are you' and I'm like how do you remember my name and it makes me happy so I think it is good an that it helped me to meet some of the people in my classes." Karen had a very similar impression of the impact SWE had on her transition, "The SWE events were the most influential. Having dinner at the Dean's house was the most memorable and when you put 20 freshman girls together its pretty amusing. The girls I met there and I became instant friends because we had all seen each other in class but was too afraid to talk to each other. The next day in class we all sat next to each other in a huge row."

It is clear that these societies provide academic and social support for women in the discipline. Administrators must evaluate their current resources and put an increased emphasis on finding creative means of supporting programs, particularly the WEP programs, to increase the success of women in engineering.

5. Modify LLCs to enable for exchange of interdisciplinary thought and connections. Living Learning Communities (LLCs) were identified as both supports and challenges to the success of women in engineering. It is clear that these types of communities offer immediate access to other women in

engineering; however, they were also identified as sources of social isolation for many of these women.

The Living Learning Community structure provided some critical structure and support as the women initially embarked on their undergraduate careers in engineering. These programs allowed the women to live on a floor with all engineers and fostered an immediate connection with the few women who lived on their floor. It made the transition into the discipline a little easier. The fourteen women who participated in these programs each remarked that it provided a network for them to align with in class and outside of class. It gave them access to resources in close proximity as Allison pointed out, "It's good to be in TAP because everybody has the same classes so if you have a question you can go next door." Rochelle found the TAP program to be supportive of her needs, "I have found it very helpful to be in the TAP program because everyone on my floor is in engineering and so we always check our answers with each other and help each other out."

The challenges presented by this living environment were summarized as a form of social isolation. Allison, a member of the TAP program wrote, "I find that all of my friends are people on my floor like I haven't met people outside of my floor, well I have, but for the majority my friends all live on my floor and are engineers and we have classes together too so it's like the same people all the time which is probably the downside of TAP." Cindy, a member of the Honors program, reinforced Allison's point that the ability to branch out socially is difficult, "Almost all of my friends are engineering students because

those are the people you see everyday in all of your classes. The majority of my friends are also from my EnginOptions floor. I mainly hang out with female engineers or my boyfriend, who is a chemical engineer." Rebecca explained that the way the housing is arranged, limits the ability to really meet others outside of engineering, "Since I lived on the engineering floor all of my friends are engineers."

Since the value of these types of communities is clear, an exploration of a more interdisciplinary roommate/floor paring would be beneficial. A possible scenario would include engineers living with honors students from other disciplines, such as music, psychology, anthropology, etc. These interdisciplinary pairings will provide more access to diversity which was cited as lacking in the current structure of the community. These pairings allow engineers to connect academically and socially, but also allow for critical associations outside of the major.

6. Create college-wide academic engineering advisory boards including female students to review and modify the curriculum. The structure of the academic curriculum and the course content, across all disciplines, posed significant challenges. The women mentioned a false sense of security developed during the first-year since they were only required to take one engineering course. The academic confidence gained during the first-year changed dramatically, beginning in the sophomore year. Annie recalled that during her sophomore year she began to struggle academically, "I expected to do just as well in following years because of the confidence I had after last year…this year that

changed." That sentiment was confirmed by all the upper-class women in the study.

To address this problem, the EE major created an advisory board consisting of faculty, undergraduate, and graduate students. This fact-finding task force was exploring alternative curricular options. Carly and Sue were student representatives on this committee. Sue explained the goal of this committee, " we try to discuss subjects like moving some of the courses to earlier in the years so that we're not so packed during our junior year…that way we will have time to do other things."

The universal sentiment expressed y the women was the inability to feel fulfilled, both academically and socially, in this major. It is therefore imperative for administration to reevaluate the academic demands of the major. A first step would be to look at institutions with high retention rates and evaluate the curriculum they follow.. Incorporating female student representatives on these boards will empower women to feel connected to making a positive impact on the discipline.

Policy

Building on the approaches to practical application identified above, the research pinpoints clear policy implications to further promote the success of women in engineering.

Beginning in 1969, the impact of WEP programs has been thoroughly researched. Much of the research was conducted under the STEM field, making impact results

specifically for engineering hard to measure. As discussed throughout Chapter 2, in 2002 the National Science Foundation (NSF) and the Alfred P. Sloan Foundation funded the Women's Experiences in College Engineering (WECE) study as a response to the lack of multi-institutional data on WEP programs. This study was commissioned to quantitatively understand if increased funding for support activities for women in engineering programs was effective. This study, the first of its kind, provided a longitudinal, cross-institutional look at women's experiences and retention in engineering programs. Its ultimate goal was to "identify aspects of women's educational experiences that are critical to their retention in engineering" (NSF, 2002). One of the most surprising findings from this study was that there were "no statistically significant differences in retention between women at schools with WEP programs and women at institutions without formal WEP programs." An anecdotal explanation for this finding suggested that those schools without formal WEP programs offered similar services through other avenues (NSF, 2002). This finding was a precursor to my assumption that the impacts of WEP programs on its members are still not fully understood.

The data from this study clearly showed the importance and high degree of support WEP programs provide women. This finding establishes clear policy implications for administration and the need to explore creative solutions for supporting these programs. Clearly, additional funding would be a tremendous support, however, more creative solutions for providing additional resources should be explored. Reaching out to female engineering alumni to forge partnerships between their organizations and the college WEP program is one cost-efficient method for enhancing the offerings of

these programs. These types of partnerships will provide younger alumni, without large financial resources, to make a contribution to the program.

Secondly, the importance of an internship or REU experience at an early point in the undergraduate experience should be addressed. It will be important for the curriculum to provide a solid foundation of engineering principals early to properly prepare students for an enriched experience. Institutions should work with their faculty to create a policy for early incorporation of undergraduate students in their labs. Additionally, reminding faculty about the ability to request supplemental funds, specifically for women and under-represented groups in engineering, when submitting grant proposals will open up additional opportunities for women to work closely with faculty, upper-class and graduate students in a lab environment, early in the undergraduate experience.

It remains imperative for institutions to create incentives for identifying and creating partnerships with the NSF and other government programs offering research grants or other opportunities and internships for women in engineering. An example of this type of partnership is The National Aeronautics and Space Administration's (NASA) sponsoring of the Motivating Undergraduates in Science and Technology (MUST) Project. The MUST Project, open to freshman, sophomore and juniors, offers support to under represented undergraduate students majoring in science, technology, engineering, and mathematics (STEM) disciplines. Program participants receive a scholarship, NASA internship, mentoring and access to a wealth of professional development opportunities.

Finally, conversations with administration at NSF should commence to secure funds specifically target towards women in engineering. Devoting specific resources to this targeted population will allow the impact of these funds to be accurately measured.

Implications for Further Research

The purpose of this study was to add to and enhance the current knowledge base regarding how women enrolled in undergraduate engineering programs perceive their experiences in relation to their anticipatory socialization into the engineering profession. The study surpassed its goal and identified key areas of future research that may assist practitioners and policy makers in on-going efforts to close the gap between men and women in engineering.

First, additional research should be conducted about the influence of the father and father figures on women entering engineering. The results of this study suggest that there is a direct relationship between paternal support and success in engineering. This finding coupled with McCarthy and Berger's (2008) finding of the importance in adult male role models on a girl's ability to integrate into a man's world, suggest that more needs to be done to understand the underpinnings of the support. Supporting qualitative studies need to be conducted to measure how far reaching "male" support can be expanded and how to clearly define this influential group. This research should also identify at what point the support makes the highest degree of impact. Results would allow for future targeted programming efforts.

Secondly, the demographic and family backgrounds of these women point to a need for an expansion of research. This sample was primarily white and sixteen came from households with two parents residing in the home. These facts may account for the significance of the father influence among the women. Additional research should be conducted to identify all the influential figures in a young woman's pursuit of engineering. Conducting research among women from single parent homes, blended

families, and families of color will help identify the specific roles associated with key figures. It will also allow practitioners to evaluate if current curriculum and policy addresses each unique constituency.

A third area of research needs to focus on the competition and collaboration dynamic that the women were not able to fully understand. The total impact of the social and academic competition among women in these programs needs further exploration. The data from this study indicated that the female relationships changed over time and influenced the undergraduate experience. To begin the exploration, a quantitative study could be conducted among women in the engineering profession to probe specifically about the female peer connections throughout the undergraduate experience. The results of this national study could be followed up with several smaller case studies at a cross sampling of institutions (community colleges, liberal arts pre-engineering programs, female institutions and research institution) to provide a more in-depth exploration of the issue.

Another interesting aspect for further consideration is the importance of race compared to gender in engineering and how women of color are socialized into the profession. During the in-depth interviews, a woman of color mentioned that she felt that she was treated differently by her peers, but she equated it to her skin color not her gender. The qualitative methodology utilized in this study could be used to explore how the specific challenges and supports identified, by this predominantly white sample, are perceived and experienced by women of color. The results might provide insight into how diversity in engineering, in addition to gender, impacts the discipline.

This study focused exclusively on women in engineering and their experiences. The women admitted that the challenges they faced were common to all students, males included. Future research should be conducted to generate an understanding of how men perceive their undergraduate experience as socialization into the profession.

Finally, this study could be replicated at other types of institutions to get a clear picture of how women best succeed. In 1969, Purdue University launched the first Women in Engineering Program (WEP) in the country designed to combat attrition of women in their engineering programs. During the first ten years of this program, retention rates improved and today, more young women have earned engineering degrees from Purdue University than from any other institution of higher education in the country (Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development, 2000). Conducting a qualitative case study at Purdue would allow for a comprehensive identification of all the factors contributing to the success of these women. Research could also be conducted across pre-engineering programs at community colleges. These institutions are feeder schools to many research institutions and a clearer understanding of how prepared to succeed these women feel prior to transfer would add to the research base of the early years in an engineering program. In addition, studying the success of women enrolled in more recently created engineering programs at women's colleges would provide a comparison of supports and challenges of an integrated experience. Finally, research should be conducted about curriculum, faculty, support systems, retention rates and professional success to identify differences between co-educational and single sex programs.

Conclusion

The significant and unique contribution of this research is derived from the depth and eloquence of the stories of the female students who participated in this study. The experiences and voices of this particular group of remarkable young women provide a powerful window that reveals new insights about what a woman needs to succeed in engineering. Some of the more significant implications for future consideration include:

First, this research provides an in-depth, qualitative exploration focused exclusively on women in engineering. Over the past few decades, millions of dollars have been invested to combat the shortage of women in engineering undergraduate programs. To date, very little improvement has been achieved. More importantly, although many factors have been determined to perhaps influence the under representation of women in engineering, a clear understanding of why this phenomenon continues has not yet been established.

One potential reason for the continued ambiguity surrounding this topic is that very little research has been conducted that focuses exclusively on women's experiences in college engineering programs (NSF, 2002). Most of the research surrounding this topic is conducted under the umbrella of STEM (Leslie, McLure & Oaxaca, 1998; Brainard & Carlin, 1991; Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development, 2000; Clewell & Campbell, 2002) which assumes that these very different disciplines pose the same challenges to women. This study provided an in-depth, qualitative approach which specifically targeted women enrolled in engineering programs and, generated a comprehensive understanding, from their perspective, about what women really need to succeed. The data

As discussed in Chapter 4, the data suggest several elements key to their success. Critical to these women were the following points:

- importance of a supportive father
- involvement in WEP and other engineering society programs
- participation in REU or internship experiences early in the academic program
- strong internal motivation, ambition and commitment
- the need to find equilibrium between challenges and supports

Secondly, this research highlights the inability of women to negotiate competition and collaboration with their female peers. The term equilibrium, introduced by the women, is central to these findings. While the most obvious source of disequilibrium occurred between academic and social demands, the findings pointed to a woman's inability to find equilibrium between collaboration and competition among women in the field as a strong component for dissatisfaction with the discipline. This finding identifies a new component of the undergraduate experience that has not been explored. Previous studies have shown and focused on the fact that women are more likely to persist in programs that foster a sense of community building among peers and faculty (Hobbs, Millett, & Minkley, 1999). In fact, the longitudinal, cross-institutional study of women in engineering programs, the first of its kind, conducted by NSF and the Alfred P. Sloan Foundation (2002) found that a sense of community allowed these women to "build networks and to feel that their presence in engineering is important to others." The findings from this study uncovered that woman find it

particularly hard to make these connections due to the inability to balance their competitive nature and work collaboratively with their female peers.

Finally, this research suggests a need for redefining the class room and lab experience. These data clearly found that previous research findings about women in engineering may no longer be the important factors affecting the success of women in engineering, particularly the notion of a chilly climate on campus. This study captured a sense of inclusiveness in the classroom and labs by faculty and male students. The perceptions documented in this research contradict findings of past literature focusing on the chilly climate and roles in the classroom and laboratories. Most came into engineering feeling they would need to work harder than their male counterparts and would experience differential treatment from professors. In all cases, the women confirmed that they did not experience differential treatment by faculty due to their gender. In fact, most cited faculty as being supportive of all students in the program. Instead, the women commented on the accessibility and fairness of all professors, both male and female. Annie wrote, "I find them [faculty] very involved with students, and very willing to meet up with you at any time, always encouraging you to go to office hours and get help."

The ultimate goal of this study was to understand what women enrolled in engineering programs need to succeed. The women in this study clearly articulated what they needed and, this study has identified key implications for practice, policy and research. We are indebted to these women for sharing their stories for our benefit; it is now our responsibility to use this knowledge to help as many women as possible achieve what they want and deserve in order to be successful in the still male-dominated world of engineering.

APPENDICES

APPENDIX A

INITIAL JOURNAL QUESTIONS

1. What were your expectations coming into the College of Engineering? How have they changed over time?

2. What are the positive aspects about being a woman in engineering? Describe the negative aspects of being a woman in engineering.

3. Did you ever contemplate leaving engineering? Why? What made you stay?

4. Describe your interactions with faculty, administration, and peers.

5. What are your plans after graduation?

APPENDIX B

GUIDING INTERVIEW QUESTIONS

- How did you become interested in engineering?
- When did you become interested?
- Did any people play a role in your interest?
- Looking back, what were your academic and social expectations coming into the college of engineering? How did they change over time?
- Tell me about a typical day in your life.
- Talk about any clubs, sports, jobs, extracurricular activities you are involved with outside of the COE.
- In your journal you mentioned "XXXXXXXX" can you elaborate on this.
- Tell me about your experiences in the classroom with faculty and peers.
- Tell me about your experiences outside of the classroom with faculty and peers.
- Talk about your expectations for your next X years.
- Tell me what you do for fun.

APPENDIX C

MODERATOR OUTLINE

Welcome and introductions (10 minutes)

Purpose of the group (5 minutes)

- hear their experiences and stories
- one person talks at a time for tape/transcription
- speak loudly and clearly

Define what success means to them (15 minutes)

What factors contribute to this success (20 minutes)

What role does the college play in your success (15 minutes)

Clarification, review and wrap –up (10 minutes)

BIBLIOGRAPHY

AAUW. (1995). *Achieving Gender Equity in the Classroom and of the Campus: The Next Steps*. AAUW Pre-Convention Symposium, Orlando FL. Washington, DC: AAUW.

Adelman, C. (1998). *Women and men of the engineering path: A model for analyses of undergraduate careers* (PLLI-98-9088). Washington, DC: National Institution for Science Education.

Anonymous, (2005). Princeton, Smith College partner to increase women in engineering. *Black Issues in Higher Education*, 21 (25), 12.

Astin, A.W. (1975). *Preventing Students from Dropping Out*. San Francisco: Jossey-Bass.

Astin, A. W. (1984). Student involvement: A developmental theory for higher education. *Journal of College Student Personnel*, 25, 297-308.

Astin, A. W. (1996) Involvement in learning revisited: Lessons we have learned. *Journal of College Student Development*, 37 (2), 123-134.

Atkin, A., Green, R., and McLaughlin, L. (2002). Patching the leaky pipeline: Keeping first-year college women interested in science. *Journal of College Science Teaching*, 32 (2), 102-108.

Ayalon, H. (2003). Women and men go to university: Mathematical background and gender differences in choice of field in higher education. *Sex Roles*, 50, (5/6), 277-290.

Bandura, A. (1986). Social Foundations of Though and Action: A Social Cognitive Theory. Englewood Cliffs, New Jersey: Prentice-Hall.

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

Bean, J. (1980). Dropouts and turnover: The synthesis and test of a causal model of student attrition. *Research in Higher Education*, 12, 155-187.

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

Belenky, M., Clinchy, B., Goldberger, N., Tarule, J. (1997). *Women's way of knowing: The development of self, voice, and mind* (10th Anniversary Edition). New York: BasicBooks, Inc.

Berger, J. and Braxton, J. (1998). Revising Tinto's interactionalist theory of student departure through theory elaboration: Examining the role of organizational attributes in the persistence process. *Research in Higher Education*, 39 (2), 103-119.

Berger, J. and Lyon, S. (2005). Past to present: A historical look at retention. In A. Seidman (ed), *College Student Retention: Formula for Student Success*, Praeger Publishers, In print.

Berger, J. and Milem, J. (1999). The role of student involvement and perceptions of integration in a causal model of student persistence. *Research in Higher Education*, 40 (6), 641-664.

Blaisdell, S. (2000). *Student's decisions to enter engineering: How men and women differ*. Paper delivered at the 2000 WEPAN National Conference.

Brainard, S. and Carlin, L. (1991). *A longitudinal study of undergraduate women in engineering and science*. Alfred P. Sloan Foundation: University of Washington.

Brainard, S., Kelley, J., and Wadsworth, E. (1993). Women in engineering programs: No longer a question of effectiveness. In C.M. Deno (ED), *Women in Engineering Conference: WEPAN Conference Proceedings*. 105-111. Washington, DC: Women in Engineering Programs Advocates Network.

Braxton, J., Sullivan, A., and Johnson, R. (1997). Appraising Tinto's theory of college student departure. In J.C. Smart (ed), *Higher Education: Handbook of Theory and Research*, 12, 107-164.

Braxton, J. (2000) ed. *Reworking the student departure puzzle*. Nashville: Vanderbilt University Press.

Braxton, J. and McClendon, S. (2002). The fostering of social integration and retention through institutional practice. *Journal of College Student Retention*, 3(1), 57-71.

Canes, B. and Rosen, H. (1995). Following in her footsteps? Women's choices of college majors and faculty gender composition. *Industrial and Labor Relations Review*, 48 (3), 486-504.

Clewell, B. and Campbell, P. (2002). Taking stock: Where we've been, where we are, where we're going. *Journal of Women and Minorities in Science and Engineering*, 8, 255-284.

Congressional Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development. (2000). *Land of plenty: Diversity as America's competitive edge in science, engineering and technology*. Retrieved on-line at www.nsf.gov/od/cawmset/report/cawmset_report.pdf.

Creswell, J.W., Clark, V.L.P., Gutmann, M.L., & Hanson, W.E. (2003). Advanced mixed methods research designs. In A. Tashakkori & C. Teddie (Eds), *Handbook of mixed methods in social and behavioral research* (pp. 209-240). Thoushand Oaks, CA: Sage.

Crombie, G., Pyke, S., Silverthourn, N., Jones, A., and Piccinin, S. (2003). Students' perceptions of their classroom participation and instructor as a function of gender and context. *The Journal of Higher Education*, 74 (1), 51-77.

Daniels, J. (1995). Organizations, conferences, publications and funding for women in engineering: A historic review. *SWE Magazine*. March/April.

Denzin, N. and Lincoln, Y. (2000). Introduction: The discipline and practice of qualitative research. In N.K. Denzin & Y.S. Lincoln (Eds), *The Handbook of Qualitative Research*, 2nd ed., 1 – 28, Thousand Oaks, CA: Sage.

Devarics, C. and Roach, R. (2000). Fortifying the federal presence in retention. *Black Issues in Higher Education*, 17.

Didion, C. (1998). Mentoring – An essential teaching tool. *Journal of College Science Teaching*, 27, 3, 173.

Drake, K., Clewell, B. and Sevo, R. (2002). Meeting the challenge: The impact of the National Science Foundation's Program for women and girls. *Journal of Women and Minorities in Science and Engineering*, 8, 285-303.

Elizabeth S. Johnson College & University (1993). College women's performance in a math-science curriculum. Online Ethics Center. Retrieved from http://onlineethics.org/div/abstracts/perfmathsci.html

Fidler, P. (1991). Relationship of freshman orientation seminars to sophomore return rates. *Journal of the Freshman Year Experience*, 3 (1), 7-38.

Fogg, P. (2005). Harvard's President wonders aloud about women in science and math. *The Chronicle of Higher Education*, 1/28/05, A12.

Freeman, C. (2004). *Trends in educational equity of girls and women: 2004* (NCES 2005016). U.S. Department of Education, National Center for Education Statistics: Washington, DC. Retrieved from http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2005016.

Gallaher, J. and Pearson, F. (2000). Women's perceptions of the climate in engineering technology programs. *Journal of Engineering Education*. 89, 3, 309-315.

Gallos, J. (1995). Gender and silence. *College Teaching*. 43(3), 101-106.

Girl Scout Research Institute (2001). *The girl difference: Short-circuiting the myth of the technophobic girl*, New York: Girl Scouts of the United States of America.

Haines, V. and Wallace, J. (2002). Exploring the association of sex and majoring in science. *Alberta Journal of Educational Research*, 48, 188.

Haines, V., Wallace, J., and Cannon, E. (2001). Exploring the gender gap in engineering: A re-specification and test of the hypothesis of cumulative advantages and disadvantages. *Journal of Engineering Education*, 90 (4) 677-685.

Hall, R. and Sandler, B. (1982). *The classroom climate: A chilly one for women?* Washington, DC: Association of American Colleges.

Hartman, H. and Hartman, M. (2003). *Empowering Female Students: SWE vs disciplinary organization participation*. Paper delivered at the 33rd ASEE/IEEE Frontiers in Education Conference: Boulder, CO.

Hewitt, N. and Seymour, E. (1991). Factors contributing to high attrition rates among science and engineering undergraduate majors. Ethnography and Assessment Bureau of Sociological Research. University of Colorado, Boulder, Colorado, 105-108. Downloaded from http://onlineethics.org/div/abstracts/persistenc.html

Heyman, G., Bryn, M., and Bhatia, S. (2002). Gender and achievement-related beliefs among engineering students. *Journal of Women and Minorities in Science and Engineering*, 8, 41-52.

Higher Education Research Institute (1995, 1996, 1997, 1998, 1999, 2000). American freshman norms. *Chronicle of Higher Education*, Student Section. Retrieved from http://chronicle.com/free/v48/i21/major.html.

Hobbs, S., Millett, L., and Minkley, A. (1999). *A case for building inclusive research communities as an integral part of science and engineering graduate education study*. IEEE: International Symposium on Technology and Society.

Huband, F. (2002). *The diversity dilemma*. ASSE Prism. Washington.

Huang, G., Nebiyu, T., Walter, E. (2000). *Entry and persistence of women and minorities in college science and engineering education* (NCES 2000601). US Department of Education, National Center for Education Statistics: Washington, DC . Retrieved from http://nces.ed.gov/pubs2000/2000601.pdf.

Hutchison, M., Follman, D., Sumpter, M., Bodner, G. Factors Influencing the Self-Efficacy Beliefs of First-Year Engineering Students. *Journal of Engineering Education*. Retrieved from http://findarticles.com/p/articles/mi_qa3886/is_200601/ai_n17170899.

Iowa State University e-Library: Special collections department archives of women in science and engineering (2005). *4000 years of women in science*. Retrieved from http://www.astr.ua.edu/4000WS/4000WS.html.

Jackson, S. (2004, February). *The perfect storm: A weather forecast*. Speech delivered at the meeting of the American Association for the Advancement of Science Annual Meeting. Seattle, WA.

Kamens, D. (1971). The college charter and college size: Effects on occupational choice and college attrition. *Sociology of Education*, 44, 270-296.

Kamens, D. (1974). Colleges and elite formation:The case of prestigious American colleges, *Sociology of Education*, 47, 354-378.

Kennedy, M. K. (1979). Generalizing fro single case studies. *Evaluation Quarterly*, 3 (4), 661-678.

Krathwohl, D. (1998). Methods of educational and social science research, 2nd edition, New York, NY: Addison Wesley Longman, Inc.

Krunkel, C. (1994). Women's needs on campus: how universities meet them. *Initiatives*, 56(2), 15-28.

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

McCarthy, R. and Berger, J. (2008). Moving beyond cultural barriers: Successful strategies of female technology education teachers, *Journal of Technology Education,* 19 (2), 65 – 79.

Milem, J. and Berger, J. (1997). A modified model of college student persistence: Exploring the relationship between Astin's theory of involvement and Tinto's theory of student departure, *Journal of College Student Development*, 38 (4), 387-400.

Muuss, R. and Porton, H., (1999). *Adolescent behavior and society*. Boston: McGraw Hill.

National Center for Education Statistics (2000). *Entry and Persistence of Women and Minorities in College Science and Engineering Education*. US Department of Education. NCES 2000-601.

National Science Board. (2002). *Science and engineering indicators – 2002*, NSB-02-1. Arlington, VA.

National Science Foundation. (1995). *NSF in a changing world: The National Science Foundation's strategic plan*, NSB-94-183. Arlington, VA.

National Science Foundation. (2000). *Women, minorities and persons with disabilities in science and engineering: 2000* (NSF 00-327). Arlington, VA.

National Science Foundation and Alfred P. Sloan Foundation (2002). *A comprehensive evaluation of women in engineering programs*. Goodman Research Group, Inc. Cambridge, MA.

Pascarella, E., Whitt, E., Edison, M., Hagedorn, L., Yeager, P., Nora, A., and Terenzini, P. (1997). Women's perceptions of a "chilly climate" and their cognitive outcomes during the first year of college. *Journal of College Student Development*, 38, 109-124.

Perry, W. (1970). *Forms of Intellectual and Ethical Development in the College Years.* New York: Holt, Rinehart & Winston.

Rask, L. and Bailey, E. (2002). Are faculty role models? Evidence from major choice in an undergraduate institution. *Journal of Economic Education*, 33 (2), 99 – 124.

Rosser, S. and O'Neil Lane, E. (2002). Key barriers for academic institutions seeking to retain female scientists and engineers: family unfriendly policies, low numbers, stereotypes and harassment. *Journal of Women and Minorities in Science and Engineering*, 8, 161-189.

Rossman, G. and Rallis, S. (2003). *Learning in the field: An introduction to qualitative research*, 2nd edition. SAGE Publications. Thousands Oaks: California.

Rudolph, F. (1990). *The American college and university: A history*. The University of Georgia Press. London.

Ryan, M. and David, B. (2003). Gender differences in ways of knowing: The context dependence of the attitudes toward thinking and learning survey. *Sex Roles*, 49 (11/12), 693-699.

Sandler, B. and Hall, R. (1986). *The Campus Climate Revisited: Chilly for Women Faculty, Administrators and Graduate Students*. Washington, DC: Project on the Status of Education of Women, Association of American Colleges.

Sandler, B. (1988). The chilly climate for women on campus. *USA Today*, 117, 50-54.

Schneider, A. (2000). Female scientists turn their backs on jobs at research universities. *The Chronicle of Higher Education*, August 18, A12 – 14.

Schnell, C. and Doetkott, C. (2003). The first-year seminar as a means of improving college graduation rates. *Journal of the First-Year Experience & Students in Transition*, 15 (1), 53-75.

Schnell, C. and Doetkott, C. (2003). First year seminars produce long-term impact. *Journal of College Student Retention*, 4 (4), 377-391.

Seymour, E. (1992). The problem iceberg in science, mathematics, and engineering education: Student explanations for high attrition rates. *Journal of College Science Teaching*, 230-238.

Solnick, S. (1995). Changes in women's majors from entrance to graduation at women's and coeducational colleges. *Industrial and Labor Relations Review*, 48(3), 505.

Spady, W. (1970). Dropouts from higher education: an interdisciplinary review and synthesis. *Interchange*, 1, 64-85.

Starke, M. Harth, M. and Sirianni, F. (2001) Retention, bonding and academic achievement: Success of a first-year seminar. *Journal of the First-Year Experience and Students in Transition*, 13 (2), 7-35.

Stassen, M. (2003). Student outcomes: The impact of varying living-learning community models. *Research in Higher Education*, 44 (5), 581-613.

Summerskill, J. (1962). Dropouts from college. In N. Sanford (ed), *The American College*. New York: Wiley.

Terenzini, P., and Pascarella, E. (1977). Voluntary freshman attrition and patterns of social and academic integration in a university: A test of a conceptual model. *Research in Higher Education*, 6 (1), 25-43.

Terenzini, P., and Pascarella, E. (1980). Toward the validation of Tinto's model of college student attrition: A review of recent studies. *Research in Higher Education*, 12 (3), 271-282.

Tierney, W. and Rhoads, R. (1993). Enhancing promotion, tenure and beyond: Faculty socialization as a cultural Process. *ASHE-ERIC Higher Education Reports*, 6.

Tietjen, J. (2004). Why so few women, still? IEEE Spectrum, 11/29. Downloaded from www.spectrum.iee.org/careers/careerstemplate.jsp?ArticleId=n100104.

Tinto, V. (1975). Dropout from higher education: A theoretical synthesis of recent research. *Review of Educational Research*, 45, 89-125.

Tinto, V. (1993). *Leaving college: Rethinking the causes and cures of student attrition* (2nd ed). Chicago: University of Chicago Press.

Tinto, V. (1998). Colleges as communities: Taking research on student persistence seriously. *The Review of Higher Education*, 21(2), 167-177.

Tinto, V. (2002). *Establishing conditions for student success*. Speech delivered at the 11th Annual Conference of the European Access Network. Italy.

Tinto, V. and Goodsell, A. (1994). Freshman interest groups and the first year experience: constructing student communities in a large university. *Journal of the Freshman Year Experience*, 6(1), 7-27.

Tinto, V., Love, A. and Russo, P. (1994). *Building Learning Communities for New College Students: A Summary of Research Findings of the Collaborative Learning Project*. National Center for Postsecondary Teaching, Learning and Assessment, University Park, PA.

Title IX Statute (1972). Document downloaded on-line from www.usdoj.gov/crt/cor/coord/**title**ixstat.htm

Tobias, S. (1990). They're not dumb. They're different. *Change*. 22 (4).

Tonso, K. (1996). The impact of cultural norms on women. *Journal of Engineering Education*. 85 (3), 217-225.

Turner, S. and Bowen, W. (1999). Choice of major: The changing (unchanging) gender gap. *Industrial and Labor Relations Review*, 52(2), 289-309.

U.S. Department of Education (2008). Harnessing Innovation to Support Student Success: Using Technology to Personalize Education. Documented downloaded on-line from http://www.ed.gov/about/offices/list/os/technology/reports/roundtable.html.

Van Maanen, J. and Schein, E. (1979). Toward a theory of organizational socialization. In B.M. Staw (Ed), Research in organizational behavior, 1, 209-264. Greenwich, CT: JAI Press.

Wadsworth, E., LeBold, W., and Daniels, J. (1992). *Directions in and connections between enrollments, degrees and activities*. U. S. Woman Engineer, 11, 13-18.

Washburn, M. (2004). Is your classroom woman-friendly?: Ten strategies for reaching this goal. *College Teaching*, 52 (4), 156-158.

Waterman, A.S., and Waterman, C.K. (1972). Relationship between freshman ego identity status and subsequent academic behavior: a test of predictive validity of Marcia's categorization system for identity status. *Developmental Psychology*, 6, 179.

Whitt, E., Edison, M., Pascarella, E., Nora, A. and Terenzini, P. (1999). Women's perceptions of a "chilly climate" and cognitive outcomes in college: Additional evidence. *Journal of College Student Development*, 40 (2), 163-177.

Yupin, B., Choy, S., Geddes, C., Sable, J., and Snyder, T. (2000). *Trends in educational equity of girls and women* (NCES 2000030). U.S. Department of Education, National Center for Education Statistics: Washington, DC. Retrieved from http://nces.ed.gov/pubs2000/2000030.pdf.

Zuga, K. (1999). Addressing women's ways of knowing to improve the technology education environment for all students. *Journal of Technology Education*