

MOTIVATIONAL AND ADAPTATIONAL FACTORS OF SUCCESSFUL WOMEN
ENGINEERS

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ABSTRACT

It is no surprise that there is a shortage of women engineers. The reasons for the shortage have been researched and discussed in myriad papers, and suggestions for improvement continue to evolve. However, there are few studies that have specifically identified the positive aspects that attract women to engineering and keep them actively engaged in the field.

This paper examines how women engineers view their education, their work, and their motivation to remain in the field. A qualitative research design was used to understand the motivation and adaptability factors women use to support their decision to major in engineering and stay in the engineering profession. Women engineers were interviewed using broad questions about motivation and adaptability. Interviews were transcribed and coded, looking for common threads of factors that suggest not only why women engineers persist in the field, but also how they thrive. Findings focus on the experiences, insights, and meaning of women interviewed. A grounded theory approach was used to describe the success factors found in practicing women engineers.

The study found categories of attraction to the field, learning environment, motivation and adaptability. Sub-categories of motivation are intrinsic motivational factors such as the desire to make a difference, as well as extrinsic factors such as having an income that allows the kind of lifestyle that supports the family. Women engineers are comfortable with and enjoy working with male peers and when barriers arise, women learn to adapt in the male dominated field. Adaptability was indicated in areas of gender, culture, and communication. Women found strength in the ability to ‘read’ their clients, and provide insight to their teams.

Sufficient knowledge from the field advances theory and offers strategies to programs for administrators and faculty of schools of engineering as well as engineering firms, who have

interest in recruitment, and retention of female students. Future research includes expanding the research to other areas of the United States, and improving engineering education pedagogy with more active and experiential learning.

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DEDICATION

This dissertation is dedicated to my mom, Edith Bornsen, my most influential teacher.

TABLE OF CONTENTS

ABSTRACT	iii
ACKNOWLEDGMENTS	v
DEDICATION	vi
LIST OF FIGURES	xii
CHAPTER I. INTRODUCTION.....	1
Background and Statement of the Problem	2
Significance of the Problem.....	4
Rationale for the Study	4
Purpose Statement.....	6
Research Questions.....	6
Definition of Terms.....	7
Delimitations of the Study	8
Organization of Remaining Chapters.....	8
CHAPTER II. METHODOLOGY.....	10
Introduction.....	10
Research Journey	10
Directing	11
Launching	18
Sensing.....	18
Exploring.....	19
Reflection.....	20
Evaluation	20

Polishing	20
Condensation.....	20
Qualitative Research Design and Grounded Theory	21
Sampling	21
Data Collection	22
Subject Portraits	26
Coding Procedures	27
Open coding.....	27
Axial coding.....	28
Selective coding.....	28
CHAPTER III. DESCRIPTION OF PARTICIPANTS	32
Portraits	32
Allie.....	32
Brenda.....	33
Cindy.....	34
Donna	35
Edith.....	37
Fern	38
Gwen	40
Hannah	41
Isabella	42
Jean	44
Katrina.....	45

Lynne	46
Monica	47
Nadine.....	49
Olivia.....	50
Payton	52
Rae	52
Sheri	53
Summary.....	54
CHAPTER IV. CATEGORIES AND SUPPORTING EVIDENCE.....	55
Data Analysis Process.....	55
Open Coding	55
Concepts.....	56
Axial Coding.....	57
Pattern Statements.....	58
Categories.	59
Attraction to the field.	59
Learning environment.	60
Motivation.....	62
Adaptability.....	62
Selective Coding	64
Core Category	64
Attraction to the field.	66
Learning environment.....	67

Motivation.....	68
Adaptability.....	69
Relationships to Core Category.	71
Research Questions.....	72
CHAPTER V. DISCUSSION OF LITERATURE IN REFERENCE TO CATEGORIES, AND SUMMARY	74
History of Women in Engineering.....	74
Attraction to the Field.....	77
Strong Background in Math and Science.....	77
Attributes.....	77
Professional Skills.....	78
Learning Environment for Women Engineering Students.....	79
College Major Interest Tests.....	81
Gender Stereotyping	82
Retention of Women Engineers	84
Adaptability Factors for Women Engineers	88
Gender.....	88
Culture.....	89
Communication.....	90
Motivational Factors for Women Engineers.....	92
Intrinsic	92
Extrinsic	93
Workplace Strategies for Women Engineers.....	93

Success in the field.....	94
CHAPTER VI. CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH.....	96
Conclusions.....	96
Limitations	98
Future Research	98
Personal Reflections.....	100
REFERENCES	102
APPENDIX A.....	118
APPENDIX B	120
APPENDIX C	122
APPENDIX D.....	124

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1. The research journey.....	11
2. Grounded theory coding components	29
3. Web of support: concepts constructed around the core category of support	65

CHAPTER I. INTRODUCTION

There is a growing shortage of engineers in the United States and in the world. As the demand for engineers continues to grow, the number of students who plan to major in engineering continues to drop (The National Science Foundation, 2007). Rather than keeping American students engaged in math-related fields, America is relying on international students who have come to the United States to advance in these fields. Many of these engineers, rather than returning to their country of origin, remained to thrive as experts in their fields (Jacobs & Simpkins, 2005; Noeth, Cruse, & Harmston, 2003). Nowhere is the shortage of American-born, American-trained engineers more acute than with women engineers.

Although females and males now have similar achievement in math and science in high school (Hyde & Mertz, 2009; Viadero, 2009), only 12% of engineers are female (Hemami & van der Muelen, 2010). Once women are in the field, 25% leave, as compared to 10% of males (Fouad, 2010). There are two plausible explanations for this shortage: 1) The field is failing to attract women, and 2) The engineering discipline is failing to keep the women it does attract. The confluence of these two factors has been referred to as the “leaky pipeline.”

The concept of a “leaky pipeline” is well supported in the fields of science, technology, engineering, and mathematics (Blickenstaff, 2005; Cabrera, 2009; Cauble, Christy, & Lima, 2000; Chesler, Barabino, Bhatia, & Richards-Kortum, 2010; Durant, 2004). According to Jacobs and Simpkins (2005), results in researching the leaky pipeline have changed very little in the past 25 years. The National Science Foundation (2007) or NSF, notes that female engineering enrollment in undergraduate programs has declined steadily since 1999. It is difficult to recruit young women as well as to retain them in the profession (Rosser & Lane, 2002).

Steele, James, and Barnett (2002) found that women who are in male-dominated fields are more likely to experience discrimination and negative stereotyping than their counterparts in female-dominated areas. Townley (2010) contended that, even though there are empirical problems, there are practical reasons to enroll more women in the sciences and engineering, such as to increase females' wages to better compete with male colleagues and to increase the number of scientists and engineers.

The difficulties women face in male-dominated fields, such as engineering, are well established in myriad studies (see, for example, Dececchi, Timperon, & Dececchi, 1998; Faulkner, 2007; Heilman, 2001; Hersh, 2000; Logel, Walton, Spencer, Iserman, von Hippel, & Bell, 2009). Research on the paucity of women in engineering has been conducted from a purely theoretical approach in a number of fields, including women's studies, gender, feminism, and social psychology (Betz & Hackett, 1981; Callister, Minnotte, & Sullivan, 2009; Prochaska, Mauriello, Sherman, Harlow, Silver, & Trubatch, 2006). However, there is little research to link theory to practice (Preston, 1994).

According to Kuhn (1970), hard science (including engineering) is based on the concept of continual examination and improvement. Most theory and practice will, over time, be replaced by better theory and practice causing what Kuhn calls, a paradigm shift. Indeed, this is the way that disciplines advance (Enger, 2008). A greater understanding of successful women engineers and their personal experiences would help to construct the underpinning for theory grounded in practice and advance the discipline.

Background and Statement of the Problem

Early research by Maccoby and Jacklin (1974) erroneously declared boys superior to girls in visual-analytic spatial ability, a claim which was later refuted by other research. Hyde (1981)

reported gender differences were small (1-5%), not “well-established” as reported by Maccoby and Jacklin. Unfortunately, stereotyping was already established by the time additional, more stringent studies were conducted. From that point forward, girls were often, and still are being discouraged from careers in math or science.

In many ways, any woman who sought to enter male-dominated professions—which included most of the professions different from nursing or teaching prior to the social changes in America beginning in the 1960s—was a pioneer. It is well established that women entering these professions were treated with hostility and discrimination, and it is part of United States social history (Kohlstedt, 2004).

Evidence supporting hostilities faced by women in the sciences was supported by then-current medical theory (Tuchman, 2004) that women were disinclined to professions such as engineering, mathematics, and medicine (Bix, 2004). Women were seen as intellectually incapable to enter them. There was slow progress in opening up the Science, Technology, Engineering, and Mathematics (STEM) fields to women throughout the 20th century (National Science Foundation, Division of Science Resources Statistics, 2007).

Through the suffrage movement, women began to agitate for genuine social change. Their cause was aided, albeit briefly, by World War II and the lack of men in the factories on the home front (Bix, 2004). The social upheaval of the 1960s, abetted by the first real bias-neutral gender studies of the 1970s and 1980s (Scott, 1986), began to challenge previously held views of women in STEM fields and to open opportunities for the women interested in engineering (Bix, 2004; Kohlstedt, 2004). Medicine has successfully addressed the lack of women in their profession. At many medical schools, the male-to-female ratio of accepted applicants is now

50:50 (Carnes, Morrissey, & Geller, 2008). Yet at the same time, women continue to comprise only 12% of the engineering field (Hemami & van der Muelen, 2010).

Although social psychology and gender theorists have studied and published potential reasons for the inequities of the male-to-female ratio of engineers (Eccles, Wigfield, Harold, & Blumenfeld, 1993; Faulkner, 2007; Jorgenson, 2002; Logel, Walton, Spencer, Iserman, von Hippel, & Bell, 2009; Miller, 2004; Powell, Bagilhole, & Dainty, 2009), the question still remains: What factors attract and retain successful women engineers?

Significance of the Problem

Because equal numbers of female and male high school seniors named calculus as the highest level of mathematics achieved (College Board, 2008), young women have the knowledge and ability to bring about change in the low percentages of women entering engineering programs. According to the American Society for Engineering Education (ASEE), women have an opportunity to bridge the gender gap. By its failure to attract and keep qualified women, the engineering field is leaving a large pool of its intellectual and creative capital untapped (Tsui, 2010). In order for the United States to remain as one of the top in the world in STEM fields (Chubin, May, & Babco, 2005), expansion in the number of women engineers is crucial.

Rationale for the Study

Although the theoretical reasons for the low number of women in engineering have been well established, the identification of how women succeed in the field of engineering is not as clear. As societal attitudes toward women in the workforce continue to change, how women adapt in the engineering profession is as important as how they are treated.

If the low number of women interested in engineering continues unabated, the number of female engineers will stagnate and decline (Leetaru, 2010). With only 12% of the United States

engineering field consisting of women, too many bright women will choose other professions. According to Lipinski (2009), Chair of the Subcommittee on Research and Science Education, from the United States House of Representatives Committee on Science and Technology, more needs to be done to encourage women to enter the engineering field. The entrance of more women into engineering careers will strengthen the workforce of the United States, and help to retain a lead in the global economy.

As more engineering programs continue to vie for the best and brightest high school students, colleges and universities are working to increase their retention programs to include social and motivational programs integrated into their academic programs (Lotkowski, Robbins, & Noeth, 2004). Student affairs professionals work closely with academic affairs to develop pertinent programs intended for specific professional programs, such as engineering learning communities (Coll & Eames, 2008; Fox, Sonnert, & Nikiforova, 2009). The creation of faculty role models and the development of ethical and professional behaviors are found to be important educational goals for faculty in education, engineering, and nursing programs (Nadelson, Nadelson, & Osguthorpe, 2009).

This study will be of interest to engineering faculty members who are looking for program conditions necessary to increase and retain women engineering students. Engineering firms will also be interested in this study to better understand what support systems need to be in place to retain women engineers as well as to build the support systems necessary for professional development. The construction of theory grounded in practice is a necessary component of this research.

Motivation and adaptability factors that attract and retain women in engineering programs and careers will be examined in this study. Interviews of professional women

engineers will be conducted and coded, and the factors that encourage women engineers to persist in the field will be established. Grounded theory will be used to design a model of persistence to help attract and retain females in the profession.

Although there is research that offers reasons for the paucity of women engineers, (Atkin, Green, & McLaughlin, 2002; Cano, Kimmel, Koppel, & Muldrow, 2001) there is little research that addresses why successful women engineers persist and thrive in their profession. Without sufficient knowledge in the field, researchers and educators cannot advance theory and improve programs.

Purpose Statement

The purpose of this qualitative grounded theory study is to understand the motivation and adaptability factors necessary for women to persist in engineering programs and to succeed in the engineering profession.

Research Questions

Using a grounded theory approach, the study seeks to answer the following broadly stated questions:

- 1) What factors attract women to enter engineering programs?
- 2) How do women engineers perceive their learning environment in regard to successful completion of the program?
- 3) What can be done to increase the retention of women in engineering programs?
- 4) What adaptability factors encourage women to persist in the engineering field?
- 5) What motivational factors encourage women to persist in the engineering field?
- 6) What strategies do women engineers use to remain successful in their field?

Definition of Terms

In order to proceed with this study, several terms must be defined, and the rules for their use must be established.

Adaptability factors: Factors that illustrate an ability to accept and understand, to adjust to new and different environments, especially in non-traditional professions.

Code: A label used for each “concept, theme, event, or topical marker” (Rubin & Rubin, 2005, p. 207).

Designated mentor: A mentor who is selected by an outside entity, whether that be a supervisor, a computer program, or by random selection.

Engineer: One who has graduated from a four-year engineering program.

Extrinsic motivation: “doing something for an external reward” (Deci, Koestner, & Ryan, 1999).

Intrinsic motivation: “Being concerned with engaging in a task out of interest or enjoyment” (Jacobs & Simpkins, 2005, p. 18).

Leaky pipeline: The barriers found when girls and women move through their education to professional decision-making. Barriers include socio-cultural attitudes, lack of support in education, and academic appointments (Huyer, 2002).

Motivational factors: Factors that encourage individuals to make decisions about their lives.

Pipeline: “The process as students’ continued participation in mathematics, science, or engineering; achievement in those subjects; and the development of attitudes and interests that lead them to continue to pursue those subjects” (Stage & Maple, 1996, p. 24).

Self-selected mentor: A mentor who is independently selected by the individual, not necessarily based upon a mentoring program.

STEM: The areas of science, technology, engineering, and mathematics.

SWE or Society of Women Engineers: A professional group of women engineers that support and promote involvement of women in engineering. Other countries have similar organizations, such as the Women's Engineering Society (WES) in the UK (www.wes.org.uk).

Delimitations of the Study

Sample selection was done in a non-random fashion. Participants were educated or worked in the Midwest, or both. At the end of the interview, women engineers were asked if they could recommend other women who might be interested in being interviewed for this study.

As grounded theory purports, the research moves the selection of participants by the data itself. The study does not use women engineering professional groups to gather contacts for interviews. Although women engineers may be members of professional groups, it is not a requirement of the study. Also, not all types of engineers were interviewed.

Organization of Remaining Chapters

Chapter I provided an introduction to the study with a description of the problem. The chapter gives the background of the problem and significance of the study. The need for the present study is given.

Chapter II presents the research journey, the methodology, and procedures used in the study. Sampling procedures, data collection methods, and coding procedures are outlined.

Chapter III is a description of the participants and their work environment as a perspective to the reader that centers the work experiences of women engineers within the problem.

Chapter IV contains the findings of the study and the categories that evolve along with supporting evidence from the interviews.

Chapter V provides the literature review of topics related to the study's analysis of findings. The history of the profession and an exploration of the motivation and adaptation factors used by women engineers as evidenced in the categories are included. A summary of findings relating to each of the research questions is given. Findings are interpreted based on the researcher's perspective and substantiated by association with previous literature.

Chapter VI is a presentation of conclusions of the study and recommendations for future research

CHAPTER II. METHODOLOGY

Introduction

The purpose of this qualitative grounded theory study is to understand the motivation and adaptability factors necessary for women to persist in engineering programs and to succeed in the engineering profession. As an understanding of what encompasses the engineering profession for women is expanded, better tools to recruit and retain women in undergraduate programs and in the profession can be developed. With the worldwide high demand for engineers, the role of women in engineering has the ability to mold the future.

Through a rich description of motivation and adaptability facets, a system of support may aid the development of strategic undergraduate programs supportive of women in engineering. To best describe the success factors found in practicing women engineers, a qualitative research design using grounded theory was employed. In this section, the selection process will be discussed, and the participants will be described.

Research Journey

This study began in the spring semester of 2010. I used the eight stages of a grounded theory by Tan (2009) including her diagram (Figure 1) to describe the course of action. The research process was “a “zigzag” process—out to the field to gather information, analyze the data, back to the field to gather more information, analyze the data, and so forth” (Creswell, 1998, p. 57) and used the following steps: 1) Directing; 2) Launching; 3) Sensing; 4) Exploring; 5) Reflecting; 6) Evaluating; 7) Polishing; and 8) Condensing.

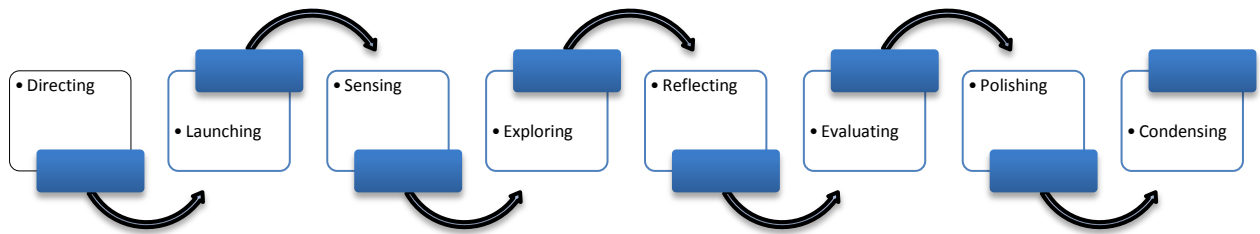


Figure 1. The research journey.

Directing

Directing is an intentional way to view problems to assess whether or not a study of the problem will foster change, and what the consequences are if the problem is not addressed. The biggest question is “Who cares?” After two months of a broad review of literature and history of women in engineering, the study began to focus on investigating what influences women to enter the engineering field, and what influences them to stay in the field; in essence, how do women become and stay successful as engineers?

I have a vested interest in seeing women advance in the field of engineering for various reasons. One of the reasons is a sense of pride. As a woman, I am proud of the work that has been done in the past by women who stood alone in fields dominated by men. The paths of these women were difficult and necessary to clear a passageway for those of us who followed. If those women had not taken an active role in making change happen, our country and world would be much different, and women would not be as visible. Advances in math and science would have come about in a much slower fashion, if at all.

Another reason for advancing women in engineering is to create important jobs for

capable women who might otherwise attend college in areas that do not develop their full potential, strictly because they are not aware of the rewards of engineering. Young women who achieve high scores in math and science aptitude testing are less likely to enter engineering programs and need support and encouragement from family and friends to strive for high goals. Areas such as medicine and law have made strident steps to open doors for bright young women, and have been successful in increasing the number of women in their fields.

My interest in this research was based on personal experience. My high school interests survey showed I shared a high level of interests with engineers. Although I did not pursue engineering, I graduated with an undergraduate degree in Mathematics from North Dakota State University (NDSU) in the mid-1990s. This research was precipitated by my past research experiences as well. According to Strauss and Corbin (1998), “The touchstone of one’s own experience might be a more valuable indicator of a potentially successful research endeavor than another more abstract source” (p. 38).

During my undergraduate studies I was the only woman or one of two women in my upper level math classes. As I entered the classroom of each class, I wondered if I had made a terrible mistake. Many of my classes were in the engineering and pharmacy buildings, two of which still had urinals in the women’s restrooms. It was obvious that originally, there were no women’s restrooms, as there was no need for them: there were no women in engineering and pharmacy. As women eventually began to enroll in those programs, men’s restrooms were converted, clearly with little effort, by changing the sign on the door. My thoughts included, “There must be women here, but they are transparent.”

Initially, as a woman in classes with mostly men, I was not invited to join study groups within the coursework. I found that I needed to invite myself to join, by asking when and where

they were meeting to study. I found that once they discovered I was good at math, they were more inclined to let me know when and where they were meeting to study. I had always gotten along well with ‘the guys’ in my high school classes and at work, so they did not intimidate me. Competition was fair and I enjoyed the friendships I made.

I had a mentor through the McNair Scholars Program, who was a professor in the math department. The choice to have a male mentor was not exactly a choice, as there were no women professors in the math department. Although there were two lecturers who were women, the structure of the program did not allow for lecturers to be mentors. Within the math department, I always felt supported and respected as a woman, although a bit of an anomaly. NDSU had very few women professors across campus at that time, and still struggles with recruitment, equity, and promotion of women (Wilson, 2007).

After I completed my Master’s degree at NDSU, I accepted a position as a director of a federal grant program on campus. I experienced lack of support as a woman, even though I had the knowledge and experience. For example, when I told my supervisor I was going to pursue my Ph. D., he said, “Now I’m going to have to go back to school and it is your fault. No woman that works for me is going to have more education than I do.” However, rather than detour me from completing my degree, those sorts of statements made me more determined to finish. As a side-note, my supervisor did not finish his terminal degree.

My research experiences in graduate school included a study conducting focus groups on a college campus (Burnett, Mattern, Herakova, Kahl, Tobola, & Bornsen, 2009). I have also been a participant in focus groups so have experience from both sides of the research. I learned about the importance of using a pilot study to refine the interview questions, the valuable skills to connect with the interviewees, the steps involved in the coding process, and the process of

analysis and connection of data to theory.

An additional research study involved interviews (Ostrom-Blonigen, Bornsen, Larson-Casselton & Erickson, 2010). Interviews were used to expand research through rich descriptions of phenomena important to the lives of participants. Through these descriptions, research was better able to view personal experiences more clearly, and build upon personal actions and reactions to create themes (Rubin & Rubin, 2005). Themes or categories were then used to assist in constructing a process of assessment to build better programs.

Research using case studies is an additional way to view a phenomenon (Yin, 2009). My experience in using a case study included research to examine the case of the market health of a drug company caught in a web of deception (Plowman, Ostrom-Blonigen & Bornsen, 2008). Although the drug company was overpricing a popular drug, its market value continued to grow. A better understanding of how and why the company thrived was discovered through the process of researching a case study.

Through these varied qualitative experiences, I grew to better appreciate and understand the value of rich, in-depth interviews and qualitative research. For this study, I examined qualitative research methods and considered how best to collect data, from whom, and what research methods would offer the best results.

Because of my prior experiences as an undergraduate in the hard sciences and my practice with qualitative methods, I pondered the idea of why women persist in the engineering field, and why so few women enter the program. After consultation with my advisor, I directed my thoughts to a qualitative study using grounded theory. According to Strauss and Corbin (1998), grounded theory requires a researcher who has experience in conducting interviews and who also has a connection to the phenomenon.

Focus groups were considered as a way to collect data, however, many women engineers are the only woman in their department and/or company. The isolation would make it difficult to find groups of women at one company. It could be feasible in larger companies, however, the isolated woman engineer in a small company has a story to tell and needs the platform in which to tell it.

A case study would be difficult to conduct because of the lack of connection to any specific woman engineer or engineering company. An ethnography study was also considered, however, participant observation would be difficult to arrange, given there were no connections to specific engineering companies and no connections to women engineers.

Although any of the qualitative methods could have been used to study women engineers, it was the process of generating theory that was closest to capturing the essence of how and why some women are successful as engineers. Because of the issues listed above, and the desire to explain the thoughts of successful women engineers, especially those who are happy at their work, it was decided that an inductive qualitative method would best fit the scope of the research problem. Additionally, an opportunity to take part in the North Dakota State University (NDSU) ADVANCE FORWARD program sponsored by the National Science Foundation (NSF), HRD-0811239 was made available to me through my graduate program advisor, Dr. Kathy Enger, a female faculty member who invited me to participate in the fourth and last phase of the research project.

The main goal of the NSF grant was to design a model that would benefit programs that encourage women to enter and remain in the engineering field. There were four phases to the project. The first phase was an interview of an undergraduate woman who was majoring in engineering. The interview included inquiry about motivating factors that encouraged her to go

into engineering (Saraswathiamma, Enger, & Stammen, 2008).

The second phase was a qualitative study that examined interviews from an on-line engineering website (EngineerGirl.org). The website is dedicated to increasing the awareness of the engineering profession to young girls. Women engineering students as well as women engineers posted their answers to interview questions on the website. Questions included what their interests were in various engineering fields. They also explained what it is like to be a woman engineer, the type of work they do, the challenges, and the best parts about being a woman engineer. The interviews found on-line were coded for motivational factors enlisted by young women who enroll in engineering undergraduate programs and adaptability measures they use in college as well as while they are working in the field.

Measures found in phase two were then used to construct a survey in phase three. The survey was posted on the websites of various women's engineering groups, selected from the Institute for Women in Trades, Technology and Science through their website, womentechworld.org. After a certain length of time, data were tabulated and statistical tests were applied. Phases two and three were the work of Saraswathiamma's dissertation (2010).

The motivation of young girls to enroll in an engineering program found from the study included factors that were suggested by participants and those reported by participants. Discovery, problem solving, and aptitude test scores are examples of motivations that were reported by participants. Family, mentors, and teachers also motivated these young women to enroll in a male-dominated career. Participants also offered advice to other young women who might view the website, which included demands of hard work, persistence, and confidence. Motivational factors were then matched with the Three-dimensional Learning Model by Illeris (2002), which included motivations based on cognitive, emotional and environmental factors.

Suggestions were made to use these factors to build a conceptual framework to suggest ways to increase enrollment of women in engineering programs.

The last phase of the grant was in-depth interviews of successful women engineers and their reasons for persistence and success in engineering which is the basis for this research. Previous research (Saraswathiamma, 2010) found factors that cause females to persist in engineering included interest in mathematics and science, problem solving skills, mentoring, and the desire to help others.

This research differs from earlier research in at least three ways. First, I conducted face-to-face interviews with women who were happy with their careers and were willing to share their experiences. All participants had graduated from an engineering program and worked as an engineer for at least five years. Whereas Saraswathiamma described motivational factors of women entering engineering programs, this study went beyond the initial phase of education to conduct an in-depth examination of the working lives of experienced women engineers. Second, women were enlisted through knowing other women engineers, not through women engineering groups. And third, in-depth interviews allowed women to respond in their own words, giving them a voice not scripted by static interview questions or survey answers.

With my experience in conducting interviews, focus groups, and case studies, and my personal connection to the phenomenon, grounded theory was chosen as the method of research. There are differences in designs of grounded theory, (see Strauss and Corbin, 1998; Glaser, 1992; and Charmaz, 2006), however, the design of Strauss and Corbin was chosen because of its systematic design that is often used in educational research (Creswell, 2005).

In the next three months gaps in the literature were defined and decisions were made on how best to proceed. I would conduct in-depth interviews to collect the data necessary to

describe women engineers and their courses of success. Through conversations with experienced researchers, grounded theory was chosen because it is a research approach that delves into concepts and categories of the phenomenon being studied. Phenomenological research includes bracketing or setting aside any preconceived ideas (Giorgi, 1997) and is not necessary in grounded theory. Rather than trying to exclude all bias, grounded theory brings forth a theme that encompasses the experiences of the participants as well as the researcher, using preconceived ideas not as a blockage, but with increased sensitivity by the researcher (Strauss & Corbin, 1998).

Launching

To launch the next phase of the research journey, research questions were developed along with interview questions to help define the study. Permission from the Institutional Review Board (IRB) at North Dakota State University was obtained (Appendix A) and a pilot study was done to solidify the interview questions. Potential participants were contacted and were asked to read and sign an informed consent form (see Appendix B). Participants were given the opportunity to withdraw from the interview process at any time. Five interviews were conducted as part of a pilot study. Interview questions were then reviewed to ensure that answers given by participants addressed areas of interest from the research questions.

Sensing

Sensing was used by the researcher after the pilot interviews were conducted. With the experience and guidance of experienced researchers, the interview questions were expanded to better grasp the common threads of what it is like to be a woman in a man's world. It was decided to include the phrase "As a woman," to appropriate interview questions. For example, a question asked in the initial interviews was, "What factors attracted you to enter your

engineering program?” After the pilot interviews, the question was changed to “As a woman, what factors attracted you to enter your engineering program?” A total of 13 additional interviews were done and transcribed.

As women shared their stories, more questions arose to the researcher. The grounded theory research process gave the researcher the freedom to wonder if the new found ideas were true for women who graduated from engineering programs in one particular area of the United States, or were they unique to a working environment? One of the questions asked at the end of the interview is if the participant would be willing to ask other women engineers if they would be willing to be interviewed. I could then target areas of interest derived from the transcripts of previous interviews.

As more interviews were conducted, the researcher and someone who is knowledgeable in the IRB process completed transcription. The transcripts were read word for word, sentence by sentence, phrase by phrase, to initiate the open coding process. The process of coding is not linear, but rather, a circuitous route of back and forth information-seeking, where I constantly asked myself to make sense of the stories. Sensing was used throughout the process to search for the design of categories.

Exploring

Six months into the research study, the exploring process evolved. As more interviews were done and transcribed, and coding was conducted, I was able to begin the process again and again, each time garnering rich descriptions of what categories were important to the success of women engineers. When categories began to be repetitious, a general sense of saturation was reached and additional interviews were no longer necessary. Categories were selected based on information gleaned from the transcriptions to generate theory grounded in data.

Reflection

The process of reflection continued through the next three months. As categories became more apparent, their linkage came forward as well. With a total of 18 interviews, the transcripts were once again read with a holistic view. Categories were checked against each other to check for overlap. Because categories can be condensed, linked, or even rejected at this point, the researcher searched for events that lead to the issue, and also looked for any change that occurred.

Evaluation

The study was then evaluated to make sure that the study was valid and reliable. The seven criteria suggested by Strauss and Corbin (1998) were used to establish credibility. These criteria include sample selection, emergent categories, events pointing toward categories, guidance of data collection, formulation of categories, discrepancy explanation, and selection of a core category.

Polishing

Data were read and reread to check properties and linkages. A spreadsheet was used to aid in the thought process with much thought given to placement of categories and subcategories. Also, a blank wall with removable tags was used and different arrangements were used to verify matching of categories, subcategories, and possible connections. The central category was verified from various angles to search for discrepancies. Finally, categories and data were again examined to assure that saturation had been reached. Data were refined to assure that codes and categories were accurately chosen.

Condensation

The condensing of categories into a single category was the final phase and included the

integration of the central category into a theory that is grounded in the data. Theory was then connected to current literature and future research.

Qualitative Research Design and Grounded Theory

A qualitative research design was used because of the need for rich, in-depth descriptions about how and why some women are persistent and succeed as engineering students and professionals. Other methods of research could be used, such as observation to describe how engineers behave at work, or a survey used to correlate sex with job satisfaction (Geertz, 1973). Interviews could have been conducted, asking what it is like to be a woman engineer. To best get at the center of the problem, interviews with participants immersed in the field are the method of choice. Qualitative research has become a preferable method when issues need to be explored in depth with great detail. Rather than examining current theory, a grounded-theory approach was used to best integrate categories “grounded” in real-world data (Gall, Borg, & Gall, 1996).

According to Strauss and Corbin (1998), grounded theory is an inductive method of research where theory emerges from data drawn from the area of study. Because grounded theories are pulled from data without the use of literature, they are likely to offer “insight, enhance understanding, and provide a meaningful guide to action” (p. 12). Rubin and Rubin (2005) maintain that grounded theory is about theory building rather than theory testing and is “less focused on finding the limitations of a study or the extent to which the results can be generalized” (p. 241).

This chapter will consist of four progressive activities: 1) Sampling, 2) Data Collection, 3) Subject Portraits, and 4) Coding Procedures.

Sampling

Purposeful and theoretical sampling methods were chosen for this study using sampling

strategies by Miles and Huberman (1994). Purposeful, non-random sampling was chosen for the interviews, where, according to Creswell (2005), participants are chosen based upon their understanding of a fundamental phenomenon (p. 204). A smaller sample is appropriate, not only because the universe is smaller, but also because “social processes have a logic and a coherence that random sampling can reduce to uninterpretable sawdust” (Miles & Huberman, 1994, p. 27). Samples evolve from initially choosing participants with similar experiences to choosing participants with much different experiences to better envision the phenomenon. This choice of participants is integral to grounded theory and, according to Miles and Huberman, is concerned with “the *conditions* under which the construct or theory operates, not with the generalization of the findings to other settings” (p. 29, emphasis in original).

Theoretical sampling, also non-random, was used to better understand the tenets of a particular category brought forth from data through interviews with successful women engineers. Choice of participants was driven by conceptual questions, not by a concern for “representativeness” as described by Miles and Huberman (1994, p. 29). The conditions under which women live and operate within the field will help to define the constructs of theory through findings of similar and repetitive experiences.

Data Collection

Data were collected from one- to two-hour semi-structured interviews of women engineers who have worked in the field for at least five years. Institutional Review Board (IRB) approval was obtained prior to the collection of data (See Appendix A).

Women engineers were solicited to participate by inquiry through engineering firms and networking with women engineers. Contacts were asked if they knew of any other women engineers who might be interested in participating in the research project. Once the participant

expressed interest, the study was explained by the researcher, and acceptance was acquired by signatures of the woman engineer and the researcher on the IRB form letter (See Appendix B).

General demographic questions were asked: Where do you currently work? How long have you been working as an engineer? Initial demographic questions also help to establish a comfortable rapport. Data were collected and analyzed until saturation was achieved. Saturation occurs when no new information can be found (Creswell, 1998).

Six open-ended questions were covered during the one-on-one interviews as time and concentration on career goals become more evident. Women were given a copy of the IRB form letter (see Appendix B) and given time to read it. IRB protocol was followed, any questions were addressed, and signatures were collected. A copy of the letter was also given to each woman. If Skype was used, the forms were emailed and/or faxed. Three interviews were conducted using Skype. An explanation was also given for the format of the interview, where questions would be asked about their college experiences and also their experiences at work (see Appendix C).

After demographic questions were answered, the interview quite naturally moved into the first question, “What motivated you to enter the field of engineering?” This question gave women a chance to think about why they chose engineering as their major in college. Personal description of women’s attraction to the field of engineering paints a vivid picture of what is important to them as they enter college. It falls into place with the first research question, “What factors attract women to enter engineering programs?”

Questions about entering an engineering program also placed women in the framework of their college education and led into the second interview question, “As a woman, what challenges did you face as a student?” As women discussed their challenges, they discussed their favorite and least favorite classes and instructors in college, and what was important to them to

complete the program. These questions were important to gain information about college for the second research question, “How do women engineers perceive their learning environment in regard to successful completion of the program?”

After naming challenges and opportunities from college experiences, the next interview question was asked, “How did you adapt to those challenges?” With a natural progression of questions about why engineering was important to them, what obstacles stood in their way in college, and how they dealt with them, the following research question emerged, “What adaptability factors encourage women to persist in the engineering field?”

When challenges were addressed, and the process of problem-solving was communicated, a question about satisfaction was asked, “What did you find satisfying in your studies? And, “What motivated you to finish?” Discussion of ratios of men to women in their first year classes compared to their graduation classes, as well as college satisfaction spawned interest in what can be done to increase retention of women in engineering programs, another research question.

Conversation then flowed into similar questions about work. Questions included their thoughts beyond college and extended into work experiences, their motivation, challenges, and adaptability on the job. These questions flowed directly into an additional research question, “What motivational factors encourage women to persist in the engineering field?”

Discussion of work paired with the initial questions about “What motivated you to become an engineer?” led to the final questions of “Why do you persist in the field?” and “What are your future goals or career plans?” A description of what success looks like to women engineers can point to strategies necessary to keep women in the field. Explanation of individual persistence in the field will better explain the strategies women engineers use to remain

successful in their field.

The focus of the interviews was to answer the following research questions:

- 1) What factors attract women to enter engineering programs?
- 2) How do women engineers perceive their learning environment in regard to successful completion of the program?
- 3) What can be done to increase the retention of women in engineering programs?
- 4) What adaptability factors encourage women to persist in the engineering field?
- 5) What motivational factors encourage women to persist in the engineering field?
- 6) What strategies do women engineers use to remain successful in their field?

Credibility and rapport are important aspects of interviewing each participant (Creswell, 1998; Kvale, 1996) and was established during the initial part of the interview by explaining the research and asking demographic questions. Rubin and Rubin (2005) speak of the “research relationship” where not all exact questions are asked of each participant (p. 33). Rather, the questions change as the relationship develops, and future questions form as the stories unfold. There was a sense of excitement when women explained their jobs and pride in their work. Depth of understanding is integral and demands an analysis of interviews throughout the research, not just in the final process.

Thick descriptions of phenomena experienced by women engineers were gathered through interviews. Gall et al. (1996) define thick description as “statements that re-create a situation and as much of its context as possible, accompanied by the meanings and intentions inherent in that situation” (p. 549). According to Rubin and Rubin (2005), credibility is established when interviewees “are experienced and have first-hand knowledge about the

research problem” (p. 64). To establish credibility for this study, all women engineers interviewed had at least five years of engineering experience.

The interviews were conducted in one of the following ways: 1) In person; 2) By the telephone; or 3) Through Skype, a computer application that allows face-to-face interaction using a computer. Security factors were discussed with the university information technology service, and because Skype is encrypted, no security problems were found. IRB approval was obtained, (see Appendix A) including the use of Skype.

Once the interviews were conducted, a transcriber familiar with IRB processes and the researcher transcribed them. Following the transcription, all interview videos were erased to protect the anonymity of the participants.

Subject Portraits

The women interviewed worked in the engineering profession for at least five years. A description of each participant will be given in Chapter III. Because of the narrowness of the population of women engineers, care was taken to protect the anonymity of the participants, who were dis-identified by assigning women’s names to them in random order of interviews completed. Because of the personal connections made between the researcher and the interviewees, and because they were all women, it was important to the researcher that each interviewee was assigned a random female first name, rather than a number and/or letter of the alphabet.

Because the types of engineers are very select, care is given to not mention the exact field of engineering in which the women work. For example, to say that a woman was an aeronautical engineer in the Midwest might be enough information to identify the participant. No data were collected that included the name of the participant.

Coding Procedures

To add rigor to the coding procedure, a standardized process was used according to Strauss and Corbin (1998). The following three broad steps were used, not necessarily in strict order: 1) Open coding, 2) Axial coding, and 3) Selective coding (see Chart 1 below). Open coding allowed for the design of categories; axial coding created pattern statements; and selective coding developed categories. Strauss and Corbin (1998) stress, “As concepts and relationships emerge from data through qualitative analysis, the researcher can use that information to decide where and how to go about gathering additional data that will further evolution of the theory” (p. 33).

Open coding.

As interviews were transcribed, open coding was conducted. Once the open coding process was initiated, the entire transcription was read and reread to help identify broad phenomena of interest. This “line-by-line” coding was used to begin to recognize themes or categories as they emerge from the data, without the use of literature. As the researcher read each line, thoughts and meanings were brought forth from the participants’ own words and codified into single-word or small-phrase codes (Rubin & Rubin, 2005).

The researcher was given the freedom to explore concepts to suggest how phenomena are related. Once completed, the document was studied line-by-line, phrase-by-phrase, and word-by-word, with intention to add dimension to meaning. Concepts were named, and similar ideas or objects were grouped together under a common thread. These concepts were then grouped together into categories and subcategories that explained and predicted outcomes. Categories are general properties, where subcategories “specify a category further by denoting information such as when, where, why, and how a phenomenon is likely to occur” (Strauss & Corbin, 1998, p.

119). Some codes may not fit into any category and may be dropped from the context of the study (Miles & Huberman, 1994). Additional interviews were then conducted to fill in gaps.

Axial coding.

The second step, axial coding, created pattern statements from categories and subcategories. Because transcription and coding began immediately after the first interviews were conducted, axial coding took place while open coding was also being done. Categories were modified or even rejected. Relationships between categories began to form around a specified category (axis). These relationships took place on a conceptual level, relating structure with process. The researcher looked for events leading up to a problem or issue, how people respond through some sort of action, and whether change happens. Because the human element comes into play, according to Strauss and Corbin (1998), it is important for the researcher to “validate his or her interpretations through constantly comparing one piece of data to another” (p. 137). In simple terms, categories are “grounded” in data (Gall et al., 1996, p. 565).

Categories are fueled by the research questions. After categories are defined, and emerging relationships are connected, the core category emerged (see Figure 2).

Selective coding.

The final coding is selective coding which is the construction of theory. At the center of the coding is a core category that is able to pull the other categories together to form an explanatory whole. Explanations linked other categories to the core category and were able to explain variation as well. The theory was validated by comparing it to raw data or by feedback from participants involved in the study. The theory may not fit every aspect of each person’s experience, but larger ideas should relate. According to Gall et al. (1996), “even if the categories are purely descriptive, the procedures used in grounded theory are applicable” (p. 565).

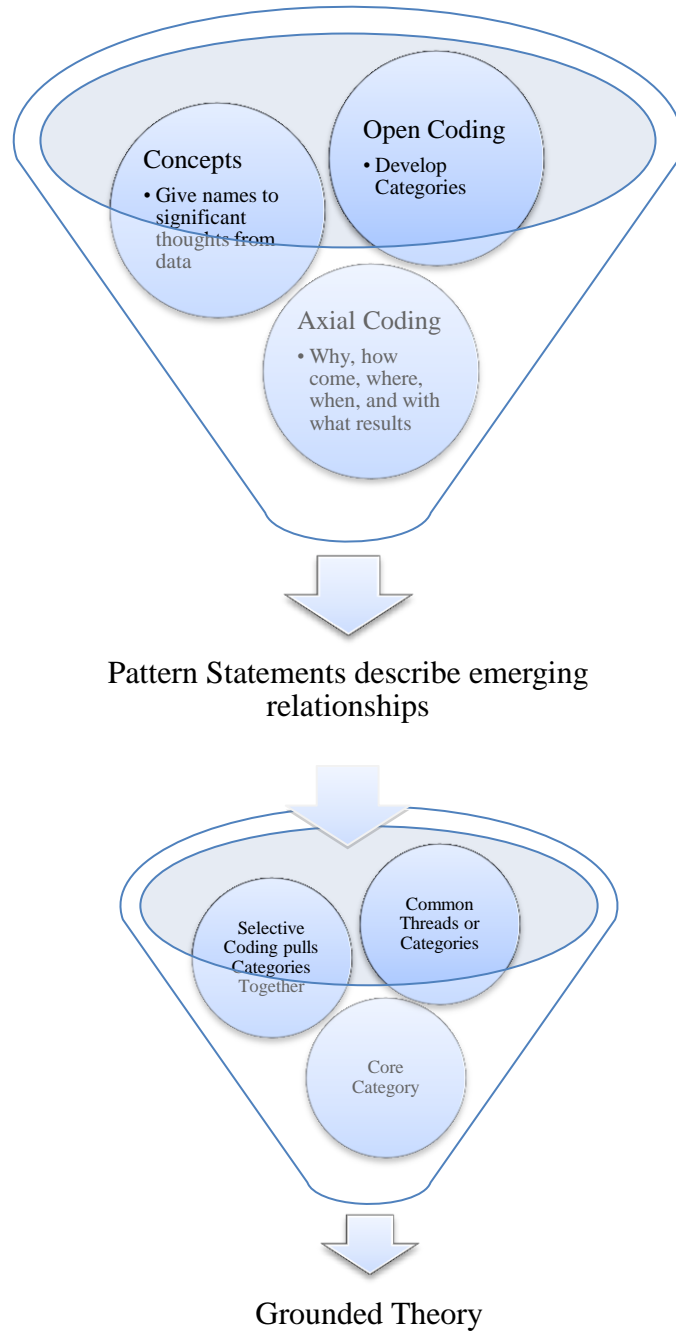


Figure 2. Grounded theory coding components.

A synopsis of the research process was conducted by answering the following questions, according to Strauss and Corbin (1998):

Criterion 1: How was the original sample selected: On what grounds?

Criterion 2: What major categories emerged?

Criterion 3: What were some of the events, incidents, or actions (indicators) that pointed to some of these major categories?

Criterion 4: On the basis of what categories did theoretical sampling proceed?[...]

Criterion 5: What were some of the hypotheses pertaining to conceptual relations (i.e., among categories), and on what grounds were they formulated and validated?

Criterion 6: Were there instances in which hypotheses did not explain what was happening in the data? How were these discrepancies accounted for? Were hypotheses modified?

Criterion 7: How and why was the core category selected? Was this collection sudden or gradual, and was it difficult or easy? On what grounds were the final analytic decisions made? (p. 269).

Another important constraint considered is the evaluation of the empirical grounding of the study. The researcher used the following criteria to evaluate the empirical grounding of a study (Strauss and Corbin, 1998): 1) Concepts generated in data; 2) Systematic concepts with strong linkage; 3) Dense categories; 4) Considerable variation of theory; 5) Broad conditions woven into analysis; 6) Identification of the process; and 7) Significance of findings.

The comparison of concepts to data offered evidence of the evolution from data to theory. Once the concepts were generated, how they are linked to each other was apparent. The linkage was woven throughout the text, rather than being listed as hypotheses, which leads to the development of the categories and subcategories.

Rather than a single description, categories had many properties that encompass the depth and breadth of the idea. With rich description, dense categories and strong linkages give theory

its descriptive power. Concepts examined from all directions, from micro to macro conditions, better explain the phenomenon. Once the process was completed, explanation of the process is important to future research.

Finally, the significance of the findings was dependent upon the insight and analytic ability of the researcher as well as the quality of the data collected. Rubin and Rubin (2005) explain qualitative research as, “*not simply learning about a topic, but also learning what is important to those being studied*” (p. 15). Theory is meaningful when it is used to better explain phenomena and produce action plans or starting points for future research.

Portraits of the women interviewed are given in Chapter III. Rich descriptions help to describe women engineers at work and also away from work. Women with families explain their additional roles of wives and mothers, as well as social roles outside of work. Chapter IV offers the coding of data from individual interviews as well as supporting evidence for the choice of categories and selection of the main theme. Findings from the interviews will be further discussed in Chapter V where interview findings meld with research findings aligned with the research questions. Conclusions and recommendations for future research are included in Chapter VI.

CHAPTER III. DESCRIPTION OF PARTICIPANTS

The number of women interviewed in this study was 18 participants, all of whom were women engineers, although one woman had recently made a career change and is no longer working as an engineer. Women were considered to be successful in their careers if they had worked at least five years as an engineer. The description of successful women engineers helps generate a theory of success factors.

Portraits

Allie

Allie went to college in the Midwest, in a graduating class of 6% women. She works in a department that has 40% women, but the norm in the company is about 20% women.

Her father is an engineer. She liked the television show *The X-Files* and found out that the characters were engineers, so that piqued her interest in the field. She liked math, art, and politics in high school. Her family was very supportive of her decision to be an engineer.

In college, she knew of two female engineering instructors. The instructors were supportive of the women students, and also encouraged women to join the Society of Women Engineers (SWE). She was active in SWE in college and is still active as a professional.

Allie would like to see engineering added to the list of careers that help people, and thinks it would be beneficial to begin the conversation in elementary school. Allie thinks it is important to talk about the importance of engineers, and what they can do to make the world a better place.

In college she said women tend to think that study groups were for people who were not as smart, so they tend to study alone. Once you prove yourself with good grades, you are more likely to join a study group.

Eventually, Allie would like to get a Ph. D. but is not sure if it will be in engineering. She would like to travel and work abroad. She has a woman mentor who is supportive and talks about goals and accomplishments.

Brenda

Brenda works in the Midwest, and went to college in the Southwest. She is not married and does not have children. She thought she wanted to be a biologist, but on a field trip she saw an electric car and realized engineers worked on them, and then decided that is what she wanted to do. She has a male cousin who is an engineer, and her sister is in computer science. She liked math and science in high school and also enjoyed it in college.

Brenda was one of two women of a class of 25 when she began her college program and she graduated as the only female in the class. The next class had two women out of 40 and the following year there were three women out of 40 students. She liked the smaller classes where everyone knew everyone else.

Her college offered a mentoring program on campus in during their first year of college. The following year she became a peer mentor and enjoyed interacting with the first year female students, and thought they benefited from having a role model, and having someone who was there to answer questions.

Brenda is not active in SWE, but has attended some of their events. She thinks it is beneficial to network with other women. There is a structured mentoring program at work, offering both men and women as mentors. Brenda's designated mentor is a male, however, she has a self-selected peer mentor to whom she goes for advice, who is a woman.

There are about 10% women engineers where Brenda works and she has friends who are engineers, both men and women. She enjoys working with the "Introduce a Girl to Engineering"

program. Brenda prefers working with men because she likes competition. She likes engineering and thinks of it as a way to help people. She is considering going back to school to get her Master's degree in engineering.

Cindy

Cindy has a cousin who is an engineer and her uncle mentioned becoming an engineer because she was good at math. She really did not know what engineers did, but thought she would look into it. She went to college in the Midwest. Her husband is also an engineer, and she cannot imagine what it would be like to not have that in common with your spouse.

She had a really great math teacher in high school who really challenged her. She realizes that she needs to be challenged in her work as well. She was the only woman in a graduating class of 25, and currently at work she is the only woman out of 50 people.

Cindy is married and has two children. She would encourage them to be engineers and thinks it is a great job. She met her husband in college and he was a great support system to her. She had a hard time asking for clarification in class, and felt like she should have been studying harder, that it would be more likely to come to her if she just studied hard enough. She had male friends in study groups that answered her questions. It not only helped with studying, but also helped with social aspects.

She avoided women's groups in college. She did not want to call attention to herself as a woman. She feels differently now, and enjoys some of the women's groups at work. She thinks it is important to include everyone.

Cindy believes promotions are given evenly at work, and it is mostly based on performance. She has seen women move up the ranks quickly but does not want that for herself. She has a lot of overtime at work but, because her husband is also an engineer, she feels he is

more supportive of her long hours. When she has long days she continues to push herself to just keep pushing.

Professionalism is an area where Cindy feels she could have used some help in school. She has noticed that professional dress is more important in other areas of the country. She thinks networking is important and likes to keep in contact with people she has met.

Donna

Donna went to college in the Midwest and works in the Midwest. She is married to an engineer and they have two children. She always liked math and science in high school and decided to try engineering. She was the only woman in her engineering classes in a class of 20, and the ratio of men to women in her math classes was 10:3. However, in the upper level math classes she was, once again, the only woman. Donna did a lot of internships while she was in college, which helped her build her confidence and see what engineering really entailed.

The ratio of men to women where Donna works is 12:1 out of about 120 employees. She classified herself as a tomboy as a child, and she found it easy to get along with the guys. Initially, Donna found she had to work to prove herself as an engineer, particularly on the work-site. She loves her work and thinks more women should look at engineering as a career.

In college, Donna was not active in SWE, although in retrospect, she wishes she would have done more things to network with other women engineers. She did not particularly enjoy the group projects in college; she would rather have done them alone and not rely on others to get the job done. However, in the work force, she realizes the importance of learning how to work together to solve a problem. She uses a lot of technology at work and does a lot of travel for work.

Daycare has not been an issue for her because she and her husband chose to live close to family knowing that they would need occasional overnight childcare. Because her husband is also an engineer, he understands that he needs to take over all parental duties when she is out of town. Sometimes it is difficult to juggle schedules, but having a supportive husband is critical to making her job and family work together.

Donna had some uncomfortable experiences adjusting to engineering as a woman. Her first day on the job, someone asked her if she was the secretary. She understands that the culture needs to change. She has worked to become more confident in who she is as a woman and who she is as an engineer. She thinks writing and communication skills are very important, and young women should start developing those skills even earlier than is currently being done.

She has worked with high school-aged girls in job shadowing. She encourages them to be diligent in their writing and communication classes, as well as the maths and sciences. She explained that they need to be prepared to do difficult things, how to problem-solve, and to not be intimidated just because it is hard.

Donna was not involved with SWE in college because the engineering program was small and did not have an active SWE chapter. She also is not involved now, however, she has attended sessions, and thought they were helpful. She said she enjoys meeting women in her field and networking with them. She initially thought SWE was a 'girlie' organization, but, after learning more about the society, has changed her mind. As for herself, she started her career being conservative in her mannerisms and dress. She is careful to not portray a sex object or a party girl image. She is now more confident in who she is and is willing to stand up for herself and her convictions.

Edith

Edith grew up on a lake and was a tomboy. She always enjoyed doing things boys did more than what her girlfriends did. The Exxon Valdese oil spill occurred when she was 10 years old, and she remembers being very upset seeing the pictures on television. She was crying and emotional, and said she was going to grow up and make sure that those sorts of things did not happen again.

Edith does not have any engineers in the family however, her parents were very supportive of her going to college. Her parents did not say, “If you go to college,” but rather, “When you go to college.” That was not the case with some of her friends and she was the person who encouraged them to go to college. Her parents impressed upon her how important it is to be able to support yourself and your family.

Edith explained how important it is to be able to communicate with the public. She works with pollutants and people ask her if they are going to die because they have been exposed to them. She realizes the importance of her work each time she inspects work sites, and knows she is helping improve the world, if but very slowly.

Edith thinks her college experience would have been better if she would have gotten more help in the harder math and science courses. A class on safety would have given her more of an idea on how to separate state and federal rules. Occupational Safety and Health Administration (OSHA) training would have been beneficial as well, and would have made her more marketable. She suggests that students be required to belong to a national organization, and be active in it as well. Internships are valuable to gain work experience. Edith was not active in SWE in college, she was not aware of any activities on her campus.

Edith was laid off from a previous job because of a personality conflict with her supervisor. She has a new engineering job, but is also working out the emotional upset of losing a job and wants to figure out if she needs to do things differently to be successful.

Fern

Fern went to college on the west coast. Although Fern was good at math, there were areas where she struggled. She became friends with a male student who graduated at the top of the class, and he studied with her on some of the difficult parts of coursework.

As a child, Fern was very good at math and science. She has a grandfather, some uncles, and one aunt who were engineers. She was interested in architecture as well, but decided engineering would give her an opportunity to be involved in environmental issues.

She does not know how many students were in her graduating class, but knows that hundreds of students dropped out of the program each year. The ratio of men to women was about 3:1.

She worked as an engineer for seven years in a high poverty area that felt like she was in a third world country. She was very impressed with the program and felt that she was improving the lives of indigenous people in that area. She spent much of her time working in the office and not as much time out in the field. She felt she was overlooked for advancement because she was a woman. However, the people of the communities appreciated her soft approach and told her, "You are not a stiff shirt." Fern felt she could better relate to their problems because as a woman, she was more likely to be soft-spoken. That was not the case when she was in the office. She was given projects that no one else wanted to do.

Toward the end of her seven years, she realized she would not be recognized as one who would move up the ladder in the company, so she knew she had to leave. She did not want to spend all of her time at a desk. She decided to go back to school in the medical field.

Internships were available at her college, but students were not encouraged to take advantage of them. She had a poor experience with her only internship, as the company wanted a secretary, not an engineer. She feels she would have benefited from a better structured internship experience, to give her a better idea of what actually happens on the job. She also thinks that having more of a focus on the liberal arts would have expanded her knowledge of the world and how it works. She said engineering has such a narrow focus. She is not sure that every engineer would feel the same way.

When Fern started her job, the company assigned her a mentor, but he was not helpful. She was later assigned to someone else, and was able to build a relationship with that person. Within her medical profession, she is a firm believer in having a mentoring program both in the college and at work, and said that she benefited greatly from them.

Her ethics class in college focused on monetary issues and bribery but did not expound on issues of environment and community. She hopes that people are becoming more conscious about environmental issues and feels that other ethical issues should be covered in that class.

Fern knows that if she decided to go back to engineering, she would be a better engineer, because she has learned a lot in the medical field. She is much more creative now, and feels she has a better fit in her current field. She said she is constantly weighing the cost versus the benefit and how that will impact the person. She would like to see more of that way of thinking in engineering, and feels that would attract and keep more women in the field. She believes that to be able to be a better professional, you have to be pushed out of your comfort zone.

Gwen

Gwen went to college in the Midwest, and only two of the 25 students in her graduating class were women. That surprised her because there were a lot more young women in her advanced math classes in high school and she expected college would be like that too. Gwen thinks it would be beneficial for young women to know they do not have to be perfect to make it in school in an engineering program.

Both of Gwen's grandfathers were engineers. As a young girl, she was very interested in how things worked. When she was in middle school, her parents sent her to engineering camps. Because good grades were no issue to Gwen in high school, she had quite an adjustment to make when she got to college. She found that she had to study, and do more than just homework. It was difficult for her to ask for help and it took her the entire freshman year to get used to the idea. She learned to ask the teacher's assistants (TAs) and joined study groups. She joined a science group and thinks mentors are a great idea.

When Gwen was in college she participated in a few activities with SWE, but they were not well attended. She was more active in groups specific to her field of engineering. Gwen learned what classes to take, and who were the best professors from upper-classmates, and thinks having them as mentors would be helpful to women in college.

At her first job Gwen was the first woman engineer to be hired by the company, and was the only woman in the company. She worked there for four years. The ratio where she is currently working is two women to 60 men. She said people are often surprised that she is the engineer. She has received comments that she must be the girlfriend of the engineer.

Most of Gwen's friends are guys and she is comfortable with that. She said she has gotten used to being the only woman in the room and it does not bother her. She is working on a

graduate degree and her company is paying a certain amount of her tuition, which encourages her to continue.

Gwen really enjoys working with people and wants to continue in that role. She is very goal oriented, but still needs to find time in a day to meet with people. She feels her job is a great fit, and wants to continue with the company.

Hannah

Hannah went to college in the Midwest, and was surprised to find out that college was very different from high school. She did not have to study in high school, and it was an adjustment to go to college and find out she needed to study. She thought it was an embarrassment to need a tutor or join a study group. She would ask “the guys” in the class when they were going to study, and asked if she could join them. They were ambivalent to have her join the group, but changed their minds after they found that she was really good at math. She was then accepted into the group, and was able to study with them as a peer.

Hannah always liked math and science in high school. Her interests test in high school said she should check into engineering and she thought she would give it a try. She was not sure what engineers did, but since it included a lot of math and science she thought it would be interesting. She does not have any engineers in her family, but she is married to an engineer.

Hannah would like to go back to college to get a master’s degree, and one of the reasons she took a job with her company is because they offered to pay for part of her tuition. Her supervisor told her it was not worth anything to get a master’s degree, so if she chooses to do this, she will need to be careful what she says to him.

Hannah would like to have a family in the future and would like to move closer to her family in order to have their help with daycare. She realizes that having a better paying job like

engineering gives her the freedom to either find work close to family or move her family closer to her. Because her husband is also an engineer, there might be times when they would both be traveling for work, and having family close will eliminate daycare issues.

Her boss insists that “the women” in the office go shopping to buy gifts from him for his wife. Each time a holiday or occasion approaches, he seeks out one of the women in the office. He gives her an expense account and asks that she buy a gift that he will give to his wife. He insists that as women, they need to do the gift-buying.

Hannah feels that she needs to prove herself to her boss, maybe not because she is a woman, but because she does not have an advanced degree or is a newer employee. She thinks that having an advanced degree will help her advance in the company.

Isabella

Isabella had two great-uncles who were engineers; otherwise, no one in the immediate family had an influence in her decision to become an engineer. Most of her friends in high school were boys, and she liked taking things apart and putting them back together, so she knew she wanted to do some kind of engineering.

Her undergraduate degree was done in the Midwest. There were 16 men to 1 woman in her class. She was the only woman in most of her classes. It did not bother her because she has always gotten along better with guys.

Internships were important to Isabella, and enabled her to travel abroad, and also in other parts of the country. She would like to travel abroad again in the future. Internships also allowed her the freedom to experience different kinds of work and see what was of most interest to her.

Isabella believes that internships are valuable, and she chose various internships in very different situations to get a better idea of what engineering encompassed. She also worked in

different sized companies, from 100 employees to over 100,000 worldwide. It was a way for her to get an idea of what actual engineers do as opposed to the theories that are taught in school.

She currently works in the Midwest and the ratio of men to women is around 30:1. It is definitely a male-dominated world. She likes working in the shop, and does not mind getting greasy and dirty.

The Southwest was of particular interest to Isabella. She is an outdoor enthusiast and because most of her friends are also engineers, she was likely to spend time with them, both inside and outside of work. She would like to work in that area of the country again someday.

Curiosity is what motivates Isabella. There are many different roles to play in the engineering world. She most enjoys testing as she does not mind going out on the floor and getting dirty. She is curious to see what machines can handle by putting them to their max and then designing something that makes them stronger. It is something different every day, and there are sometimes things that surprise you. She explains, "It is a puzzle that you've got to put back together in order to figure out what happened and that keeps me motivated."

Travel, both here and abroad, is definitely something Isabella would like to do in the future. She enjoys working directly with the product, but also enjoys working with people.

Involvement in elementary, middle, and high schools to encourage more girls to go into engineering is a suggestion from Isabella. As a child, she liked playing with Lego's and building stuff and taking it apart again. She would like to see more encouragement given to young girls and for them to see it is appropriate for girls to enjoy it. She has volunteered in her community, and sees the benefits to these girls. She thinks that if girls were encouraged at a younger age, they would be more likely to look at engineering as a viable profession.

Professional women's groups were available in college but Isabella was too busy to take part in any activities. She belongs to a professional group, but it is not specific to women. She enjoys working with people, and enjoys the time outside of work as well.

She would like to see more women in the field of engineering, and she thinks that getting young girls interested in the field at any earlier age is a good place to start. She thinks women enjoy the field as much as men do, and it is important to not be intimidated by working with men.

Jean

Jean's father is an engineer and always encouraged her to push herself and have long-term goals. She is very competitive and likes doing hard things. She went to college in the Southeast and works in the Midwest. Her husband works for the same company but is not an engineer.

The ratio of men to women at work is 10:1 and that was about the same in college. The college she attended did not have a mentoring program, nor does the company where she works. She was not active in SWE in college but thinks she might check into it in the future. She thinks it might be a way to network with other women in engineering and she would enjoy breaking some of the isolation.

Jean wonders if she was given poor information from her supervisor. She asked him if it would be beneficial to take graduate classes, and he told her no, it really would not help her move up in the company. She wishes she had not listened to him, that any additional education offers a step up when applying for other positions.

Even with all of the upsets of management, Jean still loves her job and enjoys seeing a project and knowing she had a part in making that happen. She feels secure in her job and thinks

that perhaps being a woman makes her job more secure. She hopes to take some specialized training that will enable her to move up the ladder.

Katrina

Katrina went to college in the Midwest and also works in the Midwest. The ratio of men to women was 100:3 in college and most of the women who excelled in math and science went to medical school or if they decided to become an engineer they were more likely to major in chemical engineering.

Katrina is married and does not have children. Her husband works for the same company but is not an engineer. She has an uncle who is an engineer. Katrina excelled in math and science in school. She was not a good reader and found that she could take her mind off reading by doing more math. As a child, she remembers taking great interest in mechanical things and she remembers helping her grandpa build things. Both of her parents were very supportive in whichever career she chose.

However, in high school her guidance counselor tried to convince her to go to a junior college just to see if she liked college. He also told her she should take pre-calculus, and she should not try calculus right away. She learned early that she needed to say no to some people and just stick up for herself.

In college she had one professor who was supportive to everyone and she had a third semester calculus professor who was great. She did not get preferential help because she was a woman. Because there were so few women in the program, she did not study with other women. She had a guy friend who helped her study.

Katrina loves her job, and would like to stay with the company. She is interested in doing additional training that will help her advance in the company. She has concern that she will never

be a manager because she sees herself as the “second-hand man.” She is the kind of worker who will buy into someone else’s vision and run with it. And she knows that administration will not promote her with that kind of attitude.

Lynne

Lynne went to college in the South. The ratio of men to women in college was 11:1. She has worked overseas and the ratio of men to women engineers was 10:1. When she came back to the United States, she worked in the South where the ratio was about six or seven men to 1 woman. She said there were more women working in computer software at that company. She currently works in the Midwest and the ratio of men to women there is 20:1. She was married to an engineer and has children.

Growing up, Lynne loved math and anything mathematical. She liked counting money, organizing, and breaking jobs into smaller pieces and felt a great accomplishment when she could put everything back together.

Lynne had no engineers in the family and she was the first person in her family to go to college. She had no idea even what an engineer did, and when she took her college entrance exam she saw it listed as a possible career so she went home and looked it up. She decided to become an engineer because those were the classes she wanted to take. Her father told her not to go to college because she would just get married and then stay home. Lynne said she was in college for 3 years before her father could remember what her major was. But her mother was always very supportive.

Although she tested out of her first two semesters of calculus and went directly into third semester calculus, Lynne’s professors were not supportive of women being in engineering. She remembers one of her college professors saying in class, “Women make bad engineers because

when they get out in the field the first time they have to do something it is like –ew-it’s got grease on it.” Those kinds of comments made her persist all the more, no one was going to stop her. She had the support of her mom and everything else came from within.

Lynne was always comfortable around guys, and she always felt like just one of the guys. She feels she can take the guff that is handed to her. There are always management problems, and priorities are always changing. She is happy with her job, but is not sure where the job will lead her. She wants to be rewarded for getting better at her job, but does not necessarily want to be promoted out of a job she loves. In the past, she did not think she would ever want to be in a management position, but as she matures in the company, she could see that happening however, she does not want her boss’s job.

Monica

Monica graduated from a college in the western part of the United States. She also has a master’s degree. About 20% of the 1000 engineering students were women, and in her particular area around 35% were women.

She thought college was harder than high school however, she thought there was a strong desire among faculty that everyone should have a good understanding of engineering principles. Because there were so few women, they supported each other and got to know each other, even across disciplines.

When Monica was in college she sometimes felt that when she went to study sessions there were students there who wanted plusses added to their “A’s.” She thought those who needed the help the most were overshadowed by those who wanted the top grades, and concepts were not explained in different ways that could have helped them.

Monica belonged to a student engineering organization, but she remembers it as more a social thing. She was one of the few students who had a car at college, so was asked to handle transportation issues. She said the meetings were not about coursework, and they did have speakers at the meetings. She currently belongs to a professional organization, and is on their governing board. She likes the networking, seminars, and professional development courses that the organization offers.

Mentoring was not available to Monica in college and she believes it would be beneficial. She also thinks a residential program where upper classmates live on the same floor as new students would be helpful. Intimidation would be reduced and encouragement that they can make a difference in the world would help to increase the number of women in engineering programs.

There were no engineers in Monica's family however, her parents were firm believers in getting a college education. She is married to an engineer and thinks smart women should marry men that are at least as smart as they are themselves. She would like to have children in the future and feels like engineering offers her flexible work arrangements to better accommodate family.

Currently in her job the ratio of men to women is 2:1. She said her degree was from a magnificent university and it was useful. Monica had a strong drive to go to college, and even though it was hard, she wanted it. It was all about preparing for a future career.

Monica has volunteered at local middle schools to encourage young women to think about engineering as a career. She thinks it is important to start encouraging girls that math and science can be fun and it is not scary.

Nadine

Nadine got her degrees in the eastern part of the United States. She also traveled overseas. In college, the ratio of men to women was about 10:4, as it was a program that encouraged women to go into engineering. She was involved in study groups in college and it was very helpful. She did not have engineers in the family, except her brother decided he wanted to be an engineer, so she thought if he could do it, she could too. She did not have mentors in college but thinks that would be a good idea to have peer mentors as well as mentors that are a level or two above.

At work, Nadine said the ratio of men to women is more than 10:1 and could be 20:1. She has designated mentors at work and seeks them out. Nadine further explained that there are regimented mentoring programs at work where the section of a mentor is done electronically through an on-line section process much like Match.com. Nadine believes that mentors are valuable in learning the ropes of the job as well as answering questions and they are a safe place to vent frustrations.

Nadine sees barriers at work, but does not let them stop her. She feels that the barriers are not gender-based, but rather, there are people who are obstacles. Nadine has found it best to find out who those people are and then stay out of their way. Another way she has gotten around barriers is to use supervisors to intervene for her and her team. She says it is crucial to have a good leader.

Professional organizations are important to Nadine, and she is active in more than one group. She suggests that young women need to take part in organizations like SWE to learn valuable interviewing skills and to be involved in networking with peers as well as leaders in the field.

Nadine envisions children being more active in math and science in elementary school and she volunteers after-hours in programs that introduce children in the area to math and science. She is a firm believer in involving children early in the STEM areas, and wants to make a difference in the community as well as the world.

Olivia

Olivia went to college in the Midwest and works in the Midwest as well. Her grandfather was an engineer. She discovered engineering when she was in high school and went to a summer camp. She thought it was a neat way to combine her interests. The ratio of men to women in college was 4:1, one of the higher ratios because it was a unique degree program. Her parents were always very supportive in whatever she chose to do.

The ratio of men to women where Olivia works is very small, maybe 50:1 or 2. A big challenge is there are no mentors and no peers to help you learn the process and find your way up the ladder.

SWE was an important part of Olivia's education and also with her professional development. It is also a great way to help other women just getting started in engineering by making friends and building networks. She found SWE to be a safe place to make mistakes, as peers were there to help and make suggestions.

Olivia had internships while she was in college and found them beneficial. She was interested in finding internships that were out of the area, so she had to find them herself. Although the process was time-consuming, Olivia was very satisfied with her experiences and suggests that all students have internships.

Study groups were a part of her education, and usually there was one other woman and three men. They studied well together and also worked on projects together. She had one college

professor who was a woman, and none of the engineering professors were women. She did not have mentors while in college, but relied on her friends to help her with questions she had.

Mentors at work are very helpful. It is very important to get feedback from peers and from people in other areas who can help with questions at work. Although her designated mentors at work are all men, she also has mentors through SWE. She relies on her SWE mentors to give her a female perspective.

Olivia is married and her husband is not an engineer, but is in a math-related job. They have children and she found it difficult to have children and also keep current with her work. She sees a lot of professional women cutting back on the number of hours they work to spend more time with the children, but that affects promotions at work. Most of the men engineers have wives who stay at home with the children.

Motivation comes from within for Olivia. She has pride in knowing that she is helping people through what she does. She gets to work on a project from the beginning to the end and she has opportunities to work on something new and exciting.

Olivia was the first woman to be hired by a company and felt she had to prove her abilities. She did not see that happen when new men were brought on board. Men would go out to lunch together and play on sports teams after work, and that camaraderie was not available for her as a woman. She had to build trust and confidence in herself and prove it to the men in the office. Once she showed that she has credible, she was treated well.

Olivia would like to see more work done in the community to encourage young girls to become engineers. She is active with SWE and volunteers with area schools. She also believes national attention needs to be directed to these programs to better educate young women as to the great benefits of becoming engineers. But it is going to take time.

Payton

Payton was educated on the east coast and also studied abroad. She has an advanced degree and is married to an engineer. She has worked as an engineer for more than ten years, and loves her work.

She loved math and science as a child and thought it would be fun to be an engineer. She had no relatives who were engineers, but were math teachers and in the medical field.

Payton has worked in companies where she was the only woman, and now works for a large company where there are many women in different capacities. Not all of these women are engineers, but because the company is large, there are more women doing different jobs.

Currently she is the only woman in her division because the only other woman transferred to a different company. Yet she had to remind her supervisor that she was the only woman. He commented that of course there were other women, and she asked him who that would be. When he could not come up with another name, he looked puzzled.

Payton would like to see women be more vocal in asking for flex-time. She believes we have lost a lot of talented women because they wanted to work part-time to spend more time with their family, and were not allowed to do that. Payton says they do not consider flex-time work because they think it is not an option.

Rae

Rae is not married however, her boyfriend is an engineer. She was always interested in how things worked, and liked to take things apart and put them back together. She liked math and science in school, but did not want to be a teacher.

Rae had a great math teacher in high school that encouraged her to look into engineering. She attended a summer program developed by women engineers and supported by an area

engineering company. She was very goal-oriented, and always got along well with ‘the guys’ at her school.

Rae attended college in the Midwest and also works in the Midwest. She is not sure of the ratio of men to women at work, but says it is probably 10:1.

It is important for Rae to have a job where she knows she is making a difference in the world. She feels pride in seeing a product that she knows she has been a part of, and thinks engineering is a great job, and she has fun at work. Her social group outside of work are the same people with whom she works. She says sometimes it can get sticky if wives or girlfriends get jealous.

Sheri

Sheri was a first generation college student, and attended college as an older than average student. She considered herself a tomboy growing up, and was good at math. She was interested in engineering and thought she could help improve the world in some way by being an engineer. She went to college in the Midwest and the ratio of men to women was 15 to 1. She enjoyed her engineering classes, but felt outnumbered at times.

She worked in the Midwest and was transferred into safety and environmental engineering. She did not have a good experience with her company and was let go. She saw patterns of previous safety personnel who, after years of learning the ropes of the company, suggested changes to improve safety. Shortly after the changes were suggested, they were fired and the company started over with a new hire. She felt this was a tactic used by the company to fend off federal regulators, and has decided to make changes in her career path. She no longer works as an engineer.

Summary

This chapter presented portraits of the women engineers interviewed to provide a rich description of their education experiences as well as their work environments. A discussion of the relationship between this data and current literature will be found in the following chapter.

CHAPTER IV. CATEGORIES AND SUPPORTING EVIDENCE

The purpose of this qualitative grounded theory study is to understand the motivation and adaptability factors necessary for women to persist in engineering programs and to succeed in the engineering profession. The factors that attract women to engineering are explored and described, as well as factors used by women engineers to describe their motivation and adaptation in their work. Discussion also centered on a description of their undergraduate experiences. The categories were developed from carefully coded transcripts of interviews. This chapter begins with a data analysis process.

Data Analysis Process

After careful readings and re-readings of the transcripts, coding was initiated. Because of the nature of grounded theory, transcripts of the initial four interviews were coded and reviewed as additional interviews were conducted. This zig zag effect of gathering information and analyzing the data evolved as information was gleaned from the thoughts and ideas of the women interviewed. Data were examined by studying transcripts line-by-line, word-by-word, phrase-by-phrase, and whole sentence analysis and assigned to groups of thought. According to Strauss and Corbin (1998), individual specifics are less important than the relevance of the topics at hand. Open and axial coding were completed with theoretical comparisons viewing how to best identify variations in patterns.

Open Coding

Open coding is the process of opening up data to uncover beliefs and feelings. Similarities and differences are noted to help develop a concept or “labeled phenomenon,” described by Strauss and Corbin (1998) as “an abstract representation of an event, object, or action/interaction that a researcher identifies as being significant in the data” (p. 103). Concepts

are discovered and named, thus giving voice to feelings and thoughts from participants in the field. Similar events are grouped together under a common concept.

As transcripts were read and reread, segments were underlined and notes were made in the right-hand margins listing ideas such as ‘on the job’, ‘early age’ or ‘work with others’. After combing through the notes many times, a grid was constructed in Microsoft Excel. Broad concepts were listed across the top row and related concepts were listed in the columns below (See Appendix D). The use of the computer grid simplified the many arrangements and rearrangements of concepts and sub-concepts. As an example, motivations were listed as a concept. As open coding progressed, questions such as “From where did the motivation stem?” or “Why was this motivating to this person?” were asked to verify positioning of the concept. As the thought processes moved forward, and more examples from the transcripts emerged, intrinsic and extrinsic motivations were added as sub-concepts. The ideas were then listed in the next row of the grid under the corresponding concept. Examples of quotes from women engineers were added in the rows below the related concepts. Because each woman engineer had an assigned first name which started with a unique letter of the alphabet, and to save space and time in the coding process, only the first initial was used in the coding grid.

Concepts.

Concepts discovered included attraction to the engineering field, personal attributes, roles, knowledge, skills, respect, application, ethics, family, professional organizations, communication skills, goals, mentors, cohorts, support, fit, and personality.

Concepts found that attract women to engineering programs include strength in math and science, competition, opportunity to make the world a better place, opportunity of high wages and good benefits, attention to detail, and feeling of accomplishment. Engineering is goal

oriented, offers meaningful employment, requires problem-solving skills, and is an intellectual challenge.

Women engineers described their learning environment as a demand for excellence in math and science, independent learning, cooperative study groups, enjoyment of problem-solving, support of professors, attention to detail, sense of accomplishment, competitiveness, and goal setting. Challenges in college included isolation, and threat of masculine culture. The need for growth and experience was evident in the comments about theory versus practical application that gave rise to the importance of internships, co-ops, and job shadowing.

What motivates women engineers is sub-divided into intrinsic and extrinsic areas. Concepts that described intrinsic motivation included love of math and science, competitiveness, the desire to make the world a better place, meticulousness, the feeling of accomplishment, goal orientation, and strong drive. Concepts that described extrinsic motivation included support of family, high wages and good benefits, and opportunity to travel.

Adaptability at work included struggles with gender, and generational issues and growth in communication skills. Concepts included, “girlie-girl” versus “one-of-the-guys”, sexual advances, pecking order, race, acceptance, ethics, respect, intimidation, support, networking, derogatory comments, attitude, isolation, support, motherhood, communication, mechanical inclination, self-esteem, gender roles, and discrimination.

Axial Coding

After open coding was completed, axial coding began with theoretical comparisons viewing how to best identify variations in patterns. Categories were linked together using questions such as why or how come, where, when, and with what results.

A table-like grid (see Appendix D) was used to aid in the thought process with much thought given to placement of categories and subcategories. A blank wall with removable tags was also used to arrange and rearrange categories. Relationships developed among categories as structure met process. Common threads formed connections between categories and subcategories. Interviews continued until saturation was found. Open coded topics that were not represented sufficiently in occurrence or vigor were removed from the coding process. Pattern statements were then developed to describe the emerging relationships that formed the basis for the development of categories or theoretical statements.

Pattern Statements.

Pattern statements included thoughts such as:

Women engineers have a basic love of math and science that began at an early age;

Women engineers were involved in mentoring programs in college and/or work;

Women engineers are passionate about their work;

Women engineers had the support of at least one parent;

Women engineers want to make the world a better place;

Women engineers view additional education as a way to advance in their career;

Women engineers adapted to working in a masculine world; and

Women engineers use effective communication skills.

Pattern statements overlapped with each other. For example, having a love of math and science was an attraction to the field, and it also was a part of their learning environment. The process of using a blank wall with self-sticking notes was again used to find patterns and the best fit for sub-categories.

Categories.

Following the coding of data and review of the process, identification of categories based on axial coding was processed. When a category was identified, it was set as a title for a column in the coding table and the coding wall. Four main categories included: 1) Attraction to the field; 2) Learning environment, 3) Motivation, with subcategories of intrinsic and extrinsic motivation; and 4) Adaptability, with subcategories of gender, culture, and communication skills. Each of the categories and sub-categories are described using the voices of the women engineers in the discussion that follows.

Attraction to the field.

The major concept for attraction to the field of engineering is love of mathematics and science. The enjoyment of problem-solving was also evident. Brenda said, “Math and science were always my strong suits.” Katrina explained, “I loved math in school, I am always doing math in my head. How you break something down and bring it back up, gives me a sense of accomplishment.” Sudoku puzzles are popular among women engineers, as Rae explains, “I love Sudoku puzzles, I rip through those!”

Allie said her parents gave her confidence to pursue her dreams telling her, “You can do anything you want to do in life,” and Allie enjoyed watching a television program where the characters “Did a lot of research and there were engineers on the show. I wanted to do be able to solve problems like that.” Cindy had an uncle that mentioned she should think about engineering, and she said, “What is that?” He said, “You design stuff,” and she said, “All right, I’ll look into it. It looked interesting and I was not intimidated by the guys.”

Learning environment.

In college, it was important on a personal level, to feel comfortable working and studying with men. Gwen also commented, “Most of my friends were guys.” Jean said, “I have always kind of worked better with guys,” and “I was always being one of the guys instead of being all girly with the other girls.” To learn the ropes of becoming an engineer, it is crucial to participate in co-ops and internships in college. Nadine explained, “You have to know more than engineering.” Olivia adds, “You can try out different fields and different jobs and see what you like. That is how I found out where my passion lies.”

A sense of belonging is difficult for women struggling to fit in a masculine world. Stonyer (2002) explained that women need to create their own sense of normal, by taking a stand to empower women rather than remaining quiet which marginalizes them. Rae spoke of carpooling with men from work, and commented on how she wished they would have chosen their topics of conversation more carefully. Off-color jokes were often listed as a problematic area, but women engineers did not feel they could remedy it and remained silent.

Isabella would like to see more hands-on experiences in college. She thought that the basic concepts and theory are important but, she would have liked to have had more real world applications in her classes. Isabella explained,

You can teach theory all day long and until you get out and see it in the real world, it’s not going to make sense. Or if it does make sense, it’s not easy to apply until you can see the actual components.

Isabella would also like to see classes that explain different types of engineering, “More electrical classes, a few manufacturing classes, more than just the core classes. Then if you want to specialize, then you can look at one area.”

Women engineers are aware of which male students in their college classes were arrogant and had the idea that women should not be there. For example, Fern said,

I remember especially my freshman and sophomore years there were a lot of male peers who were very arrogant and had the attitude that women shouldn't be there. That just got me livid. I just plowed ahead with my stuff.

By the time they were juniors and seniors the male students had more respect for the women students, understanding they were all in the same boat. Fern said, "Unfortunately, a lot of teachers and teaching assistants weren't as appreciative, they still had an attitude thinking women shouldn't be there."

Other woman engineers also spoke about instructors who made it clear they did not want women students in their classes. Lynne had a professor in class say, "Women make bad engineers because when they get out in the field the first time they have to do something it is like-ew-it's got grease on it." Lynne's comments continue, "And I think back, and then I didn't know what to do. Now, I would have been right in the ombudsman's office filing a complaint. If I wasn't so stubborn. I liked it, no one is going to stop me. It just made me more stubborn."

Mentors were not commonly found in the educations of women engineers. If women spoke of mentors, they were self-selected, and in most cases, were male, mostly because there were very few women engineering professors. Isabella did not have a mentor while she was in college, however, she did have a mentor at work the first 18 months on the job. She enjoyed the experience and thinks it is a good idea, as it creates camaraderie in the company. It also offers a support system to new people at work. She suggested, "Mentoring programs in college would have been a good way to learn about what was acceptable in our engineering program."

Motivation.

Motivation from within, or intrinsic motivation is a common theme among women engineers. Lynne said she had no supportive instructors in college, “Most of it had to come from within.” Cindy said, “Don’t tell me I can’t do something!” Edith explained, “I am doing something to prevent pollution, even if it is slowly.” Fern further supported intrinsic motivation with “I wanted to work for a program that had a lot of meaning.”

Extrinsic motivation is also part of the picture, as Brenda contends, “The benefits are good and you get paid a lot as an engineer. I make more money with a bachelor’s degree than my mom does with her Ph. D.” Cindy says, “We can choose to live close to our parents to babysit because we can afford it.”

Adaptability.

Adaptability is an important aspect to successful women engineers. As women experience barriers in their careers, they counteract with ways to circumvent the challenges. Women engineers gave many examples of their ability to take a less than optimum situation and make it better. Donna says, “People will remember me because I am a woman in the engineering world, so I use it to my advantage.” Situations were common in areas of gender, culture, and communication.

Gender issues could be problematic at times, as evidenced by Fern, “There were some male peers who had an attitude that women shouldn’t be there. I just plowed ahead with my stuff. A year later those same guys had a lot more respect for the women still there.” Isabella, along with many of the women engineers interviewed, “was mistaken for a secretary, but not intimidated by those comments. She noticed that with the older mechanics and engineers, she would have to prove herself before they would even give her a chance. She has also noticed that

in other areas either they accept her right away and treat her like a daughter or granddaughter, or otherwise they think, “She is just a stupid girl, she doesn’t know anything.” She respects the older men and is happy to learn from them. She has built a rapport with them that has developed into good working relationships. As Payton explained, “It is going to take more than an Engineer Barbie doll to change the way it is.”

Being part of the masculine culture at work or outside of work as “one of the guys” or “one of the boys” was a common occurrence for the women engineers in this study. There were also problems with being treated as “one of the guys.” Jean wished her college had stressed professionalism more. She felt that had she approached her first job with more professionalism, she would have been treated better, and not just as “one of the guys.” In order to be part of the team, she had to give up being a woman. Initially, she was afraid to go into the labs, where all the workers were men. She has gotten used to it, and has learned the unsaid rules. Olivia said she felt threaten to be “one of the guys,” at her first job. After she had some work experience, and moved to another company, she did not feel like she had to prove herself to be part of a team.

Isabella sees the culture at work changing somewhat, particularly in larger companies where they have less tolerance of sexist issues. She feels that you need technical knowledge and practical application to move forward as a woman. She believes women are tested more just because they think you do not know as much as a guy would to start with. But once you prove yourself, it is not bad.

Isolation was common among successful women engineers. Cindy said, “I was always one of the only women in my classes. It was never an issue.” Brenda suggests, “You have to find your niche and be the square peg in the round hole.” Fern explained, “In school I felt like I had to fend for myself.”

Hannah explained the importance of effective communication skills,” You have to be able to prove you know what you are talking about and people remember that. Men aren’t as likely to question other men.” Allie commented that men and women are more likely to communicate with the same sex, and they were not as likely to communicate with the other sex.

Selective Coding

Once axial coding is completed, selective coding followed. Once concepts were named, they were grouped together into categories. Subcategories were used to describe main categories using a thought-process of when, where, how, and why a phenomenon occurs. Four main categories included: 1) Attraction to the field; 2) Learning environment; 3) Motivation, with subcategories of intrinsic and extrinsic motivation; and 4) Adaptability, with subcategories of gender, culture, and communication skills.

Categories were fueled by the research questions and included attraction to the field of engineering, learning environment, adaptability factors, and motivation factors. After categories were defined, and emerging relationships were connected, the core category emerged. The core category pulls other identified categories together to form an explanatory whole.

Core Category

The core category identified is development of a strong web of support . The web of support is based upon the premise that support is gathered from the different areas of motivation, adaptability, environment, strategies, education, and attraction to the field. The more areas of support that are available, the more likely it is that women will stay in engineering. Whether it is parents who believed in them such as Jean, “My dad was a big influence on me, and insisted on planning for the future,” or mentors who offer advice and encouragement, support is crucial for women who work in a male environment. Women who are married to engineers are more likely

to have a partner who is respectful of time and energy spent at work. As Nadine explained, “My husband chose to stay home with the children when they were little and I was at work.” The more areas of support that are missing, or poorly represented, the more likely it is that women will remain in engineering (see Figure 3 below).

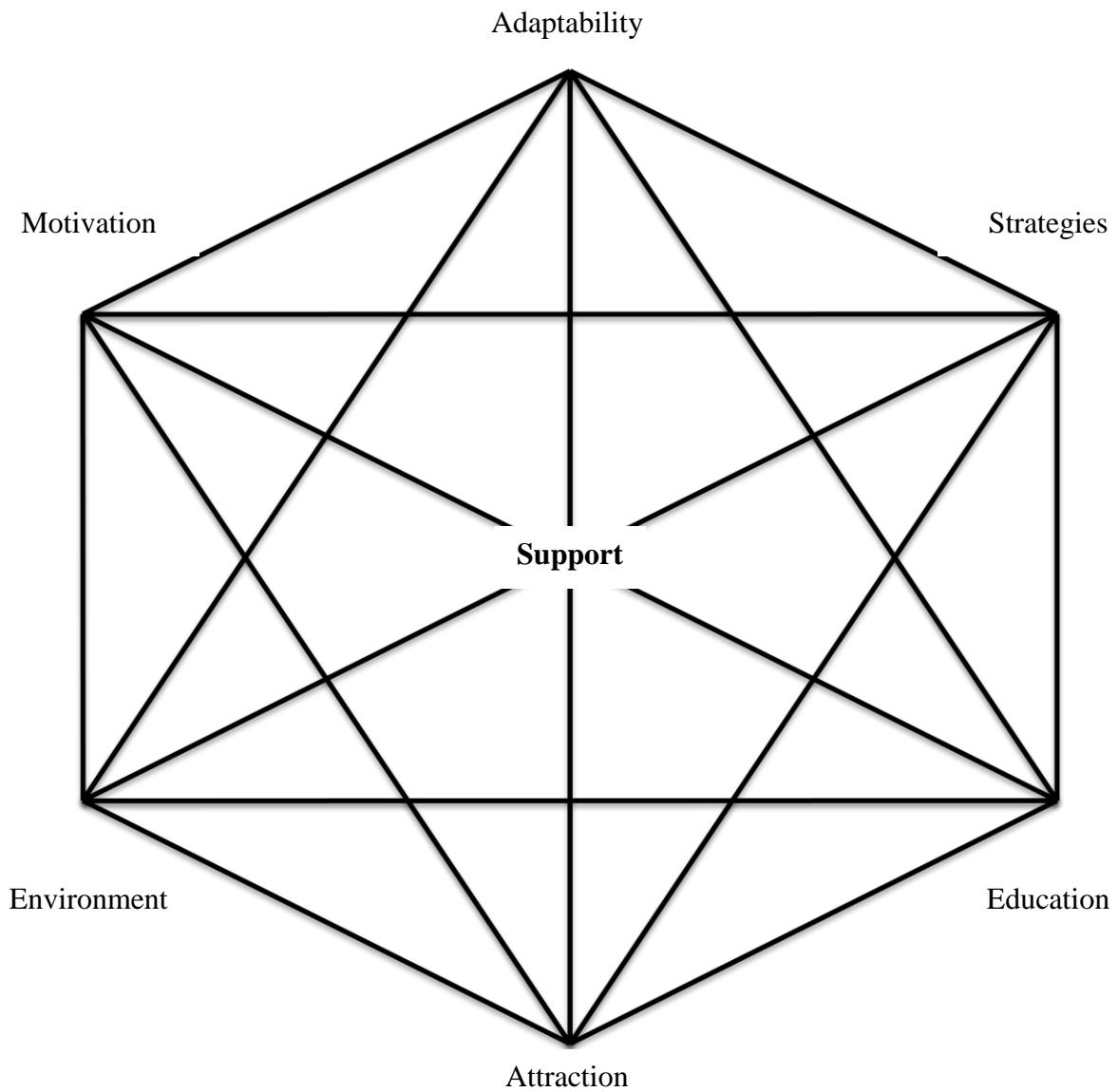


Figure 3. Web of support: concepts constructed around the core category of support.

Attraction to the field.

Attraction to the field of engineering was often described as love of math and science. Enjoyment of math and science is directly linked to the ability to problem solve. Testing in educational settings relies on the development of strong problem-solving skills, whether one is in elementary or secondary school, or in college. Lynne defined math as being able to “break a big thing down into small things. You do not solve a long equation just going at it, you solve it in pieces. I have a big problem, I solve it in pieces and then they add up.” The satisfaction felt when finding solutions to problems is supportive to the environment of both college engineering programs and at work.

When problems are encountered, women engineers were more likely to rely on their problem-solving skills to come up with creative strategies to support their positions. When confronted with challenges, women engineers were not willing to concede, but rather, would adapt to their environment by working to complete the job, even if it meant making concessions about gender.

Ability in math and science also motivated these women to go into engineering. Support from family came in the form of pride in good grades, “My uncle knew I was one of the top kids in my class and encouraged me to look at engineering” (Cindy), and engineers in the family, “My grandpa was an engineer and he encouraged me to learn how things work” (Payton).

Women engineers were also drawn to engineering because they wanted to make a difference in the world. In each area of engineering, women spoke of the pride they had when they saw their work improve the lives of others. When asked about how to attract more women to the field of engineering, Rae said, “They need to bring in the more human side of engineering to attract more women.”

Learning environment.

Learning environment also included support from the family, and in some cases, extended outward to include instructors and mentors, as illustrated by Gwen, “I had to learn in college that it was ok to not be perfect. I was in a group that helped science majors and wished I would have had someone to give me that support.” If professional groups such as Society of Women Engineers (SWE) were active on campus, women were more likely to take part. Monica explained, “I was a member of SWE and enjoyed the social networking and special projects.” Study groups were another form of support, as evidenced by Nadine, “I roomed with two women who were also in the engineering program, and it was helpful to work on homework together. I also liked the competition.”

Internships and co-ops were upheld as parts of their education that should be mandatory. “So much of college is theoretical and so much of my job is ‘on the job’. Through internships (as college students) it was easier to make mistakes and ask for forgiveness” (Olivia). Fern said, “Engineering is taught very theoretically but in practicality things happen in a really different way. They need to stress internships.” Discussion of personal learning environments led to conversation about what can be done to retain women in engineering programs.

Retention in college as well as at work relies on support systems. Support from mentors was important, and even for women who did not have positive experiences with mentors in college, they were able to find mentors either through professional women engineering groups or in their work environment. Olivia explained, “Although I did not have mentors in college, and my mentor at work is a man, I rely on my mentors in SWE to give me a female perspective.”

Motivation.

Motivation plays an important part in the decision to become an engineer, as shown in quotes such as “I want to be able to help people” (Olivia) and “I want to make the world a better place” (Allie). Both intrinsic and extrinsic forms of motivation promote the central category of a strong support system. Support most often came from parents or other close relatives, “My mom was always telling me I could do anything I chose to do” (Hannah).

The women who were interviewed were passionate about their work. A common response was “I really like my job!” or “I love my job!” The support of family is important for those who have children, and it is common for extended family to live in the area to help with daycare, especially involving overnight stays. Jackie explained, “I make good money and that allows me to have the daycare my parents can provide, as they can live near to us. We planned it that way.”

Maternity benefits are also important. Donna explained, “I was the first woman this company hired, and I got pregnant soon after I started. They didn’t have a maternity policy in place. It still was not in place when I had my second child. They have a policy now, but it is sadly funny that I never got to use it, and it was because of me that they implemented it! I guess I paved the way for other women.”

Olivia wishes she would have had more leave time after she had her children, and thinks that benefits might be better in bigger companies. While she was on leave, her boss still expected her to work from home even though she was not getting paid to work. She is much more supportive of people who take maternity leave, and makes sure that they are not working from home the way she did.

Women engineers in this research often mentioned the importance of support through education tuition coverage by their workplace companies. Continuing education may be in the form of advanced engineering degrees, certification in specialized training, leadership training, or a master's degree in business administration.

Various women engineers spoke of the desire to work in other countries or write a book. None of the women interviewed said they would give up their job to have children. They knew it would be additional work, and they might lose their position, but they would still go back to work. Flex time was an important topic of support to encourage women to stay in the field.

Support came from within themselves, from family and relatives, and from mentors and professional groups. The women engineers interviewed for this research were confident in their ability to do their job, and many voiced that the culture at work was changing for the better, but it would take time.

Adaptability.

The ability to adapt to new and challenging situations was apparent in Lynne's educational experience:

I had a guidance counselor tell me I should go to a two-year college before I go into engineering. I was like "Who are you to say that to me?" She was trying to talk me out of going into engineering. There were a lot of people who tried to change my mind along the way. But I was always interested in it and nobody's going to stop me.

Her own motivation gave her the strength to move forward and complete her degree. Lynne told a story from kindergarten:

We were doing a project about what we wanted to be when we grew up, and I said I wanted to work in space, and they said, “Oh, write down that she wants to be a nurse.” I was so mad! The biggest thing was support. Both of my parents were supportive.

Reliance on strong communication skills is crucial in adapting to the high ratios of men to women. When Allie was mentoring another woman engineer, she encouraged her co-worker to “be a bit more direct and go after what you want a bit more. Her manager got too close to her physically, and I told her to tell him to back off, or tell him you like to breathe and he’ll get your point.” Sexual advances were topics of concern as well. Allie explained:

Everybody hangs out with each other all the time. One guy would always smile at me and I would smile back. My guy friend told me, ‘It’s very inviting when you smile, but unfortunately, guys will take that and run with it. You have to reduce that a little bit.’ I took his advice to heart and it made a difference.

Donna spoke to the importance of excellent oral and written communication skills at work, “Women are better at communicating and it’s hard to find engineers who can communicate well and have a personality to go with that. Writing is 80% of my job. People skills are so important.” Rae explained, “As a woman in engineering, you have to prove you know what you are talking about and people will remember. People will remember me because I’m a woman in the engineering world, so I use it to my advantage.”

Women engineers used strategies of surrounding themselves with the support of mentors, professional groups, and support of family. Excellent communication skills were developed and used to help them adapt to their position in a male culture. The linkages within the web strengthened their ability to persist in the field.

Relationships to Core Category.

A strong support system is evident in the work and lives of successful women engineers. Propositional statements were developed to link the core category of support to the other categories of attraction to the field, learning environment, motivation, and adaptability. Linkages overlapped categories and connections were noted in sketchings on paper as well as on the note board. Examples include parents who are supportive to their young girls who are interested in math and science at an early age. Support continued as parents encouraged their daughters that they could do anything they chose to do in life.

Learning environments of women engineers included support from other women in the program. Support also came from male friends who were classmates in engineering programs. Mentors were also a form of support, whether through women engineering student groups, faculty, or extended family. Mentors could be male, and in fact, because of the scarcity of women engineering, math, and science faculty, many of the women had male mentors in college. Extrinsic motivation was important to women in engineering classes, through tutoring and study groups.

When women engineers encountered cultural issues as work or in college, they forged ahead and did not let gender issues or comments stand in their way. If they were isolated, they looked for support in women engineering organizations such as SWE.

Verification of the core category of support was gathered through emails to various participants. Emails were sent asking participants to compare the transcription of their interview to the core category of support. The responses were positive, and comments of support for the research were also included, such as, "I completely agree with your choice of 'support' as the main thought of your research. I wish you well on your project and hope it will help to get the

word out about what a great career a woman can have in engineering.” A theory grounded in data should be recognizable to participants and although it might not fit every aspect of all cases, the larger concepts should apply.

Research Questions

In-depth interviews were used to collect data that were then analyzed using six research questions. The first question asked about the factors that attract women to enter engineering programs. Personal and professional skills such as strength in math and science, competition, and the opportunity to make the world a better place were mentioned.

The second research question asked how women engineers perceived their learning environment in regard to successful completion of the program. Strength in math and science and problem-solving were personal skills. Women engineers spoke highly of mentoring programs, professional organizations such as SWE, and co-op and internships as ways of preparing themselves to work in a masculine world.

What can be done to increase the retention of women in engineering programs was the third research question. Women engineers interviewed for this study stressed the importance of companies to offer family benefits such as flex time and maternity policies. Advanced education and training were also very important. Women engineers were interested in advancing in their careers and understood that advanced training and education were stepping stones that help them achieve their goals.

The fourth research question addressed the adaptability factors which encourage women to persist in the engineering field. Successful women engineers used effective communication skills to prove themselves to male engineers. Women engineers also realized the importance of professional development to continue to learn how to best do their job.

The fifth research question examined which motivational factors encouraged women to persist in the engineering field. Both intrinsic and extrinsic factors were found, illustrating the support that comes from within, such as a positive attitude, and from outside factors such as supportive parents and mentors.

The final research question observed what strategies women engineers use to remain successful in their field. Use of effective communication skills was evident in the research, as well as development of ways to succeed within the masculine culture at work. Additional ways women engineers remained successful in their fields included the use of mentors for support as well as the support of the company through professional development.

Because of the coding process, the intertwining of the research questions and answers became evident as the concept of a web of support was being formed. The design wall was instrumental in the development of a model that best illustrated the meshing of adaptability, motivation, education, strategies, motivation, and environment. Once the diagram was in place and the connections were made, the web of support was visually and conceptually evident.

CHAPTER V. DISCUSSION OF LITERATURE IN REFERENCE TO CATEGORIES, AND SUMMARY

After reviewing the interviews, information about the backgrounds of the participants showed evidence of an engineering connection in the family. None of the women interviewed had women engineers in the family however, most knew of a male engineer in the not-too-distant family. Many of the women engineers were also influenced by women in the family with strong math and/or science backgrounds. Evidenced in the history of engineering, (only men were engineers), and because women in this study were influenced by males to enter a male-dominated field, a historical account of how women entered the field of engineering is included to provide perspective. Also, the initial research questions guiding this study will be discussed in this chapter linking the research data with current literature. The core category described by women engineers from this study is the development of a web of support.

History of Women in Engineering

According to Tietjen and Reynolds in Layne, (2009), contemporary engineering began in the fifteenth century as a way for the military to design warfare. After the Renaissance period of history, engineering moved from its strictly military focus to a more civilian design, hence, the term “civil engineer” was born. As bridges and roads were designed and constructed, the need for formal schools of engineering increased. The industrial revolution increased the need for different types of engineers and the first non-military engineering school was established in 1824. And as was the standard then, women were not allowed to attend.

As explained by Matthews in Layne, (2009), early women engineers were not formally educated, they were trained as apprentices. Women played active parts in civil and mechanical engineering through the men in their lives. For example, Emily Warren Roebling was married to

the head engineer of the Brooklyn Bridge and she assumed responsibility for completing the Brooklyn Bridge in 1883, when her husband was too sick to complete it. Although she was technically not an engineer, she had worked closely with her husband throughout the project and was able to move it forward throughout her husband's illness. To illustrate the importance of her part in the project, there is a plaque of dedication to Roebling at the bridge site. Yet, women were not allowed to become engineers.

Engineering societies grew out of the professionalization of engineering in the late 19th century. Within the college realm, women were slowly allowed to attend college and by 1920, ratification of women's suffrage opened the door to more women in the field. But when women were finally admitted to colleges, engineering societies passed regulations requiring members to possess an engineering degree, thus alienating the women who were trained as engineers, but without degrees.

Because of World War I and II, women were allowed in the work force, and were encouraged to support the war efforts. But once the wars ended, women's jobs were given to homebound veterans. Wightman (1999) reported that between 1945 and 1946, the number of women engineers was cut in half. Yet women engineers continued to work behind the scenes.

According to Light in Layne (2009), women were omitted from history books during the development of America's first electronic computer, in 1946, called ENIAC (Electronic Numerical Integrator and Computer). During development, women were hired to compute, by hand, the many computations required. Thus, women who did this work were given the name "computers." Little did they realize they were developing the very machine that would eliminate their jobs.

Although women were starting to be encouraged to enter the work force, jobs for men and women were still listed separately. A woman could not apply for a man's job. Trescott in Layne (2009) explained that women were conditioned to be modest about their contributions to science and engineering, and were left out of any mention of their accomplishments.

According to Layne (2009), Margaret Ingels, the first woman to graduate from the University of Kentucky's College of Engineering, spoke of women engineers of the 1950s as pioneers, working to advance the frontier with little support from men or other women. Prejudice and discrimination were the norm, yet these women asked for no favors. Wightman (1999) contended that the choice of hiring women workers was based not solely on gender ideology, but also included "market circumstances, the nature of engineering production, the need for flexibility in work organization and a continuing reliance on skilled male workforces" (p. 13).

With the launching of Sputnik in 1957, more technical and scientific educational programming was necessary to project the United States into becoming a world power and women were again encouraged to become a part of the work force (Lucena, 2000). However, the idea of equal pay for equal work was not yet formulated in public policy.

The women's movement of the 1960s and 1970s coincided with the space race but engineering was not growing as quickly as other fields of math and science. For example, in 1968, there were five women who received Ph. D.'s in engineering (Engineering Workforce Commission 1998, societyofwomenengineers.swe.org). Although the number of women engineers has slowly increased through the years, those numbers lag behind medicine, law, and accounting. In the late 1970s and early 1980s, the number of women in engineering began to increase.

Attraction to the Field

Women engineers are attracted to the field because of the skills involved in the job. Skills include a high level of math, problem solving, and a strong desire to help the world. Women are also attracted to high wages and good benefits associated with engineering.

Strong Background in Math and Science

Women engineers interviewed for this study enthusiastically spoke of their passion for math and science. As with men, women who have strong backgrounds in math and science are more likely to go into engineering. However, few are encouraged to become engineers by their high school teachers and guidance counselors (Geppert, 1995). Also, women college students who have high math scores also have a tendency to have high math anxiety (Haynes, Mullins, & Stein, 2004).

Although math scores have shown young women to be just as advanced as young men, (see Hyde, 1981; Hyde, Lindberg, Linn, Ellis, & Williams, 2008; and Hyde & Mertz, 2009), women experienced doubt in their math abilities in college, many for the first time. The formation of study groups was important to improve skills and alleviate doubt. Women were more likely to blame themselves for a poor grade and said that their male counterparts were more likely to blame a low grade on the teacher or the book, according to Trautwein and Ludtke (2007). However, young women are more likely to adopt the idea that all young people should be able to do whatever they so choose to do, thus challenging the perception that only men should be engineers (Valian, 1998).

Attributes

Strength in math and science complements attributes such as enjoyment of competition, attention to detail, and feeling of accomplishment.

Career benefits of high wages and good benefits are important to women when choosing a career. Mascone (2003) described benefits originally used to attract and retain women engineers that have evolved into standard policy for both men and women, including extended maternity leave, flexible hours, and onsite childcare. According to Mascone, additional benefits suggested by women engineers included provision of laptops, individualized education and training, equal salary between men and women, increasing the number of women engineers, and work/life balance mentoring programs.

Women engineers who were interviewed for this study spoke of being part of the original group of women who were responsible for the benefits mentioned above. Comments were made about work that is needed in areas of flex time and the opportunity for additional education and training to jump back into employment after raising a family.

Professional Skills

Leadership is an important component of any high level career. Although leadership has been linked with stereotypic male-gendered traits according to Marchant, Bhattacharya and Carnes, (2007), women engineers take on leadership roles and strive for promotion to project managers. More importantly, women lean toward social issues, issues that help to make the world a better place. As Brenda said:

I feel like this is a good profession and I know there are more women out there who can do this. I feel like I'm helping somebody which is important to me and I think it's important to this whole generation.

According to Fern, "They need to bring in the more human side (of engineering) to attract women."

Learning Environment for Women Engineering Students

Engineering has been labeled the ‘stealth profession’ according to Todaysengineer.org. The work of an engineer is a mystery to many people. Even first year engineering students have little accurate information about what engineers do, according to Tsui (2009). Becker (2010) suggested that engineering programs should do more in public relations to emphasize the importance of engineering.

In Australia, research has shown that young women may benefit from same-sex secondary schools that encourage women to excel in mathematics and enroll in engineering programs (Tully & Jacobs, 2010). Encouragement fosters belief in young women who positively respond to support. Fern observed, “Engineering is taught very theoretically, but in practicality things happen in a really different way. Internships should be stressed to women engineering students.”

The use of additional teaching methods such as service learning has been studied by Ropers-Huilman, Carwile, and Lima (2005) and shown that women and non-white participants assessed their learning higher than white men. Service learning projects offer real life experiences outside of the classroom and gives opportunities to work in groups and polish their communication skills.

The lecture-based classroom is a common form of instruction for students in science, technology, engineering, and mathematics (STEM). However, a meta-analysis conducted by Springer, Stanne, and Donovan (1999) found that small group work was more conducive to academic achievement than larger highly competitive classrooms. In addition, women were found to have more favorable attitudes when working in small groups.

Salminen-Karlsson (2002) described a curriculum redesign in Sweden that included the addition of problem-based learning to teaching methods, changes in actual curriculum, and training in gender stereotyping. Salminen-Karlsson's findings supported Ropers-Huilman, Carwile, and Lima (2005) in that women gave problem-based learning a higher rating than traditional learning methods. The classroom analysis of real life problems help to create a safe learning environment for women who emerge more confident in their abilities.

Shull and Weiner (2002) suggested additional open dialogue between instructor and students including questions about "why the students chose to participate in the course and what they expect" (p. 441). Students are better able to communicate independent thinking and set challenging goals. In particular, women are encouraged to believe in their abilities.

Women interviewed in this study noticed many of their classmates in college math classes pursued medical fields or switched to chemical engineering. The desire to make the world a better place was part of the decision-making process. Katrina clarified that

All the other women in my upper level math classes went to med school. Women are more likely to go into chemical engineering because this particular type of engineer has a better chance of feeling like they have made in difference in the world.

Olivia explained, "At the end of the day we all want to help someone but when you hear engineering that's not what you think of."

Schreuders, Mannon, and Rutherford (2009) surveyed 969 engineering students from 21 US universities where 27.5% of the respondents were female. The study found that women were more likely to enroll in biological, biomedical, or biochemical engineering. Women were less likely to be proficient in the use of lab tools and machines. Suggestions were made to develop positive recruiting materials describing areas of interest such as bio-engineering, and the human

benefits of an engineering profession. Women engineers interviewed for this study agree and offer, “You really need to put in that human factor” (Allie).

Use of effective communication skills can improve how male engineering students view non-engineering students as well as women engineering students, according to Wolfe and Powell (2009). Wolfe and Powell found that comments showing weakness were rated negatively by male engineering students, and self-promoting speech was less likely to be dismissed by male students. If women engineering students learned to avoid statements of weakness, such as, “That was my fault,” they may gain more respect from male counterparts. This was particularly important in areas of technology. It was also suggested that the quality of group work would improve if male engineering students would reduce the amount of self-posturing language, such as, “The textbook is wrong, I know more than the book does.” The reduction in self-posturing language also could increase learning within the group or classroom.

College Major Interest Tests

The process of choosing a major in college is often initiated in high school, with little help from over-worked high school counselors who have average high school student-counselor ratios of 500 to 1 (Greene and Greene, 2004). Web quizzes are abundant (10.5 million hits on Google) which help students to match personality traits with college degree programs, with little guidance from scholarly information.

The decision to enter an engineering program is not an easy one. Strength in math and science is a common reason for young women to examine engineering as a career choice. Social cognitive career theory (Bandura, 1986; Betz & Hackett, 1983), explained learning to occur through self-efficacy (confidence in ability) and outcome expectations (belief in the outcome). Additional research has been done using social cognitive career theory (Feldt & Woelfel, 2009)

to explain career indecision, even to include science and engineering (Byars-Winston, Estrada, Howard, Davis, & Zalapa, 2010). Fernandez, Castro, Otero, Foltz, and Lorenzo (2006) described high school career choices as influenced by gender stereotypes, which are masculine or feminine characteristics typical to traditional careers such as engineering (masculine) and nursing (feminine).

A sense of belonging is vital to successful completion of an engineering program. Connections are made through study groups and work on group projects. According to Rodgers and Marra, (2012), engineering students need to feel like they belong in engineering, as well as having prerequisites of high academic preparation, self-efficacy and motivation. Clafferty (2011) encourages the use of social networking to form close-knit groups. Jackie spoke of being part of cohort groups in her engineering program, “You get used to the same people, you are going through it together, the harder courses, the easy courses, so that was enjoyable.”

Gender Stereotyping

Current research finds that both internal and external factors influenced young people’s decisions for a certain career path. Easterling and Smith (2008) described external influences as job availability and pay, and internal influences such as personality, interests, and ability. Even girls gifted in mathematics are influenced by gender, and self-report lower academic ability than their male counterparts (Preckel, Goetz, Pekrun, & Kleine, 2008). White and White (2006) explained both positive and negative stereotyping as a strategy for social interaction.

According to Lesko and Corpus (2006), stereotype threat is a pressure that women strong in mathematics encounter because of fear of confirming a stereotype about themselves or their group. When the threat was removed, women performed as well as men. However, it is common for students, once they are in college, to be easily influenced by stereotypes such as gender

(Lackland & De Lisi, 2001) and to change their major at least once before graduation (Lore, 1998).

In Europe, as well as in the United States, gender issues are prevalent in college engineering courses, according to Alpay, Hari, Kambouri, and Ahearn (2009). Workshops have been implemented that target negative gender stereotyping. Topics of discussion included communication of marginalization and invisibility, and were necessary to open dialog to both men and women. Commitment to teamwork as well as personal development was encouraged to combat gender stereotyping.

In engineering, according to Conrad, Canetto, MacPhee, and Farro (2009), the results of major interest tests may not be the best way to motivate diverse students to enroll in the physical sciences and engineering. Because of the history of dominance of males in engineering, “masculine” skills are likely to be entrenched in college-entrance interest tests, and could steer capable women away from rewarding careers in engineering. Uden (2002) contended that men employ men as engineers in a male field, and they did not view engineering as a gender neutral nor a mixed gender organization. Integrating women into that large of a male culture takes time and energy and the will for men to change. According to Heilman (2001), even though women can be successful at work, they can still be socially ostracized.

Engineering companies such as ExxonMobil offer “Introduce a Girl to Engineering” programs targeting middle school aged girls, hoping to bridge the gender gap, according to Gender and Health, (2012). Programs such as this were introduced in the U. S. in 2001, according to Lehr (2004) and have now gone global, including countries such as Canada, Egypt, and India. As suggested by Haemmerlie and Montgomery (1991), deliberately presenting

competent women in high-status positions may begin to break the gender stereotyping that is so prominent in masculine fields.

Although excellence in math and science in high school can be an indication of success in college, much of later intellectual development begins in college (Perry, 1968). Because engineering involves critical thinking and complex problem-solving (Palmer & Marra, 2004), college student development theory is a necessary component of engineering program development.

When institutions offer higher ratios of women to men faculty, women are more likely to have positive experiences on college campuses and remain in the program. Sonnert, Fox, and Adkins (2007) explained that to increase the number of women entering fields of engineering, two ways of thinking need to be addressed. Individual characteristics such as skills and experience require attention, as well as institutional characteristics such as campus climate and gender proportion. Palmer and Marra (2004) suggested that the development of higher levels of epistemologies is important for college students, and in particular, science and engineering students. Active learning through open-ended projects based on real-life problems may encourage such growth. Class engagement through peer review and self-assessment projects may also promote learning, according to Willey and Gardner (2010).

Retention of Women Engineers

Women engineers interviewed for this study spoke of the necessity to increase public information on what women engineers do. Women engineers take pride in their work to improve the quality of human life, whether it is through improving groundwater supplies, or developing a better airplane part. Much can be done with better marketing about what women enjoy about their work as engineers. As Olivia suggests, “Change the message of engineering. It’s not a white

man in a lab coat, it's all about wanting to change the world." Use the skills that attracted women engineers to their field to keep them there. According to Industrial Engineer, 10% of men leave engineering midcareer, while 25% of women leave, after completing their education.

The women engineers interviewed talked about women in their math and science courses in college who chose to focus on areas that had a direct impact on the world, such as chemical engineering. Lynne explained, "The women were definitely more in the chemical engineering (program) and those that didn't want to go into chemical ended up going pre-med or pre-pharmacy." Frehill (2010) described a concentration of women in chemical and civil engineering, and a much lower representation in mechanical and electrical engineering.

Poor job satisfaction is the number-one reason both men and women engineers change jobs. According to Frehill (2010), women engineers are more likely to leave their job than men because they want a work environment that is supportive of the family. This comes as no surprise as men engineers with families are more likely to have wives at home who are responsible for the family. References to wanting a wife or being asked to do shopping (a wife's job) by men engineers help describe the frustrations voiced by the women in this study.

Successful women engineers are likely to take uncomfortable situations a step further. For example, when told by her (male) supervisor she was expected to buy his wife a birthday gift using a gift card, Olivia explained to him there are personal shoppers available and she would email the information to him on how to access them online. Follow-up might be necessary, but in the future, he would be more likely to use online sources, instead of women in the office. Women were quick to explain that it as a learning curve, especially for the older men who were accustomed to women doing 'women's work.'

Many of the women engineers were mistaken for secretaries or wives of engineers and were not offended by it. Isabella explains it as, “I have to prove myself before they’ll even give me a chance. It helps me figure out how to work with different groups of people. They have never seen a woman engineer before, and I want it to be a positive experience!”

The study of the retention of women engineers is being conducted through National Science Foundation (NSF) grants. The University of Wisconsin-Milwaukee is investigating engineering tasks, work/family balance and workplace climate for women at different stages in their career at five year increments. Cornell University is also using NSF resources to research the recruitment and retention of women engineering faculty (Hemami & van der Muelen, 2010). Women comprise just 12% of engineering faculty at Cornell University (similar to the national average), and their study hopes to debunk myths of hiring diversely, such as, “There aren’t any women.”

Chilly climate is used to describe a discriminatory work culture where women are not treated as equals, or may be treated as though they are invisible (Crawford & MacLeod, 1990; Whitt, Edison, Pascarella, Nora, & Terenzini, 1999). Women engineers spoke of not wanting to “go out on the floor” (in the lab or the production floor) because it was “really intimidating, I felt like everyone was looking at me” (Jackie). Cech and Waidzunus (2011) described one of the feelings of a chilly climate as not being a “real” engineer, and further describe similar situations for lesbian, gay and bisexual engineering students. Hostile work environments for women have also been documented among academic faculty in STEM fields, according to Blackwell, Snyder, and Mavriplis (2009). However, barriers do not stop the women of this study.

Successful women engineers who were interviewed for this study love their work and do not consider leaving their jobs. They appreciate efforts made by companies to create and expand

policies important to them such as maternity leave, flex time, travel, and advanced education. Strong leaders are important, not only to move projects forward, but also to provide mentoring and support to women who might not yet have the training necessary for success.

Tenacity and perseverance are attributes of women engineers that are necessary when encountering the masculine culture of men engineers. According to Cech, Rubineau, Silbey, and Seron (2011), in order for women to be retained in engineering, individuals must have confidence in their abilities necessary to do the job (professional role confidence). If this confidence is diminished or lacking, there is a greater likelihood that they will leave the profession of engineering. Comments such as “I have a strength, so do you, let’s work together” (Nadine) and “I take it as a challenge, bring it on!” (Olivia) illustrate determination and strength.

Mentoring

Women engineering groups, such as SWE are important for mentoring and support. Olivia explains, “SWE played a big part in preparing me for the workplace. We need the ground roots organizations like SWE but also we need our national leaders. But it is going to take time.” Steinke (1997) expressed the need for role models for young women interested in becoming engineers. Exposure to public media where successful women engineers are evident help to increase the perception that women can not only be successful as engineers, but also that they can change the world with a fascinating occupation.

According to Mattis (2005), engineering companies can increase the number of women engineers by concentrating on recruitment and retention strategies, and by building an attractive image of what engineers do to improve the world. Recruitment should begin in elementary school and continue through high school. Students and teachers need information that presents

engineering as an interesting and innovative career. The development of mentoring programs through engineering companies would also help to retain women in the field.

Adaptability Factors for Women Engineers

Women engineers who had families expressed the large amount of responsibilities outside of work necessary to balance career and family. After work, when women engineers were rushing off to the grocery store, daycare, or Target, their male peers were playing basketball together. How women engineers adapted to differences in free time was evident in the data. Women who spoke of being the first woman ever hired at their company spoke of persistence and open communication. Because there were company sponsored men's basketball and softball teams, women asked for company-sponsored women's basketball and softball teams, or co-ed teams. As Nadine explains, "Barriers? Yes, every day! It's an interesting challenge, to find a way. That's what makes it fun."

Gender

Barrier-free work environments have been discussed for decades, largely because of previous work by the women's movement. Robinson and McIlwee (1989) explained that the structure of engineering was built on hierarchical (male) dominance and change is difficult. Although women bring the proper skills to the job, real opportunities must be available for women to advance. Tonso (2006) studied how engineering students develop an engineer identity and found that college culture is based upon masculine privilege from the past and is difficult to change. Women engineering students are pushed to the margins on college campuses, and it comes as no surprise that it continues in engineering companies (McIlwee & Robinson, 1992). Pell (1996) suggested that programs where inclusion and mentoring are implemented help to turn isolation into successful integration.

Women engineers interviewed for this study spoke of isolation, both in college and at work. With tenacity they spoke of it as a non-issue. As Cindy explained, “I was always one of the only women in the class. It was never an issue. I am the only woman in my department of about 50 men. Getting through those tough classes boosted my confidence.” Mills, Gill, Sharp, and Franzway (2011), found limited success with programs working to increase the number of women engineers because both men and women were not supportive. The absence of women engineers was ignored and research continues to search for workplace change that will address isolation and gender issues.

Culture

The demands for more equitable pay, better benefits, and adjustment of work/family issues have brought forth changes in corporate culture (Maskell-Pretz & Hopkins, 1997). Work culture in engineering is dominated by male influence, according to Bastalich, Franzway, Gill, Mills and Sharp (2007) and Gill, Sharp, Mills, and Franzway (2008). Women engineers often spoke of being treated as ‘one of the guys’ or ‘one of the boys’ and adjusting to a work culture where they were either the only woman, or one of very few women.

However, the changes needed in engineering culture are not complete, according to Auster and Ekstein, (2005). According to Rosser and Lane (2002), institutional change is necessary to address barriers. Supportive work environment is necessary for individual job satisfaction.

Women are lead to believe that there is no place for feminine traits in engineering, according to Phipps (2002). Brochures and company literature are much more likely to portray men as engineers conjuring masculine images where women would be out of place doing engineering work. Faulkner (2007, 2009) studied the invisibility of women as engineers.

According to Faulkner, if women are accepted as “one of the guys”, they lose their feminine identity and the male dominant work culture remains. Gwen explained, “In my first job I was the first woman ever to work there. There was a bit of an adjustment. I didn’t have gender issues. I didn’t expect to see women.” The way an engineer works, talks and acts was studied by McIlwee and Robinson (1992), and was described as a way of excluding women from being a part of professional engineers. Fern expounded, “Being an engineer is really a different way of talking, thinking, and acting.”

Powell, Bagilhole, and Dainty (2008) contend that when women act like ‘one of the boys’ they are undoing their own femininity, creating a no-win situation. If women take on masculine traits, they are viewed as competent, but unfeminine. If they use feminine traits, they are thought to be incompetent. Femininity was an important topic with the women interviewed. As Cindy explained, “There are women engineers that wear dresses and heels, there are women that wear crop pants and flip flops.” Payton pointed more to the dilemma, “If I want to paint my fingernails, I will. No one is going to date me, so I don’t worry about it.”

Communication

Open communication is an important skill to cultivate as a woman engineer. Women described their maternity leave situations with companies where there was no policy in place. They did not get paid while they were out, but they were still expected to work from home. One woman did not breastfeed because she did not ask for a breastfeeding room, and she was not going to breastfeed in a bathroom. As Edith explained, “You have to know how to communicate.”

Sharp communication skills help women engineers to excel in the field. Donna explained, “I can pick up on how the customer is feeling and men can’t. I can be more caring. I try to make

clients happy and it helps to understand how they feel.” According to Wirth (2010), communication skills are the number one trait necessary to be successful in the boardroom. Reeder (2004), a board member of SWE Magazine, explains generational problems at work as a matter of respect. Communication needs to remain strong, whether it is through face-to-face conversations, or technological such as email, texting, or Skype. A common ground of respect is necessary to keep communication channels open. Isabella viewed generational problems as, “I understand that these guys probably know more than I’ll ever know and if you approach them like that it is fine. If they are willing to teach me, I am willing to learn.” Fern explained, “I think the younger generations are having a harder time know what the norms are in certain settings at work.”

Flex-time is a popular request made by women engineers. Women engineers who have families have a need to rearrange work schedules for field trips and although when asked if they would bring the idea forward to their supervisors, they were not sure they would be the ones to do that.

The glass ceiling phenomenon describes how women are not paid as much as men to do the same job, nor are they promoted as often. According to Altman, Simpson, Baruch and Burke (2005), women are more likely to emphasize relationships in the growth and development of their careers. Excellent communication skills are important to combat the phenomena of the glass ceiling. Allie suggested, “The way to combat that (men being paid more) is really through conversation, negotiation and demanding more...you need to ask for what you want.” According to Olivia, the glass ceiling still exists. When she took on a project, the senior project manager did not think she could do it. That made her work even harder to get it done to the best of her team’s ability and to also be done ahead of schedule. She took it on as a challenge.

A large portion of the women interviewed had children. They spoke of work/life balance and how important it was to have the support of their husbands. Ranson (2005) explained that retention of women engineers is problematic when women have children and try to balance both work and family. Part time work is not an easy solution in a male-dominated career where wives stayed home with the children. Women who are married to engineers agree as Monica said, “Both my husband and I take turns being away from work for school functions, or if a child is sick. Because we both have the freedom of flexible time, we can work it out.” Some women become the major breadwinner of the family when the husband stayed home with the children. Communication is crucial, as Payton said, “We are losing a lot of great (women) engineers because they don’t ask about flex time and maternity leave.”

Jean described her maternity leave that coincided with a heavy lay-off period at work. Before she went on leave, she was a project manager. When she returned after her maternity leave, she was told she was not the project manager anymore, that because of the lay-offs, they had restructured. But during a team presentation, the first slide of the project listed one of the men as the project manager. She tried to talk to her supervisor, but he explained it as part of the restructuring of the company.

Motivational Factors for Women Engineers

Intrinsic

According to Walcott (2007), women engineers must be able to see that what they do makes a difference in the world. A common comment from women engineers was, “I like the feeling of seeing something and thinking, ‘I designed that’ (Jackie)” or “I want to be able to help people (Olivia).” Motivation is important to women engineers because it brings value to their lives through their work.

Extrinsic

Extrinsic motivation encourages women from the outside. As Edith explains, “Teachers need to encourage students more that they can do the difficult math.” According to Tiedemann (2002) and Gunderson, Ramirez, Levine, and Beilock (2012), math attitudes and math anxiety begin early in life and how teachers and parents deal with math stereotypes may affect how children, particularly girls, develop math skills. As Hannah explained, “I was good at math and my mom was always telling me I could do anything I chose to do.” As Haupt (2005) clarified, “Sometimes a bit of personal encouragement can make all the difference in the world” (p. 123).

Walcott (2007) also suggested women seek out organizations that are resources for information and change such as Women in Engineering Programs and Advocates Network (WEPAN). MentorNet, a project of WEPAN, links engineers willing to mentor engineering students, a majority of them women and/or minorities.

Mentors provide encouragement and support through the development of meaningful work relationships, according to Pisimisi and Ioannides (2005). Mentors should possess good communication skills as well as technical skills. Monica spoke of her experiences and explained, “I didn’t have a mentor in college and think that would have been helpful. I have several mentors in my current job and find them wonderfully helpful.” Most of the women engineers in this study did not have mentors in college, but were actively engaged in mentoring programs at work or through SWE or other women engineering groups.

Workplace Strategies for Women Engineers

Mattis (2005) described best practices in engineering companies who are moving forward in creating a culture where women engineers are welcomed and thrive. One of the companies implemented a deliberate method of communication between head administration and employees

of the company by using a regular distribution of employee satisfaction surveys. Survey questions included topics of diversity to get feedback on what is working and improvements that need to be made. Diversity is targeted to remind staff of the importance of diversity to the company. Because this communication strategy was implemented from the top down, employees are more likely to view diversity and fairness as important aspects of the company.

Leadership development is another best practice that encouraged women and minorities to take part in professional development that prepares them for leadership positions, according to Mattis (2005). In addition, progressive companies have implemented coaching and mentoring programs to new employees. Seasoned professionals are willing to network with newly hired employees to increase personal and professional growth. Finally, best practices included benefits of flexible work schedules to illustrate the company's desire for proper work-life balance.

Examples of women engineers who are experiencing best practices include Donna, who sees the culture at work changing slowly. When she began her job she was pregnant and they did not have a maternity leave policy at her work. They had never hired a woman before Donna was hired. She asked for a policy to be developed, and the company agreed to work on it. A few months after her baby was born, she got pregnant again. The company still had not finalized a maternity policy however, they have since implemented it. Donna finds it a bit ironic that although the company now has a maternity leave policy, she was never able to use it. She commented that she "paved the way for other women."

Success in the field

Comments of "I love my job," or "I wish there were more women in engineering," are examples of how women show success in the field. The interconnectedness of the categories of attraction to the field, education, environment, adaptability, motivation, and strategies answer the

research questions by forming a web of support, as illustrated in Figure 3 at the end of this chapter. As areas of support are removed, the web weakens, and success is at risk. To increase the protection of the web, all categories should be addressed.

Brenda summed up the pride and excitement of her career saying, “If I had a daughter I would definitely tell her to become an engineer...Even if it’s a boy, I guess he could become an engineer too.”

CHAPTER VI. CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

Conclusions

There is no simple answer to increasing and retaining the number of women engineers. Problems and barriers have been identified through much research, but action is what is needed. As shown by this research, the stronger the web of support, the more likely it is that women who enter engineering programs will graduate and remain in the field.

Research and development in public relations and branding could help to increase the knowledge base of just what it is that an engineer does. Financial support from engineering companies and programs would increase the visibility of engineering and attract more women interested in making the world a better place.

Internships and co-ops are crucial to the development of women engineers and should be part of engineering programs. Real life experiences are beneficial to challenge college students to reach outside their comfort zones and in turn develop higher levels of learning.

Mentoring programs in undergraduate studies can include conversations about what to say when a man says, “I am so glad you are just ‘one of the boys’” or tells a sexist story. Mentoring programs are also important on the job, and matches should be carefully planned to give optimal experience to new hires. There are companies that offer computerized mentor match-ups similar to on-line dating. Engineering conferences might offer workshops on best practices of online mentor matching, where women engineers present the information.

Companies could include workshops in professional development and pay expenses for women to attend and present best practices. Women engineers are willing to explain what is important to them, and experienced mentors can offer the guidance and support necessary for personal and professional growth.

Varied teaching methods such as service-learning projects should be better utilized in engineering programs. Real world problems with hands-on applications better equip students to transition from student to professional. Engineering programs might present different teaching methods at faculty workshops and encourage revamping of past teaching methods to include more effective communication skills and group work.

Teachers underestimate the importance of support and encouragement in math classes, even in elementary school. Mathematics and science teacher education and school counselor programs should stress the importance of provision of encouragement to girls as well as boys in the classroom, to encourage girls and boys to enter fields based on mathematics and science, and to explore the wide areas of engineering and the many benefits provided by an engineering career. An active research project could create and distribute information about women in engineering to kindergarten through 12th grade math and science teachers and conduct interviews and focus groups with first year college students about the choices made in choosing a major. “Bring a Woman Engineer to School” presentations could be implemented by schools to offer girls and young women role models for their future careers.

Public relations must play an important role in attracting young women to engineering. The presentation of competent women in high-status roles is vital in social media, print material, as well as television and movies. It is also important to promote the concept of making the world a better place through engineering. Touting the social aspects of engineering would make engineering programs more attractive to youth with skills in STEM fields. Women need to be visible if more women are to be recruited. Public relations can build a more accurate picture of who women engineers are and what they do. For the number of women engineers to increase,

interest in the different types of engineering must grow, and young women need to be able to visualize how a career in engineering can help to improve the world.

Communication skills could be developed in college during group work where men and women learn to recognize appropriate and inappropriate language. This might increase the quality of work done in teams. Faculty would need to develop curriculum where there is buy-in from the top down, stressing the importance of teamwork, respect, and diversity. Women engineers must be willing to learn a communication style that is assertive yet not abrasive to present benefit package ideas that are beneficial to them as well as to the future development of the company. The culture of engineering needs to continue to evolve into a place where women can be feminine if they so choose, and still be supported for being women.

Limitations

The results of this research are limited by the connection of interviewees to the Midwest. The sample could be expanded to include other areas of the US or countries outside the US. Data collection could also be restricted to certain kinds of engineering fields. Gearing data collection to only electrical or mechanical women engineers, for example, may find that individual engineering groups have areas of concern specific to their group.

The selection process may limit the research results in that some of the women engineers interviewed were suggested by their co-workers or friends from college. Selection of participants through membership in women engineering professional groups such as SWE may give a different view to the research.

Future Research

Future research that investigates the public relations of engineering companies that have high retention rates of women engineers is needed to determine which methods of

communication best attract and support women engineers. Action research could also be done to work with a specific company to improve retention.

Changes in teaching methods and curriculum redesign are instrumental in attracting and retaining women in engineering programs. Problem-based learning, service learning projects, and other forms of experiential learning that address technology need to be developed and researched. Quantitative research could be done with women engineering students who enroll in classes where experiential learning is prominent. Do women have higher scores in technology-based (on-line) versus classroom (face-to-face) lecture? Also, better assessment processes could be developed that record data, whether qualitative or quantitative, to describe successful measures of in-class and out-of-class projects.

The current research could be expanded to reach other areas of the US with connections outside of the Midwest. Are results similar in other areas of the US? Research could also be done outside of the US to compare and contrast experiences of women engineers in other countries.

Future research could include the use of communication to break barriers between the dominant and muted groups in engineering companies using co-cultural theory. Also, an ethnography would provide a window into the life of a woman engineer, not only in the work environment, but also the challenges and opportunities experienced outside of work.

Student development theory could be researched in engineering programs to better understand how female students view knowledge, and how the role of the instructor may change based upon stages of development. Teaching methods could be evaluated to best describe the development of higher critical thinking that is much needed in engineering education.

Personal Reflections

Without doubt, the most personally energizing aspect of my research, and the aspect that I will take with me, is the realization of the commonalities I share with women engineers. Certainly the single most rewarding part of my research process was the interviews with the women engineers themselves. I found a natural bond with these women on several levels. Engineers and mathematicians, whether male or female, automatically share a certain amount of common ground in an appreciation for, and an expertise in, math. We also, of course, shared the commonality of being women. But I think the starkest and pleasurable shared common ground I discovered was being women in male-dominated fields. This reminded me that, in my own training and work, I had gone through experiences parallel to theirs, and that I tended to value that experience in the same ways as did they. As is engineering, mathematics is dominated by men. And, as did my female engineers, I was reminded not only of how I also had adapted to overcome those barriers, but of how many things there were about my own training and profession that I really like!

In some ways, I can say that I had an agreement with this dissertation; I agreed to write and re-write it, and it agreed to re-write me. In high school, I excelled at mathematics. My brothers were also very bright, and also strong scholars. But, whereas teachers encouraged them to attend college and pursue a course of study in engineering, I was encouraged to become a dental assistant. There is nothing wrong with becoming a dental assistant, but I believe that, in today's world, I would have been encouraged to reach for more; today, I believe that I, also, would have been encouraged to look at engineering as a profession.

If I were to be in contact with my participants again, there are two gifts I would pass onto them. The first is to remember that, no matter their political leanings, they owe a debt of

gratitude to those pioneering women who came before us. Not that many years ago it was considered acceptable to openly berate women trying to crack male-dominated professions. And with that slight easing of pressure sometimes comes complacency—a tendency to forget that we women, in these disciplines today, stand on the shoulders of giants. We must learn their names, and never forget their accomplishments.

For the second gift, I would encourage my participants is to consciously return the support they themselves received, by becoming a mentor, a friend, or a confidant to young women pursuing a degree in engineering. The most oft-cited factor in this study that directed women toward engineering, and helped them stay there, was the support of others. Most participants mentioned at least one person (not always a woman) who, at just the right time, encouraged them to consider a career in engineering, and most cited a friend or mentor who helped ease their passage.

Finally, it is also a pleasure to acknowledge that by the very act of my becoming a mathematician, I have helped to effect these changes in the STEM disciplines. As I talked with these women, I was reminded that the STEM disciplines tend to draw women made of unusually stout fabric, a sort of obdurate type who is drawn to these very fields, not in *spite* of the challenges facing them there, but *because* of the challenges facing them there. One of the reasons they were determined to prevail, was that someone had told them they couldn't. I found in myself a renewed pride in being one of these women.

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APPENDIX A

Institutional Review Board

...for the protection of human participants in research

North Dakota State University
 Sponsored Programs Administration
 1735 NDSU Research Park Drive
 NDSU Dept #4000
 PO Box 6050
 Fargo, ND 58108-6050 231-8995(ph) 231-8098(fax)

Date of Receipt

IRB Protocol #:

IRB PROTOCOL FORM

Application to Conduct Research Involving Human Participants

1. Title of Project: Motivational and Adaptability Factors that Determine Success at the Undergraduate and Professional Levels for Females in Engineering

2. Principal Investigator: Dr. Kathy B. Enger Dept. name: College of Human Development and Education, School of Education
(PI must be an NDSU faculty or staff member; graduate students must list their advisor as PI)

Campus address/phone: 701-231-5776 Email address: Kathy.Enger@ndsu.edu

Specify role in this research: direct/supervise research

Highest earned degree and field of study: Ph.D., Education

3. Co-Investigator(s): Susan Bornsen Dept. name: College of Human Development and Education, School of Education

Campus address/phone: Cell: 701-541-2516 Email address: sbornsen@cord.edu

Specify role in this research: perform research interventions

Highest earned degree and field of study: ABD, Education. Doctoral candidate

4. Research team: *List all other individuals who will be involved in the research (project design/oversight, recruiting participants, obtaining informed consent, intervening or interacting with participants to obtain information/data, and/or handling identifiable information for research purposes). May provide as a separate attachment.*

Name, dept. or affiliation:	Specify role in research:
Manjusha Saraswathamma, ABD, Doctoral Student NDSU School of Education and Assistant Professor Minnesota State Community and Technical College, Moorhead	Review findings
Canan Bilen-Green, Associate Professor Industrial and Manufacturing Engineering, North Dakota State	Review findings

March 3, 2010

Kathy B. Enger
 School of Education
 FLC 210D

IRB Expedited Review of: "Motivational and Adaptability factors that Determine Success at the Undergraduate and Professional Levels for Females in Engineering", Protocol #HE10169

Co-investigator(s) and research team: Susan Bornsen, Manjusha Saraswathiamma, Canan Bilen-Green

Research site(s): varied

Funding: NSF (pending)

The protocol referenced above was reviewed under the expedited review process (category # 7) on 2/23/2010, and the IRB voted for: approval approval, contingent on minor modifications. These modifications have now been accepted. IRB approval is based on the original submission, with revised: protocol and consent (received 3/1/2010).

Approval expires: 2/22/2011

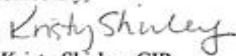
Continuing Review Report Due: 1/1/2011

Please note your responsibilities in this research:

- o All changes to the protocol require approval from the IRB prior to implementation, unless the change is necessary to eliminate apparent immediate hazard to participants. Submit proposed changes using the *Protocol Amendment Request Form*.
- o All research-related injuries, adverse events, or other unanticipated problems involving risks to participants or others must be reported in writing to the IRB Office within 72 hours of knowledge of the occurrence. All significant new findings that may affect risks to participation should be reported in writing to subjects and the IRB.
- o If the project will continue beyond the approval period, a continuing review report must be submitted by the due date indicated above in order to allow time for IRB review and approval prior to the expiration date. The IRB Office will typically send a reminder letter approximately one month before the report due date; however, timely submission of the report is your responsibility. Should IRB approval for the project lapse, recruitment of subjects and data collection must stop.
- o When the project is complete, a final project report is required so that IRB records can be inactivated. Federal regulations require that IRB records on a protocol be retained for three years following project completion. Both the continuing review report and the final report should be submitted according to instructions on the *Continuing Review/Completion Report Form*.
- o Research records may be subject to a random or directed audit at any time to verify compliance with IRB regulations.

Thank you for cooperating with NDSU IRB policies, and best wishes for a successful study.

Sincerely,



Kristy Shirley, CIP
 Research Compliance Administrator

Last printed 3/3/2010 2:11:00 PM

APPENDIX B

NDSU

NORTH DAKOTA STATE UNIVERSITY

School of Education

605 U. Sigm. 2525

601 Box 6000

Bism., ND 58105-6000

Administrative Offices

210 Emily Life Center

ND 581 7521

fax: 701.231.7415

email: ndsu@ndstateeducation.com

Title of Study: *Motivational and Adaptability Factors to Determine Success in the Undergraduate and Professional Levels for Females in Engineering*

Researchers conducting the study: Kathy B. Enger, Ph.D. (phone: 701-231-3776; email: Kathy.Enger@ndsu.edu), Assistant Professor in the School of Education at North Dakota State University and Susan Bornsen, ABD; (cell) 701-541-2516; email: sbornsen@engr.ndsu.edu) Student in the School of Education at North Dakota State University.

You are asked to participate in the study because you are either a female student in engineering or a female engineer in the engineering profession. Thirty females will be interviewed.

Females are underrepresented in non-traditional profession like engineering. Females' motivation to enter the field, their persistence and adaptability in the field are very low. The purpose of this study is to understand the "leaky pipeline" for females in engineering by examining the motivational factors that lead females to study engineering and the adaptability factors that cause them to stay in the profession. Through an analysis of the motivational and adaptability factors of females in undergraduate engineering programs and in engineering practice, a research-based model will emerge. The model will be used as a framework that may be applied to programs seeking to retain females in the engineering discipline. This research is supported by an NDSU Advance FORWARD grant for \$10,000. Funding through the National Science Foundation will also be sought.

This study will involve 30 interviews with a cross-section of females in engineering, including undergraduate female engineering students and females in the engineering profession. Both groups will be studied to determine the factors needed to enter undergraduate studies and persist, as well as those factors needed to enter the profession and persist. A grounded theory approach will be adopted (at least 30 interviews are needed to saturate the data in grounded theory). Grounded theory is a qualitative approach that places emphasis on the creation and meaning of social experience, where the constructed nature of reality and situational constraints shape inquiry. Grounded theory explores the common experiences of individuals, considering the perceptions of subjects that effect action in actual context in order to develop a theory (Denzin & Lincoln, 2003). Both motivating factors and adaptability factors will be extracted from the interviews in order to design a model of persistence to help retain females in the profession. The interview will last for at least one hour and up to two hours.

The study will take place at locations throughout the United States and will be completed by August 31, 2010, extended to 2011.

The interviews will be recorded by voice on an electronic recording device and transcribed onto a laptop. Some interviews may be conducted using Skype. Only voice will be recorded and transcribed. Once the transcription is complete, all recorded material on the recording device and laptop will be erased.

You are not expected to get any direct benefits from this study. Overall benefits to you and others are summarized as follows:

A comprehensive theoretical approach needs to be developed to determine persistence factors that motivate females to enter and remain in engineering. The study will design a model of persistence for females in engineering. This model will be useful in developing: a. better outreach and awareness programs; b. tools for enrollment counseling; c. a standard framework for designing female friendly curriculum; d. as a guideline for promoting adaptability in the workplace.

Your participation in this research is your choice. If you decide to participate in the study, you may change your mind and stop participating at any time. It is not possible to identify all potential risks in research procedures, but the researchers have taken reasonable safeguards to minimize any known risks to the participant. Proper security protocol as prescribed by NDSU's IT Security Officer, will be used including the proper anti-virus and anti-spyware and the "firewall" will be enabled. Skype communications are typically encrypted, so there should be no problem with security when using Skype.

There are no costs associated with participation in this study.

Cooperating	Excellence in Leadership	Teacher Education	Institutional Analysis	Occupational Assist. Education
2nd. Emily C.	210 Emily Life Center	155 EMU Hall	215 Emily Life Center	215 Emily Life Center
				1 of 2

NDSU is an equal opportunity institution.

All of the information collected for this study will be de-identified. In other words, there will be no direct link between you and the transcript of your words used from the five interview questions. All of the data collected will be kept in a locked file cabinet in the office of the lead principle investigator, Kathy B. Enger.

We will keep private all research records. Your information will be combined with information from other people taking part in the study. When we write about the study, we will write about the combined information that we have gathered. You will not be identified in these written materials. We may publish the results of the study; however, we will keep your name and other identifying information private.

Before you decide whether to accept this invitation to take part in the research study, please ask any questions that might come to mind now. Later, if you have any questions about the study, you can contact the researcher, Kathy B. Enger or Kathy.Enger@ndsu.edu or 701-231-5776 or Susan Hornsen at Susan.Hornsen@ndsu.edu or 701-241-2516.

If you have questions about your rights, or complaints about this research you may talk to the researcher or contact the NDSU Human Research Protection Program by:

- Telephone: 701.231.8908
- Email: ndsu.hrb@ndsu.edu
- Mail: NDSU HRPP Office, NDSU Dept. 4000, PO Box 6050, Fargo, ND 58108-6050.

The role of the IRB is to see that your rights are protected in this research; more information about your rights can be found at: www.ndsu.edu/research/irb.

You are freely making a decision whether to be in this research study. Signing this form means that

1. you have read and understood this consent form
2. you have had the consent form explained to you before the beginning of the interview session, either in person, via phone, or through Skype.
3. you have had your questions answered, and
4. you have decided to be in the study.

You will be given a copy of this consent form to keep.

Your signature

Date

Your printed name

Signature of researcher explaining study

Date

Susan Hornsen
Printed name of researcher explaining study

APPENDIX C

Woman Engineer Interview Format

Time: Date: Face-to-face Skype

De-identified name:

Introduction:

Thank you for agreeing to participate. Have you read over and signed the informed consent form? Do you have any questions before we begin the interview? Explain the interview process, first asking questions about education, then following with similar questions geared toward your career experiences. Explain my interest and personal experience in obtaining a degree in mathematics.

Background questions:

1. What was the ratio of men to women in your program in college?
2. Where did you attend college?
3. What is your area of expertise?
4. How long have you been working as an engineer?

Education questions:

1. What motivated you to enter the field of engineering?
 - a. What factors attract women to enter engineering programs?
2. As a woman, what challenges did you face as a student?
 - a. How do women engineers perceive their learning environment in regard to successful completion of the program?
3. How did you adapt to those challenges?
 - a. What adaptability factors encouraged you to persist in the engineering program?
4. What did you find satisfying in your studies?
5. What motivated you to finish?
6. What can be done to increase retention of women in engineering programs?

Career questions:

1. What motivates you as an engineer?
2. As a woman, what challenges do you face as a woman engineer?
 - a. How do women engineers perceive their working environment?
3. How did you adapt to challenges?
 - a. What adaptability factors encouraged you to persist in the engineering field?
4. What do you find satisfying in your work?
5. What motivates you now?
6. What can be done to increase retention of women in engineering?
 - a. If you could change anything about your work, what would it be?
 - b. If you could create the 'perfect' job, what would it include?
7. Is there anything else you would like to tell me that I haven't asked you about?

Closing:

Thank you for allowing me to get to know more about you, your education, and your career. I will be randomly selecting interviewees to review the transcript for accuracy, so you might hear from me in the future. Again, thank you for your contributions toward my research.

APPENDIX D

Attraction to field Skills	Attraction to field Professional Attributes	Learning Environment Personal Experiences	Learning Environment Theory to Practice	Motivation Intrinsic	Motivation Extrinsic
		G: It was a huge adjustment to ask for help in my studies.	Internship: I: It is not going to make sense until you can see the actual components. You get an idea of what actual engineers do as opposed to the theories that are taught in school.	I: For me it is curiosity. I am curious to see what these machines can do or what these components can handle. It's a puzzle that you've got to put back together in order to figure out what happened and that keeps me motivated.	Support of parents: E: I always had my parents' support.
		F: In school I felt like I had to fend for myself.	O:co-op: just learning how to function in the workplace.	F: I wanted to work for a program that had a lot of meaning.	E: The Exxon Valdese accident motivated me to want to fix what happened.