AC 2010-1247: DESIGNING MODEL-BASED SOLUTIONS TO LEAKY FEMALE ENGINEERING PIPELINE: A QUALITATIVE STUDY OF FEMALE ENGINEER NARRATIVES

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Designing model-based solutions to the shortage of females in the engineering profession: A qualitative study of female engineering narratives

Abstract

This paper describes a case study conducted to explore the two major causes of attrition in the female engineering "pipeline." These are (a) factors motivating females to enter engineering programs and (b) females' adaptability in the engineering profession. This study proposes a theoretical framework for designing better models for engineering outreach programs as well as creating female-friendly professional climates. The two major research objectives for the study are: (a) identifying factors that motivate females to become engineers and (b) determining the extent of female engineers' job adaptability. This study analyzed 123 case interviews conducted with female engineers featured on the website *engineergirl.org*. The majority of participants believed their strength in high school mathematics and love for problem solving led them to the engineering field. The study also found the female engineering sample adapted well to the profession, as inferred from their professional and learning goals.

Keywords

Motivating factors, Qualitative, Grounded Theory, Leaky Pipeline, Engineering, Females, Adaptability, Theoretical Framework, Illeres' Three Dimensional Learning Model, McClusky's Margin in Life Theory, Margin in Life, Power, Load

Introduction

<u>Motivation and Adaptability</u>. Gender identity, social acceptance, and social perceptions of gender stereotypes shape the concept of traditional and non-traditional professions for females. Engineering has long been stereotyped as a male profession. Although research has proven this stereotype wrong, the perception remains that females are cognitively and physically less qualified to be engineers[23, 34]. State and federal affirmative action laws and Title IX of the constitution (U.S.C. § 1681) protect females against discrimination at work[20], yet females remain underrepresented in non-traditional fields, particularly engineering[3, 6]. It is difficult to enroll females in engineering training programs and difficult to retain females in the engineering profession or engineering academia[18, 35]. Only a small number of the females who enter undergraduate engineering programs graduate in engineering and enter the engineering workforce. Once in the profession, females find it difficult to gain and hold administrative positions [3, 6]. The resulting shortage of females in engineering has been compared to a leaky pipeline[3, 6].

America must fix this leaky pipeline. According to engineering job projections, the country faces a severe shortage of engineers[33]. Two options exist to meet the nation's future need for engineers. These are to increase the number of students enrolled in engineering schools and to retain current engineers. According to National Science Foundation (NSF) data from 2007, male enrollment in engineering is almost saturated. Therefore, to increase engineering school enrollment and the nation's supply of engineers, America must recruit and retain females as engineers[15].

Unfortunately, NSF data for 1995-2005 are not encouraging. These data show vast differences in the numbers of male and female engineering students in undergraduate programs across the nation[32]. Female enrollment in engineering schools increased from 18.5% in 1995 to 19.8% in 1999; however, by 2005, female enrollment in engineering schools had declined to 17.5%, a full percentage point lower than 1999 (See Table 1).

Table 1. NSF Data on Undergraduate Engineering Enrollment by Gender from 1995-2005.

Year	Female	Male
1995	18.5	81.5
1996	19.0	81.0
1997	19.4	80.6
1998	19.7	80.3
1999	19.8	80.2
2000	19.5	80.5
2001	19.2	80.8
2002	18.5	81.5
2003	18.0	82.0
2004	17.7	82.3
2005	17.2	82.8

Although proven competent as engineers, females remain a small portion of the nation's engineering workforce. To address the shortage of female engineering students, America must determine what factors motivate females to enter or to avoid the engineering field. Studies of female engineering school enrollment suggest the existing trend could be caused by prevailing professional traditions of gender stereotyping and society's perceptions about engineering[14, 39]. Several factors discourage females from becoming engineers. High school girls in particular were influenced by: (a) fear of success in a non-traditional, male-dominated field[9]; (b) mathematics anxiety[13]; (c) co-ed classroom environments[25]; and (d) lack of female role models and mentors[2]. Anderson and Gilbride[2] noted that girls could be motivated to become engineers if they had engineers in their immediate family. In general, young women are unfamiliar with the engineering profession and unaware of its possibilities for females.

Many engineering outreach and awareness programs are being developed to bring more females into the engineering field[5, 21]. The website *engineergirl.org* is part of such an initiative sponsored by NSF. However, these initiatives have yet to achieve the goal of increasing female enrollment in engineering schools[27].

The website *engineergirl.org*[31] informs girls of the possibilities the engineering profession offers females. This website states, "The *engineergirl.org* website is part of an National Academy of Engineering (NAE) project to bring national attention to the opportunities engineering offers to all people at any age, but particularly to women and girls"[31]. This website relates the stories of females currently working as engineers. These females serve as ambassadors for the engineering profession and state why they enjoy engineering and believe women can thrive in the engineering field.

Scholars have studied the factors that drive females away from engineering[18, 26, 35]. The most important of these factors are: gender discrimination, stereotyping, pay discrepancies, lack of advancement opportunities, and balancing the obligations of work and family[30, 34]. The purpose of this study is to examine the factors leading females into the engineering profession and the adaptability factors keeping females in the profession.

Theoretical Framework

Although researchers have studied the leaky engineering pipeline, the problem remains unresolved. Many of these studies rely upon convenience sampling, making it difficult to generalize the results. However, if the results of these studies could be explained within an existing theoretical framework, their findings could be generalized and transferred. This study proposes to utilize a modified version of Illeres' three-dimensional learning model to analyze factors that motivate females to enter the engineering field. This study shall also use McClusky's[28] theory of margin to analyze how females adapt once they have entered the field of engineering. McClusky's theory shows how adults use available energy to achieve self-actualization and personal growth.

<u>Illeres' Three-dimensional Learning Model</u>. According to Illeres,[16] learning is a social process occurring in three dimensions: cognition, emotion, and environment. Illeres defined learning as functionality, "…both knowledge and motor learning, both of which are controlled by the central nervous system" (p. 18). For Illeres, emotion is a sensibility representing mental balance and best understood as "…psychological energy, transmitted by feelings, emotions, attitude and motivations, which both mobilize and, at the same time, are conditions that may be influenced and developed through learning"[16]. Illeres' third dimension, environment, represents sociality. According to Illeres, this "…is the dimension of external interaction, such as participation, communication, and cooperation. It serves as the personal integration in communities and society, and thereby, also builds the sociality of the learner"[17].

This study applies Illeres' model[17] to females' decisions to enter and remain in engineering. This study shall explore how Illeres' learning dimensions of cognition, emotion, and environment influence females and how females are affected when one of the domains is missing or inadequate. This study will explain how engineering outreach and training programs built around Illeres' three dimensions can motivate females to enter and remain in the engineering profession. Hence, this study will be a pilot for future theoretical studies on this subject.

<u>McClusky's Theory of Margin</u>. McClusky's theory of margin[28] discusses the dynamics of adulthood in terms of energy. Merriam, Caffarella, and Baumgartner[29] note that adulthood is a time when one constantly seeks balance between amounts of energy available. This energy is referred to as *Margin in Life* (MIL) and is often represented as the ratio of the load of life to the power of life. The formula for calculating MIL is: (MIL) = 1 – Load/(Load + Power). A ratio from 0.30 to 0.70 denotes satisfactory MIL, meaning power exceeds load. However, an MIL score below 0.30 denotes lack of MIL and an unbearable load. Scores above 0.70 denote surplus

power[22]. This results in not enough load to motivate an adult into useful self or professional development activities like learning. *Load* of life is any internal or external factor that dissipates a person's energy. This could include work and family issues, personal problems, or stress. Conversely, *power* is any internal or external factor that accumulates energy needed to deal with the load. Power could be family support, self-confidence, collaboration, community support, or optimism. When power exceeds load, MIL increases and the person has enough energy to pursue personal development activities like learning. McClusky's theory is used in human resource development counseling for assessing and preventing burnout[40].

Madsen, John, and Miller[24] investigated the relationship between MIL and Readiness of employees For Change (RFC). RFC refers to employees' readiness to adjust, improve, learn and develop as part of the long and short-term goals of organizational strategic plans:

> This study found that employees who have higher MIL levels (meaning they feel more energy, strength, joy, and power from their working and nonworking lives and environments) might be more open and ready for changes the organization may require of them. Furthermore, employees who feel good and are not burdened down by various concerns at work (job in general, job demands, relationship with boss, workplace social support, job knowledge and skills, and commitment to the organization) and possibly concerns outside of work (family, balancing work and family, physical and mental health) appear to be ready to make necessary individual and organizational changes. This provides support for organizations to offer assistance to employees so that they can have more energy to commit to change efforts. Interventions may include assisting employees with balancing work and family responsibilities (flexible schedules, childcare assistance, job-sharing, training (and more), offering wellness programs, organizing communication improvement activities with management and employees, providing continual help related to improving job knowledge and skills, adjusting job demands when appropriate, providing programs to improve organizational commitment, and increasing employee autonomy.(Madsen, John, & Miller, 2006, p. 108)[24]

In a similar readiness-for-change study, conducted with manufacturing company employees, Hanpachern, Morgan, and Griego[12] determined that all work-related factors, except social relations, were load factors. Factors enhancing power were non-work factors such as family, self, and health. Both studies recommended interventions that improve employees' MIL and prepare employees for useful change. Interventions supporting employees could create female-friendly work atmospheres within the engineering profession.

In an earlier study, Baum[4] focused on widowed women by using McClusky's theory to identify power, load, and margin in women's lives. Baum found that major load factors included financial constraints and unemployment. The power factors common to these women included the support of family and friends, and voluntary training services, which these widows preferred to the various formal training services available to them. He showed how MIL analysis could be used to design programs to meet the needs of a specific group of females.

Thompson, in a 1992 study of female persistence[44] in baccalaureate nursing programs, found that females who dropped out of these programs lacked satisfactory MIL. In Thompson's model, female students sought a balance between load and power and dropped out because they could not find adequate margin in their lives. Participants in Thompson's study pursued the program in a condition where power and load were equal. In such circumstances, when load increased even slightly, these women lost their MIL and discontinued their study. Major causes of load affecting these women were balancing work and family, and high personal, academic, and family expectations. For these women, power came from their knowledge and skills coupled with a support system of family and partners. From this research, Thompson concluded that these females needed proper MIL to face increases in load and to persist in completing their degrees.

The engineering pipeline leaks mainly because females find it difficult to survive in a non-traditional, male-dominated field.[18] Although other studies have explored adaptability issues affecting female engineers, no practical solutions have yet appeared. McClusky's MIL theoretical framework is a model that can be used for designing working atmospheres more conducive to females. Such work environments could increase MIL for female engineers and help retain them in the profession.

Definitions

<u>Motivating factors for engineering enrollment</u>. These are factors influencing females in making the choice to enter college engineering programs. (Note that engineering is a male dominated profession.)

<u>Adaptability</u>. Adaptability is the ability to adjust to an environment that is new and unconventional. In this study, adaptability refers to respect for a gender-stereotyped, non-traditional profession.

<u>Margin in life (MIL)</u>. According to McClusky's theory[28], MIL represents the residual power available to participate in personal and professional development activities like learning. MIL is a function of load (external or internal factors that dissipates personal energy) to power (external or internal factors that increases personal energy). A higher MIL represents the availability of more power.

Method

Grounded theory approach was employed for the qualitative study. "…grounded theory is a qualitative research design in which the inquirer generates a general explanation (a theory) of a process, action, or interaction shaped by the views of a large number of participants"[8]

<u>Sample</u>. This study's data came from the 123 profiles of female engineers posted on the *Women Engineers* section of the *engineergirl.org* website. These profiles are in the format of an interview questionnaire. Except for profiles of old or deceased engineers, all participants were asked similar questions. These questions sought information on various topics, including: what female engineers do; why these women had selected the engineering profession; what these women considered the best parts of the profession; what challenges female engineers face; and how being an engineer impacts a female's family, dreams, goals, inspiration, hobbies and schooldays. The website also offers advice to girls wanting to be an engineer.

Questions posed to the 123 participants became sub-questions related to the research questions of this study. Each major research question included three of these subordinate questions. The number of participants responding to each research question depended upon the number who had responded to particular sub-questions. Except for one area containing only 45 responses, the number of participants selected for each sub-question varied from 59 to 101. Data for all sub-questions were saturated. This grounded theory study drew data from all interviews posted on the website.

Research Questions. The two major research questions, along with the three sub-questions of each, are:

1. What motivates females to enter engineering?
- What factors motivated females to enter engineering?
- Who or what inspired these females to enter engineering?
- What advice do these females offer to girls who want to pursue a career in engineering?

2. How adaptable are females in the engineering field?
- What is the best part of being an engineer?
- What challenges do females in the engineering field face?
- What do the career plans and ambitions of these females indicate about their adaptability in the engineering field?

Coding. Data analysis for this study followed Strauss's and Corbin's[42] outline for grounded theory research. The researcher analyzed data by immersing herself in the profiles of female engineers posted on the *engineergirl.org* website. Then, analysis began with open coding, continued with axial coding, and concluded with selective coding. Following Creswell's suggestion[8], researchers saturated categories by using the constant comparative method. Only as data saturation occurred did categories and subcategories develop for each research question.

Limitations

The following limitations are associated with the study:

1. This study is based on interview questions asked by other researchers. Except for early responses of the elderly and since-deceased females, the questions were similar in content. In approximately 10% of the cases, questions were framed differently. It should be noted that profiles of deceased participants were not considered in this study.

2. Participants ranged in age from females currently in baccalaureate engineering programs to females retired from the profession. This wide range may limit the study's applicability to current times. However, data from sub-questions was saturated. This could counter the problem of age distribution.

Results

A chart has been developed for the emergent themes that shows the importance of various factors in influencing females' decisions to enter the field of engineering (Table 2). The most powerful influence was *Influence in mathematics and science. Problem-solving skills* was another important influence for these participants. Many participants identified *an engineer in the immediate or extended family* as a major factor in their decision to study engineering. Another source of motivation was *family support*, followed by: *mentors, teachers, role models, and friends.* The third most important influence was a *desire to help people* or community. However, upon further reflection, this translated into personality and personal passion. *Opportunity to work* was another significant factor. Females often entered the field after learning of the employment opportunities available to engineers. *Financial security or job security* ranked as average factors. *Intrinsic motivators* and *self-confidence* were of minor importance to these females. Some females found inspiration in religious beliefs, and others cited communication skill along with planning and hands-on work as factors influencing their decision to become engineers.

Table 2. Motivating factors for females enrolling in engineering programs.

Reported from experience		**Suggested for engineering aspirants**
Motivating factors	**Inspiration**	
Interest in math & science	Family support	Interest in math & science
Problem solving skills	Mentors	Mentors
Engineers in family	Teachers	Personality
Desire to help people	Role models	Passion
Job variety	Friends	Exposure
Opportunities	Intrinsic motivation	Opportunities
Curiosity	Self confidence	Persistence
Hands-on	Finance	Problem solving skills
Application of learning	Religious belief	Outreach programs
Discovery	Outreach programs	Creativity
Creativity	Thirst for excellence	Communication skills
Financial security	Prove worth	Intrinsic motivation
Job security		Hands-on
Passion		Planning
Parental influence		
Influence of mentors and role models		
Love for challenge		
Career advice		
Exposure		
Outreach programs at high school		

Many engineering students found it difficult to persist in the field and to finance their education. Female engineering students needed financial support to continue undergraduate programs. As one participant said, “It was hard to pay for my own schooling, plan my future without the help of parents or counselors and then in graduate school find advisors who had funding. It was very hard to work and go to school at the same time”[31] (See Table 2 for the motivating factors).

Adaptability positively impacted the females interviewed on *engineergirl.org*. A majority of the females interviewed found satisfaction in the field because they could solve problems and directly apply their problem-solving skills. Collaboration was another positive aspect of engineering for participants in the study; many felt rewarded by opportunities to share their knowledge. Most participants enjoyed the process of discovery and liked the opportunity to pursue continued learning. Females in the study who were motivated by a desire to help others, found satisfaction in opportunities to help people and communities through engineering. Female participants also expressed enthusiasm about the variety, freedom, and creativity offered by the engineering profession (See Table 3)

Table 3. Adaptability factors for females in the engineering profession.

Positive influences	**Negative influences**	**Proof of persistence (Manifested as goals)**
Problem solving	Gender discrimination	Learning goals
Collaboration	The need to prove worth	Professional goals
Family support	Taking risk	Giving back to community (book writing, outreach programs etc.)
Discovery	Career and family balance	
Satisfaction in helping people	Communication	
Continuous learning		
Application of learning		
Job variety		
Creativity		
Facing challenges		
Opportunity		
Financial security		
Freedom		
Sharing of knowledge		
Social status		

Female engineers reported facing many challenges such as gender discrimination and earning respect in the workplace (See Table 3). Female engineers felt pressured to prove themselves in the workplace. Female engineers also faced problems with risk-taking in the workplace and balancing the demands of work and family. The females interviewed on *engineeringgirl.org* urged female engineers to develop strong communication skills.

Overall, the female engineers intended to remain in the field. Many had various professional ambitions, ranging from immediate project goals to long-term plans to move to management. All participants felt a need to be life-long learners, the second most cited goal. Results of the study indicated that female engineers were motivated by the desire to help people and to give back to the community. Participants did not cite financial goals as motivating factors.

Discussion

Table 2 presents factors motivating females to enter engineering. The interviews on the *engineergirl.org* website involved a group of enthusiastic, involved female engineers; hence, the motivators listed in Table 2 are real and can be generalized to the greater population. Furthermore, literature on this topic confirms the importance of these motivating factors. The foremost factor is interest in mathematics and science. Other factors are: problem solving, having engineers in the family, engineering outreach programs, hands-on experiences, and the creative aspect of engineering[11]. In addition, this study revealed a new factor, the desire to help others.

Most factors motivating females to become engineers have been discussed for some time[10, 26], and outreach programs targeting high school females have developed around those factors[21, 37, 38]. However, for undetermined reasons, enrollment of females in engineering programs is not increasing. Strand and Mayfield[41], suggest that traditional teaching techniques and curricula are not female friendly and must be altered. According to Agajanian[1] pre-college preparation impacts females' career decisions, and females are often less prepared and less encouraged to enter engineering than their male counterparts.

The *engineergirl.org* interviews indicated that family influence was a motivating factor separate, from having engineers in the family. Parental influence was a major influence on career choices in Asian cultures. Eighty-six percent of the females interviewed in this study cited the importance of parental influence in enrollment decisions, compared to 24% of males interviewed. Both males and females considered their father's influence to be important; however, girls were more influenced by their fathers than were boys[43]. A previous unpublished study by the authors identified parental influence as a major factor in females' decisions to become engineers. The student was unaware of the engineering profession while in high school and was channeled into engineering by a father, who although not an engineer himself, knew the profession's value and saw the student's potential as an engineer. This study was based on a single group of subjects.

The *engineergirl.org* interviews revealed a factor not previously reported in the literature, which was females' desire to help people through engineering. Two participants' statements reflect this. One said, "I derive great satisfaction in solving problems and providing services that make life better for people." Another said, "I want to be the person who takes math and makes it into something that helps people and our different societies all over the world." This motivating factor needs further study, especially in comparison to male attitudes. This is an emotional factor and possibly could be used to cultivate an interest in engineering among high school girls.

Although only a few participants reported being motivated by counselors or aptitude tests to consider a career in engineering, these factors should be explored. If counselors and tests can influence females, these would be cost-effective, easily accessed tools for increasing the number of female engineers.

Winkelman[45] explored the various factors that motivate females to become engineers. Depending upon the factors being studied, Winkelman used four different social theories to analyze this subject. Winkelman used human development theory to study gender identity, role models, self-esteem, family relations, and academic preparation. Cultural theories were used to study values and social acceptance. Organizational theory focused on interest congruence, authority relationships, and social environments. Finally, Winkelman used learning theory to study self-efficacy, learning styles, and academic preparation. Winkelman's study, well grounded in social theory, indicates the difficulty of using one model or theory to explain the various factors influencing females to enter the engineering profession.

Illeres' three-dimensional model may[16] prove useful for increasing the number of females who become engineers. This model describes the learning process as having three interdependent elements: cognition, emotion, and environment. If these *three dimensions of learning* could be modified into *three dimensions of factors leading to learning* (enrollment decisions), all motivating factors could be fitted into a single model (Figure 1). Winkelman's[45] factors of social theories could also fit into this one model. Using one model would allow for transferability and generalizability and could enable the analysis of the various motivators influencing females' decisions to become engineers. Once developed, this model could provide a single source of information on motivating factors. In turn, this information could be a tool for guidance counselors and a standardized framework for designing female-friendly, pre-engineering curricula and outreach programs.

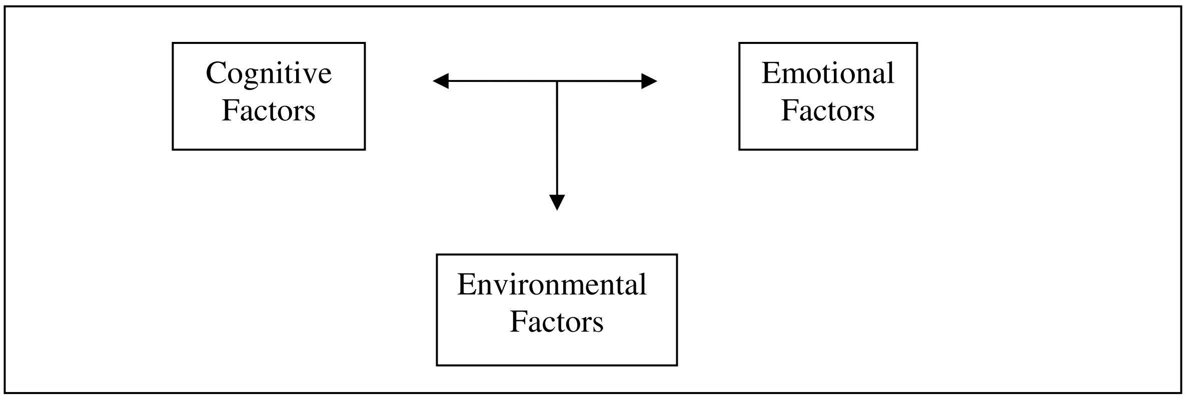

Figure 1. The three dimensions of female engineering enrollment decision: Modified Illeres' three-dimensional learning model.

Table 4 divides motivators identified in this study into three dimensions: cognitive, emotional, and environmental. The cognitive dimension includes interests in and the efficacy of mathematics and science classes, problem-solving skills, and hands-on experience. The emotional dimension, with the majority of motivators, includes a desire to help others, the satisfaction of applying learning, the joys of discovery and creativity, a love for challenge, passion for the work, job variety, family support, role models, intrinsic motivation, self-confidence, religious beliefs, a thirst for excellence, the need to prove one's worth, personality characteristics (self-confidence, persistence, etc.), planning, financial and job security, and the influence of parents. The environmental dimension includes the influence of mentors, the importance of teachers, high school outreach programs, having engineers in the family, career opportunities, career advice, exposure to the field of engineering, the influence of friends, and communication skills. These dimensions are interdependent and equally crucial for females making career decisions.

<u>Adaptability</u>. Various problems unique to females keep women from becoming engineers and make it difficult for academic institutions to retain female scientists and engineers. In 2002, Rosser and Lane[35] analyzed major obstacles unique to women in the field of engineering. These are (percentages indicate the percent of participants citing each obstacle) : balancing work and family obligations (77.4%), time management (13.1%), isolation in a male-dominated field

(11.9%), gaining the respect of peers and administrators (20.2%), balancing the female's career with her spouse's career (28.6%), inability to obtain funding (7.1%), job restrictions such as location and salary (7.1%), networking (1.2%), discrimination (6.0%), establishing independence (4.8%), negative social image (2.4%) trouble gaining access to non-academic positions (2.4%), and sexual harassment (1.2%).

Table 4. Adaptability factors for females in the engineering profession. Female engineering enrollment: Three dimensional factors based on modified Illeres' three-dimensional learning model.

Cognitive Factors	**Emotional Factors**	**Environmental Factors**
Interest in math& science	Desire to help people	Mentors
Problem solving skills	Curiosity	Teachers
Hands-on	Discovery	Mentors
Interest in math & science	Creativity	Engineers in family
	Passion	Opportunities
	Love for challenge	Career advice
	Job variety	Exposure
	Family support	Friends
	Role models	Communication skills
	Intrinsic motivation	Outreach programs at high school
	Self-confidence	
	Religious belief	
	Thirst for excellence	
	Prove worth	
	Planning	
	Parental influence	
	Desire to help people	
	Satisfaction in the application of learning	
	Personality (self-confidence, persistence etc.)	
	Financial security (Job security)	

Although Rosser's[35] study focused on engineers in academics, our study of interviews on the *engineergirl.org* website found similar deterrents. The main barriers the authors found were: gender discrimination and gender isolation, the need to prove one's worth or establish credibility, the difficulty of taking risks, difficulties in finding a proper balance for one's career, and difficulties in communication. However, female engineers listed several positive aspects of the profession that indicated these females liked their jobs. These positives were: the opportunity to solve problems, a collaborative work environment, the possibilities of discovery, and the opportunity to help people. Although the gender gap remains painfully real, the female engineers who participated in the *engineergirl.org* interviews seemed little affected in pay. Communication difficulties ranked as a minor problem; however, it deserves attention since participants in the study included it in their advice for females aspiring to become engineers.

McClusky's[28] theory of Margin in Life (MIL) addresses the dynamic nature of adult life. According to McClusky[28], a person must balance his or her load and power to achieve the proper

MIL. This holds true for male and female professionals. Female engineers who leave their profession may do so because they cannot find the right MIL. This problem should be analyzed through the lens of McClusky's[28] theory to determine what remedies, if any, can be found to retain female engineers in the profession. Human resource professionals must strive to design workplaces and job duties to enable females to better balance their power and load.

Table 5 shows this study's classification of female adaptability factors based on McClusky's[28] MIL theory. Females participating in the *engineergirl.org* interviews identified a number of positive aspects of the profession. These factors would increase a person's power and satisfaction with the engineering career. These positive, power-building factors are: problem-solving, collaboration, discovery, helping people, continuous learning opportunities, application of learning, job variety, creativity, challenges, opportunities, financial security, freedom, knowledge sharing, social status, and foremost among power factors is family support.

Table 5. Model for female adaptability in engineering profession based on McClusky's margin in life theory: power, load and margin in life.

Power	**Load**	**Proof of margin in life**
Problem solving	Gender discrimination	Learning goals
Collaboration	The need to prove worth	Professional goals
Family support	Taking risk	Giving back to community (book writing, outreach programs etc.)
Discovery	Career and family balance	
Continuous learning	Communication	
Application of learning		
Job variety		
Creativity		
Facing challenges		
Opportunity		
Financial security		
Freedom		
Sharing of knowledge		
Social status		
Satisfaction in helping people		

The corresponding, and offsetting, load factors identified in this study were: gender discrimination or gender isolation, the females' need to prove their credibility, risk taking, difficulties balancing work and family, and communication problems. However, the females who participated in the *engineergirl.org* interviews had goals to learn, to grow in the profession, and to give back to the community. These goals imply the participants had found proper MIL.

According to McClusky's[28] theory, if MIL is available, people will use it for learning. This study found these females' goals such as, "to build a solid research program," "to finish a PhD," and "to write a book" as proof that these females had found MIL. It is assumed this particular group of female engineers found ways to increase power overload, which implies that females can adapt to the male-dominated field of engineering.

Conclusion

In conclusion, this study identified factors motivating females to enroll in engineering programs. These factors coincide with factors found elsewhere in the literature. However, this study developed a single theoretical framework by organizing motivating factors to better analyze their impact upon female engineers. This study suggests creating a database for building better outreach programs and also suggests utilizing McClusky's Margin in Life theory[28] to categorize adaptability factors as power, load, and proof of MIL. This database, together with the theoretical framework, could provide a template for analyzing the work environments of female engineers and for developing practical interventions to retain females in the profession. Were these accomplished, solutions could be designed to stop the leakage of females from the engineering pipeline.

Recommendations

Better professional development and human resource policies need to be developed to retain females in the putatively male field of engineering. A comprehensive model needs to be developed to approach this problem. To design such a model, researchers need a clear understanding of what factors attract females to the engineering profession, those factors that keep them in the profession, and the obstacles or forces that drive female engineers out of the profession.

Based on the findings of this study, the following recommendations are made. The recommendations are categorized under the two research questions asked in this study. These criteria are motivating and adaptability factors.

Motivating factors. The following recommendations have been made to increase female enrollment in engineering:

1. Further research is needed to determine the effect of communication skills and persistence in engineering programs.
2. Extensive research must be done to find the affect of female-friendly mathematics teaching strategies and curriculum in motivating females to join undergraduate engineering programs.
3. More studies, both national and international, are needed to understand the effect of parental influence (other than engineers in family) or channeling efforts in female enrollment decisions.
4. Studies are needed to investigate the role of high school career counseling and aptitude measuring tests in identifying potential female engineering students and in motivating those students to join engineering programs at college.
5. Engineering schools must provide more scholarships for females to attract women into the field. Agajanian[1], while studying female enrollment in electronics engineering programs at DeVry University, noticed that more female than males came from lower income households. Agajanian also recommended more scholarships and loans be provided to female students to encourage them to join engineering programs.

6. **6.** Outreach and awareness programs based on theoretical frameworks must be designed to better reach female students.
7. **7.** There remains a need for an extensive review of literature to find all reported factors influencing females' decisions to enter engineering. This information should be categorized into the modified Illeres' three-dimensional model.

Adaptability. The following recommendations have been made to increase female survival in engineering:

1. **1.** Study the effect of communication skill and female survival in engineering profession. How do the communications skills differ among the genders in the profession?
2. **2.** Conduct MIL studies for female engineering students, similar to the study that Thomson[44] conducted for female baccalaureate nursing students.
3. **3.** While studying professional identities of women in technical work, Jorgenson[19] suggested "…greater attention to work and family policies that allow more integration of work and personal life" as a remedy for improving the low rate of retaining women in the engineering profession. An MIL analysis of female engineers' needs must be conducted to determine the power and load in their lives, and to design and implement better interventions to improve female engineers' MIL based on more work and family balance.

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