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ASEAN Journal of Science and Engineering Education

AJSEE
ASEAN Journal of Science and Engineering Education

Journal homepage: http://ejournal.upi.edu/index.php/AJSEE/

A Case Study at the University of West Florida on Improving Recruitment and Retention of Female Students in Engineering

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ABSTRACTS

Women have increased their numbers in many professions previously dominated by men, including law, business, medicine, and other STEM fields in the U.S; however, the number of women in engineering in the U.S. has not increased since the early 2000s. A survey conducted by the Society of Women Engineers reveals that as of Nov 2019, the percentage of women in the engineering workforce is 13% and the percentage of bachelor's degrees awarded to women in engineering and computer science is 19.9%. The authors of this research article understand the need to recruit and retain more female students in engineering colleges that would result in an increased percentage of women in the engineering workforce. To achieve this goal, the authors hypothesize that exposing female students to engineering at an early age and educating their parents about the engineering profession will increase gender diversity in engineering fields. In this research paper, the authors have designed a survey that explores and builds on the underlying connections between female students' aspirations, their parental motivation, the presence of engineers in their family/friends' circle, and hands-on exposure to engineering. The results from the survey are used to develop capacity-building activities for local high school students at the university.

ARTICLE INFO

Article History:
Submitted/Received 10 Mar 2022
First revised 20 Apr 2022
Accepted 04 May 2022
First available online 05 May 2022
Publication date 01 Dec 2022

Keyword:
Female students in engineering,
Family influence,
Capacity building,
Recruitment and retention,
Gender diversity.

1. INTRODUCTION

Engineering education in the United States has a gendered history that, until recently, prevented women from finding a significant place in the predominantly male technical world. Throughout the nineteenth century and most of the twentieth, American observers treated the professional study of engineering as male territory. Despite this prejudice, bias, and treatment of women in engineering as being oddities and/or outcasts, as they defied traditional gender norms, women have made innumerable contributions to engineering fields for decades, often as hidden figures, such as Mary Jackson (NASA engineer) and Stephanie Kwolek (discoverer of Kevlar).

It is interesting to note that in the 1950s, women made up less than 1% of students in U.S. college and university engineering programs. Almost seventy years later, women earned 20.6% of engineering bachelor's degrees, 29% of master's degrees, and 24% of doctorates, and female faculty members held 13.8% of tenured or tenure-track positions in engineering departments (see https://research.swe.org/2016/08/degree-attainment/).

As of Nov 2019, only 13% of engineers in practice are women, 19.9% of degrees are awarded to women in engineering and computer science and they earn 10% less than their male colleagues. Engineering, a field that encourages creative methods of problem-solving for great pay, ought to attract many female students. It should attract female students who aspire to do things like design and build state of the art bridges and buildings, build robots, design computer systems, design and develop aircraft and spacecraft, explore various renewable energy source options and find ways to integrate them into the electric grid, invent new engineering products and dig into many other facets of engineering.

It should attract and retain those female students who want to make a societal impact and work for companies like Google, Apple, Microsoft, GE, Northrop Grumman, and Boeing. It *should*, but it does not. Presently, engineering disciplines attract fewer female students compared to other majors due to low interest in engineering-related subjects while at school, which leads to fewer women being employed in the field of engineering and technology. This results in the underrepresentation of women in these fields (see https://www.stemwomen.net/the-issues-and-barriers-facing-women-in-technology/#more-1429).

Collectively, in STEM fields, women make up ~50% of all U.S. workers, though their presence varies widely across occupational clusters and educational levels. Women account for most healthcare practitioners and technicians but are underrepresented in several other STEM occupational clusters, particularly in computer science and engineering. Analyzing the reasons for this gender disparity at colleges and in workplaces, it is of utmost importance to observe where it all starts. From middle school through college, female students perform worse in some areas of science and mathematics exams when compared to their male peers and report having less confidence and aspiration (Else-Quest *et al*., 2010).

Even when female students perform better than their male peers in STEM exams, many lose interest and do not pursue advanced courses, majors, or careers in STEM. Researchers report that there is an exodus of talented females who could otherwise become the next generation of scientists, engineers, and creators of technology (Dasgupta, 2011).

For nearly a century, the social work profession has advocated, utilized, a person in an environment (PIE) perspective to assess, intervene, and evaluate the effectiveness of social interventions (Reynolds, 1935). With this perspective, understanding the role of the environment as a crucial predictor of student success in both the degree to which families encourage learning at home and to the extent to which they are involved in their child's

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

education is important. A diverse set of factors including familial influences have an impact on the choice of major/career among middle/high school students. Specifically, with female students, perceptions of career fields and parental career paths are critical factors in decisions regarding their choice of major in college. From this vantage, parental involvement may be the first step to parental engagement.

To transcend parental engagement from involvement would mean that pedagogical initiatives need to move beyond providing information to that listening to what parents think, worry, and dream about their children's future and careers inclusive of the female children. Effective family engagement would require a systematic and strategic way of developing a relationship-building process that focuses on listening to family members and community representatives. One way to begin this process is for teachers and other staff members to make prearranged visits to students' homes (Ferlazzo, 2011).

During these visits, school personnel could share the opportunities for their female children in STEM, and then, talk about upcoming STEM-themed events organized by the Parent-Teacher Association (PTA). The Annenberg Institute for School Reform has documented through a multiyear study the positive effects community organizing can have on students, schools, families, and neighborhoods. The concept of active community involvement in students' lives is in line with advancing the idea of *social capital*, i.e., the societal and economic value of building connections among people (Hanifan, 1916).

This paper has designed a survey that explores and builds on the underlying connections between female students' aspirations, their parental motivation, the presence of engineers in their family/friends' circle, and hands-on exposure to engineering. The authors hypothesize those female students can be motivated to pursue engineering as their career by several points:

(i) educating/bringing awareness among their parents about what engineering is and how their female children can succeed in engineering careers,
(ii) having role models in family/friends circle early on in their life, and
(iii) mentoring and nurturing the talent found in female students and encouraging them to become engineers by exposing them to summer camps/workshops.

To better understand the issues governing the underrepresentation of women in engineering, a survey was given to undergraduate engineering students at the University of West Florida. The viewpoints suggested by students in the survey guide the authors in suggesting remedies as a necessary preamble to increasing women's recruitment and retention in engineering.

2. HISTORICAL PERSPECTIVES

During World War I, in the United Kingdom, organizations such as the National Council of Women aimed to get women into the workforce so that men could join the war effort. A subcommittee of this organization formed the Women's Engineering Society (WES) on 23 June 1919. This group of influential women had government backing to support women engineers who were welcomed into the profession during World War I. Nevertheless, at the end of the war, these women were forced to leave the workforce to provide jobs for men returning to the workforce.

These women founded WES, not only to resist this pressure but also to promote engineering as a rewarding job for women (see www.theiet.org/resources/library/archives/research/wes/WES_Vol_1.html). It was a welcome change to see the engineering world open its doors to women, where up until then the field was felt not to be an ideal area of work for women. In 1919, the tremendous work performed by women during the war was universally acknowledged. Further, given women's systematic participation in the labor market, and their ability to adapt to the changing economic environment, it was illogical that they would be prevented from giving their willing and effective assistance in many other industries (Parsons, 1920). The following resolution (Selby, 1920), was passed establishing the educational and economic rights of women at the Women's International Congress:

All opportunities for education, general, professional, and technical, should be open to both sexes. Women should have the same opportunity as men for training and for entering industries, professions, civil service, and all administrative functions. Women should receive the same pay as men for the same work. Lastly, the right to work of both married and unmarried women be recognized; that no special regulations for women's work different from regulations for men should be imposed contrary to the wishes of the women themselves.

In the early 20th century, a large proportion of the human population believed that the right place for women was in their homes and that their duties should be entirely domestic. This view was founded on an incorrect generalization taking what may be true for some and applying it to the whole (Doxford, 1921). As the engineering industry became closed once more to women after the war ended in 1919, it reopened through persistent effort and the passing of the Pre-War Practices Act (Willison, 1921).

Moving forward, women in engineering remained a minority, in the 1960s for example, less than 1% of practicing professional engineers were women. Women engineers were a minority throughout the world, and it was only through congregating at conferences and meetings that they made themselves heard and seen (Winslade, 1967). While women have been a minority in engineering, potentially due to misguided perceptions of their abilities/capabilities, researchers have observed that women globally, given the right education and social climate, could equal men in intellectual achievement (Winslade, 1967).

Looking at workforce statistics from 1977, the participation of women in engineering professions was less than 1%, compared to 2% in accounting, 5% in architecture, 15% in dentistry, 10% in veterinary surgery, and 14% in medicine. Based on these statistics, WES, in 1983, decided to discover how its members were faring by surveying its members. The results were summarized in the literature (West, 1983).

The survey was sent to 60 members and 26 replies were received. Most of the respondents thought that their promotion was a result of their hard work alone; Only two rated their chances of promotion as good. Half of the respondents indicated that their progress might have been easier if they were male. 18 of the respondents were married and 16 of them had children. Out of the total number of replies, half of them stated that children were a hindrance to their progress.

Female students were largely prevented from pursuing higher education until the 19th century. Before the 19th century, female seminaries were the primary alternative for women who wished to earn a higher degree. However, women's rights activists fought for higher education for female students, and college campuses turned out to be fertile grounds for gender equality activism (see https://www.thoughtco.com/history-women-higher-ed-4129738).

We during this time (early 20th century) believed that opportunities for women in engineering would emerge, and they encouraged female students who wished to take up engineering to persevere through initial difficulties and the absence of well-defined openings (Crawford, 1920). The movement of women in higher education started to see success

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

starting in 1979 when more women enrolled in higher education than men in the United States. However, this trend did not extend to the field of engineering.

On 19 June 1964, the United States passed Title VII of the Civil Rights Act of 1964 prohibiting employment discrimination based on sex, race, color, religion, or national origin. This act made it possible to increase the number of women in engineering. Another important milestone was the passing of Title IX of the Education Amendments of 1972, which states that no person in the United States shall based on sex, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any education program or activity receiving Federal financial assistance. These legislations have helped to increase the number of women in professions previously dominated by men, such as law, business, medicine, and some STEM fields. However, the representation of women in engineering has not reflected the same rate of change. The current degree of gender disparity in engineering may be a factor discouraging female students from opting for engineering as a major or choosing it as a career.

3. METHODS

Study Design and Sample: Using a cross-sectional design, a convenience sample of engineering students at one public university in the southern part of the United States of America (University of West Florida, US) was surveyed for the current study. The university represented is located in a semi-urban region in Florida with 86 students responding to the survey. 34% were identified as female. 77% were Euro-American, 8% were African American, and 10% were Asian American. Other ethnicities were represented in the remaining 5%, including Hispanics/Latino and Native American students. Perspectives from across program stages in engineering were also represented. 6% of respondents (year in college) were from freshman year, 21% from sophomore year, 26% from junior year, and 47% from senior year.

This study investigated the barriers to entering the field of engineering. This included both participants of the survey who were men and women. This information was useful to assess how similar or different the barriers encountered by students who were female as opposed to students who were male. This information was also useful to understand the unique experiences of female students who were from the deep south of the united states. Given the small sample size for this study that utilized a case study method, this study was very cautious and cognizant of sampling limits, and hence it did not engage in broad generalizations.

4. RESULTS AND DISCUSSION

4.1. Identifying Barriers to Recruitment and Retention of Women in Engineering

The gender gap in education and employment in STEM fields is detrimental due to a variety of reasons. First, as science and technology became increasingly important in addressing issues affecting humanity (varying from climate change to reproductive technology), there must be female representation in the development of such advancements. Second, STEM fields have value and power in society, and so, unequal representation in these fields can lead to conscious/unconscious perpetuation of inequalities and inequities. Further, given the significant investment in science and technology, both in terms of financial resources and in the movement for "progress," it is imperative to have a diverse group of people with a variety of experiences leading development. Hence, the removal of barriers will help to address social injustice in the fields of STEM and will help to increase the participation of women and minorities. But what are the barriers? There may be many factors contributing to the discrepancy of women in engineering programs, including a lack of awareness about possible

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

career options, lack of female role models, gender stereotyping, lack of familial support to pursue engineering, and lack of gender-sensitive workplace policies (e.g., paid maternity leave, on-site daycare, etc.). Research highlights the need to encourage and support women in STEM fields, and in engineering specifically. While the climate for women in engineering has improved in recent years, misconceptions about engineering, lack of encouragement, peer pressure, and other factors still are barriers preventing more women from pursuing a career in this non-traditional field (see http://www.ewh.ieee.org/soc/es/Nov1999/10/BEGIN.HTM).

According to Bandura's self-efficacy theory (Bandura, 1977), a person's belief about his/her ability to successfully perform a task may be an important factor in the choice of certain behaviors or activities. Wigfield and Eccles (2000) built upon Bandura's theory by arguing that in addition to self-efficacy, an individual's choice of activities and behaviors will depend not only on how well the individual believes that he/she will do on a given task but also on the value that the individual places on the activity or behavior. According to this theory, expectancy and value directly influence achievement choices. If an individual expects to do well at a given task/goal and has placed a value on succeeding at that task/goal, then he/she will work toward accomplishing the said task/goal. These observations extend to women in engineering as women sometimes shy away from choosing engineering careers because they are not sure of their capability to work in technical jobs (see https://www.forbes.com/sites/markfidelman/2012/06/05/heresthe-real-reason-there-are-not-more-women-in-technology/#75070a9a7b73).

Perceptions of career barriers are based on an individual's belief about environmental or interpersonal conditions that inhibit career development and advancement, these perceptions along with external obstacles have prevented women from pursuing engineering careers (Lent *et al*., 2000; Mendick & Moreau, 2013). An example of external barriers was seen in 1933 when Kamala Sohonie was denied admission to the prestigious Indian Institute of Science (IISc) in Bengaluru, India by the then director because she was a woman. Sohonie was undeterred. She insisted that she be allowed to study at the institute. She was eventually admitted but with many restrictions like a conditional/probationary admittance. Sohonie later went on to earn a Ph.D. from Cambridge University. Persistence and determination led to her success in the career she wanted to pursue.

Numerous studies in the United States have shown trends of females in engineering programs reporting feelings of isolation or psychological alienation due to a male-dominant environment, where male students are often hostile toward female students. Some papers Seymour (1995) and Seymour (2002) found that reports of intellectual intimidation for female engineers in the United States are linked to working in group settings or social settings. In individual interviews, women reported experiencing negative attitudes and behaviors from male peers in science and engineering programs. Female engineers expressed anger about male remarks and jokes that they assume was aimed at devaluing them and making them feel unwelcome. Women also reported male assumptions that females were incompetent in practical matters such as repairing an automobile or a household appliance etc. Women reported that men did not allow them to participate in lab experiments or other practical projects and often ordered them around.

Recent studies (see https://www.aspiringminds.com/blog/researcharticles/women-in-engineering-a-comparative-study-of-barriers-across-nations/) suggest more females are participating in the growing technology sector in India. In India as of 1980, women earned less than 2% of engineering degrees, however, since then India has seen a growth in the number of engineering degrees earned by women (Patel and Parmentier, 2005). In 2018, the Ministry

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

of Human Resource Development's of India annual survey of higher education institutions found that over 31% of engineering and technology degrees awarded were earned by women. One of the reasons cited for more female students pursuing engineering degrees in countries like India is that the college environment was more open and welcoming to female engineers as opposed to in the United States. Studies indicated a significant difference in the way female engineers in India feel about the college environment when compared to that of female engineers in the United States and suggest that the "chilly climate" does not exist for females in India as it does for females in the United States (see https://www.aspiringminds.com/blog/researcharticles/women-in-engineering-a-comparative-study-of-barriers-across-nations/).

In another study (see http://www.ewh.ieee.org/soc/es/Nov1999/10/BEGIN.HTM), conducted in Canada, females in both engineering and non-engineering disciplines consistently reported having more confidence, being open to working with males, and feeling respected as compared to male students. The *female engineering students came out to be the most confident among all the groups*. Identifying strategies that worked to increase female participation in engineering in countries like Lithuania, Bulgaria, Latvia, Portugal, Denmark (see https://www.weforum.org/agenda/2019/03/gender-equality-in-stem-is-possible/) and India (see https://timesofindia.indiatimes.com/blogs/minorityview/indian-parents-have-very-highexpectations-about-their-childrens-education-and-careers/ and https://www.thebrowndesi.com/arts-and-culture/girl-going-stem-way/) will assist the researchers in understanding the reasons for a higher percentage of women in engineering in those countries.

One of the variables in this survey was parents/guardians' awareness of female students' understanding of engineering. This awareness is investigated to evaluate the impact it has on influencing female children's interest in studying engineering. Another factor that was considered is the influence on female students' education/career choices concerning the presence of role models in the household/family when the female students are at a young age (typically middle school). The third factor that was researched was the impact of nurturing female students' interest in pursuing a career in engineering through attending and participating in summer camps, workshops, science fairs, and math Olympiads. This paper explores these 3 factors and comes up with strategies and capacity-building activities to increase the recruitment and retention of female students in engineering at UWF.

Female students are diverted from math and science courses early in high school where preuniversity career choices are made (Madara and Namango, 2016) leading to fewer female students enrolled in engineering colleges and fewer women in engineering careers. Concerns about the underrepresentation of women/female students in engineering careers/colleges have been raised and expressed by various researchers in the U.S. The major factors which contribute to the underrepresentation of women in engineering have been identified to include lack of relevant policies, inadequate curriculum content, and delivery, issues of competition, isolation, lack of female role models, etc. Systemic obstacles include cultural influences, gender stereotyping (both at home and in school), peer pressure, and images in the media.

Many middle and high school students do not have a clear idea of what engineering is or what engineers do. The same is also true with many parents who cannot provide guidance to their children (especially young girls) or pique their interest in career choices in engineering. Often, the female students assumed that engineering was too complex and difficult for them. The perception of difficulty presents an obstacle that discourages female students from

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

pursuing engineering as a career; this results in them pursuing careers that society perceives to be more achievable. On the other hand, boys are often encouraged by their parents and peers to engage in mechanically oriented hobbies, which prepare and generate interest, for various aspects of engineering. According to http://www.ewh.ieee.org/soc/es/Nov1999/10/BEGIN.HTM:

Engineering is perceived as a technical, often a solitary pursuit, in which one works with machines rather than people. Career options in engineering are not well known to most adults, let alone teenagers, and are not well represented in high school curriculum or through career guidance counseling. This affects girls disproportionately, as they typically have less access to information about engineering outside the school environment.

Teachers often have stereotypical views which result in them encouraging male students to choose STEM subjects more than female students; this attitude and stereotyping impacts female students' choices (Good *et al*., 2008; Owens and Massey, 2011). In contrast, those teachers that do support female students and their interest in STEM results in female students progressing further in STEM fields (Ertl *et al*., 2017). Research documents that female and non-white students faced significantly more barriers in their careers than men (Gnilka and Novakovic, 2017). Instances, where there are women role models, may be useful in providing a more balanced view of the field and help in forming a realistic perception for female students about engineering and engineering careers.

4.1.1. Impact of role models and perception of female students

Studies have been conducted to determine the impact of female role models' visits to high schools, as speakers in math and science classes where female students were enrolled. The visits by female role models raised awareness about career options and possibilities for female students. At the high school age, projecting themselves into long-term career paths may be difficult for students. Female students may need long-term mentoring by female role models (Taylor *et al*., 2001). A student's determination is influenced by the role models with whom he/she relates. This can be seen in female students who read biographies of female engineers and can identify with them, being more likely to pursue engineering careers (Stout *et al*., 2011). Thus, the utility of role models is very germane.

Access to role models and mentors influences successful professional development. Female young adults identify with successful female role models whose presence allows them to think: "If she can be successful, so can I" and "I want to be like her." Typically, however, female college students encounter few female role models who are faculty in STEM departments. STEM faculty members (especially full professors in physical sciences and engineering) are four times more likely to be male than female (see http://www.nsf.gov/statistics/wmpd/2013/digest/theme5.cfm).

However, when STEM professors are female, their presence in classrooms has clear benefits for female students. For example, one study found that female students enrolled in college courses in calculus taught by female faculty, as compared to those taught by male faculty, felt more confident about their math ability and viewed mathematics as central to their sense of self, which in turn increased their intentions to pursue STEM careers (Stout *et al*., 2011). Role models also serve as mentors who guide professional development, champion students' work and broaden their professional network. A dearth of role models means undergraduate female students are less likely to learn how to navigate the path from their first year in college to engineering careers, which is critical in persisting to a career in engineering.

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

4.1.2. Awareness about what is engineering and what engineers do

To increase awareness about the field of engineering among female students, it may be important to start with increasing awareness at the middle school level and then continue these efforts at the high school level. This could lead to sustained interest in the subject, improved recruitment percentages, and increased retention rates in engineering programs. In middle and high school, mothers' (more than fathers) support adolescent girls' motivation to persist in science and math (Leaper *et al*., 2011). However, on average, mothers apply gender stereotypes about math and science to their children more than fathers do (Yee and Eccles, 1988). These studies have led the authors to hypothesize that early awareness about what engineering is and what engineers do must be imparted both to females in middle and high school as well as to their parents.

This increased awareness is likely to bring about a positive change in the perceptions of the field. Another hypothesis is that a positive attitude toward the field of engineering may help to increase the recruitment and retainment of female engineering students. Further study could be done to see to what extent positive parental attitude toward engineering could be attributed to the student's attitude toward the field. British Gas did a survey (see https://www.theengineer.co.uk/research-highlights-stem-gender-gap/). The research involved over 2,000 young people aged between 15 and 22. The survey found that women are turning their back on the STEM sectors for a variety of reasons, including a lack of science, technology, engineering, and mathematics knowledge (30%), a perception that the industries are sexist (13%), and a belief that science, technology, engineering, and mathematics-based careers are better suited to men (9%).

4.1.3. High school context and formation of educational and career plans

Schools could play a positive role in highlighting the importance of gender in career-relevant decisions including the gender gap in science, technology, engineering, and mathematics orientations (Legewie and DiPrete, 2014; Gentry and Owen, 2004). A strong high school curriculum in math and science provides more opportunities for concrete experiences and competence and provides a partial antidote to gender stereotyping and the discouragement of female students' interest in STEM fields. Therefore, if there are events where STEM professionals, including women, interact with high school students to provide experiential learning opportunities, there might be an increase in female students' interest in STEM.

Additionally, students find STEM courses more meaningful when they connect classroom experiences with personal goals. Academic tasks that are personally relevant enhance motivation, attention, learning, and task identification (Gentry and Owen, 2004; Hidi and Harackiewicz, 2000). For example, when students learn math via hands-on projects, rather than abstract instruction, they view the subject as more interesting and personally meaningful (Mitchell, 1993). Importantly, female students are more interested in math instruction taught from an applied perspective than male students (Geist and King, 2008; Halpern, 2004).

STEM fields are perceived, often incorrectly, to impede communal spirit, whereas service professions (social work, nursing, teaching, human resource) are perceived to facilitate communal/community spirit (Diekman *et al*., 2010). Because communal/community goals interest females more than males (Su *et al*., 2009), the seeming mischaracterization of STEM impeding communal goals may lead to female students moving away from STEM careers. Stereotypes about STEM are inaccurate: physical and life sciences as well as engineering and

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technology involve intense collaboration within teams and are critical to solving real-world problems that help people and society. However, female students in middle and high school are unexposed to the communal values inherent in STEM occupations.

Recent research on gender differences in math ability shows that the gap in math performance and courses studied has largely closed (Hyde et al., 2008). Not only are female students' performances in math tests very similar to those of male students, but female students also take at least as many math classes in high school as do their male counterparts with a similar level of class rigor. Different characteristics of classroom teaching show substantial effects on students' academic self-concept and their interest in a subject (Lazarides and Ittel, 2012).

Comparisons in the classroom set an external frame of reference for the self-assessment and attribution of achievements (Rost *et al*., 2005). Teachers' support in the attribution of achievements can help students overcome gender-specific attribution patterns (Heller and Ziegler, 1996). Teachers' behavior can support students' interest and the development of a positive academic self-concept and encourage them to consider STEM as their favorite field; it is important to also keep in mind that the opposite effect is possible as well (Ertl *et al*., 2017).

4.1.4. Workplace environment

Research shows that when men and women apply for jobs – whether it be blue-collar positions or those with high qualifications – men are more likely to be boastful and self-promote while women are more likely to be "modest" and "undersell" themselves. Even in groups and workplace discussion settings, the views of women are either ignored or listened to less seriously than those of men. As a result, women tend to underestimate their ability relative to men, especially in public settings, and negotiate less successfully. For example, in the United States, over 60% of B.Si., M.Si., and Ph.D. degrees in biological and chemical sciences are held by women. Only 25-30% of them study computer science, physics, and engineering. Cheryan *et al*. (2017) suggested three socio-psychological reasons, namely

(i) masculine culture;
(ii) lack of sufficient early exposure to computers, physics, and related areas compared to boys in early childhood; and
(iii) gender gaps in self-efficacy.

Occupational turnover is costly, especially in fields like engineering that are characterized by rigorous education and training requirements (Rost et al., 2005). Women who go to college intending to become engineers stay in the major less often than men (Fouad et al., 2017). Most women who left engineering stated that it was difficult for them to find part-time jobs (since they had to care for their families) in the engineering field and that was the main reason they left the occupation altogether. Some women reported that their supervisors did not support them when they needed maternity leave or requested more flexible work schedules (Fouad et al., 2017). Furthermore, a recent survey by SWE reported that only 30% of women who graduated with a degree in engineering are still working in the engineering field after 20 years.

The underrepresentation of women in engineering creates an environment where women are the minority and often do not get the support they need from their managers or colleagues. Numerous explanations are offered for this discrepancy, including a lack of mentorship for women in the field, events/instances that lower self-confidence, and the demands of maintaining a work-life balance.

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

According to https://www.beckershospitalreview.com/healthcare-information-technology/survey-8-things-toknow-about-the-gender-gap-in-stem.html Blickenstaff (2005), the top reasons why women elect not to work in STEM-related jobs are:
(i) Faced discrimination in recruitment, hiring, and promotion (39%)
(ii) Not encouraged to pursue science, technology, engineering, and mathematics from an early age (39%)
(iii) More difficult to balance work/family in science, technology, engineering, and mathematics jobs (33%).

4.2. Proposed Recruitment Strategies

Despite the efforts being made to increase the number of females working in STEM fields, according to the Congressional Joint Economic Committee, only 14% of all professionals working in the engineering industry are women. This number is drastically lower than the percentage of women who are part of the entire U.S. labor force (see https://www.dol.gov/wb/widget/). The Department of Labor reported that women made up 55% of the country's workforce as of March 2020.

Research conducted by the National Science Foundation (NSF) documents that the percentage of female science and engineering workers continues to be the lowest in engineering, where women constituted only 14.5% of the workforce as of 2015 (see https://nsf.gov/statistics/2018/nsb20181/report/sections/science-andengineering-laborforce/women-and-minorities-in-the-s-e-workforce). Among engineering occupations with large numbers of workers, women accounted for only 9% of the workforce of mechanical engineers and about 10–13% of the workforce that included electrical and computer hardware engineers, aerospace, aeronautical, and astronautical engineers. During the past two decades, the proportion of women engineering employees increased (from 9 to 15%). This increase was in part due to the increase of women in the workforce (108% in engineering), while men's numbers barely changed between 1993 and 2015 (see https://www.nsf.gov/statistics/2018/nsb20181/report/sections/science-and-engineering-laborforce/highlights).

This background motivated the authors to investigate the participation of women in engineering simultaneously attempting to answer the following questions:
(i) What are the main reasons for female students' interest in engineering?
(ii) What are some barriers to female students' developing an interest in engineering?
(iii) How can more young women be encouraged to develop an interest in engineering before enrolling in college?
(iv) What are the issues that are critical to the recruitment and retention of women in engineering and how do develop strategies to overcome them?

While there have been several suggestions/measures published to date, in this paper, the authors primarily focus on the relationship between familial influences and females pursuing engineering careers. The paper focuses specifically on the impact of family and PTAs providing awareness and relevant information (e.g., salary, growth, societal benefit, etc.) of engineering careers to the recruitment and retention efforts of engineering programs at the University of West Florida (UWF). To determine the issues that are faced by women in engineering, a survey was given to the engineering students (both male and female) at UWF.

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

4.3. Survey Analysis

Purposive sampling was utilized to collect information on why students were interested in engineering and the barriers students encountered. 86 students took the survey, 57 were male, and 29 were female. **Figures 2 - 4** show the gender, ethnicity, and year in college mix of the students who participated.

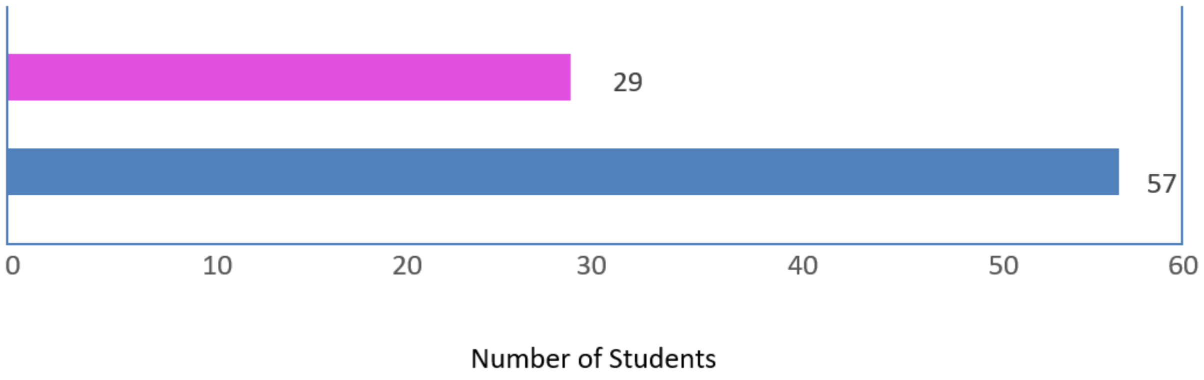

Figure 2. Gender of students who took the survey.

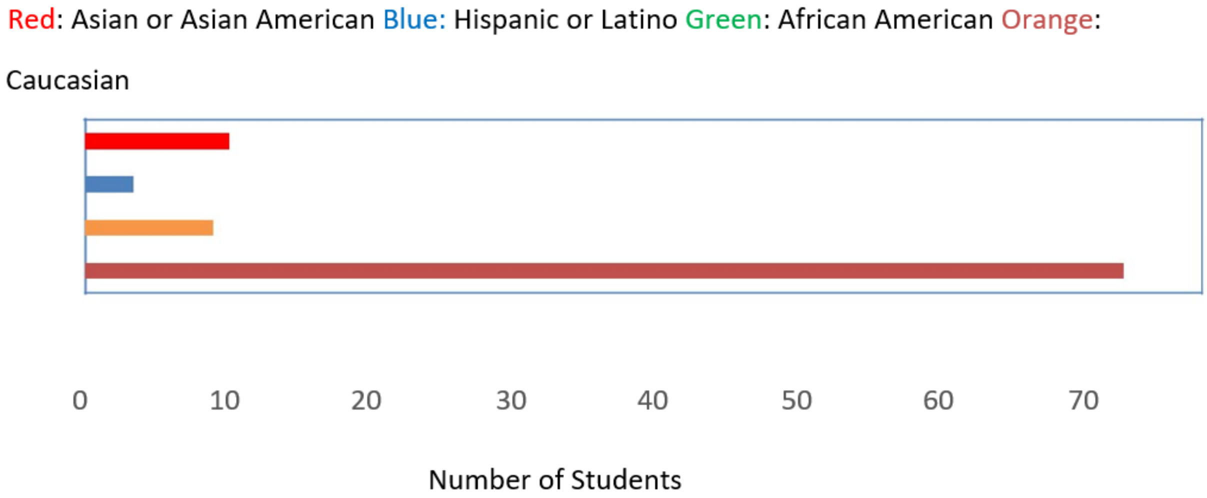

Figure 3. Ethnicity of students who took the survey.

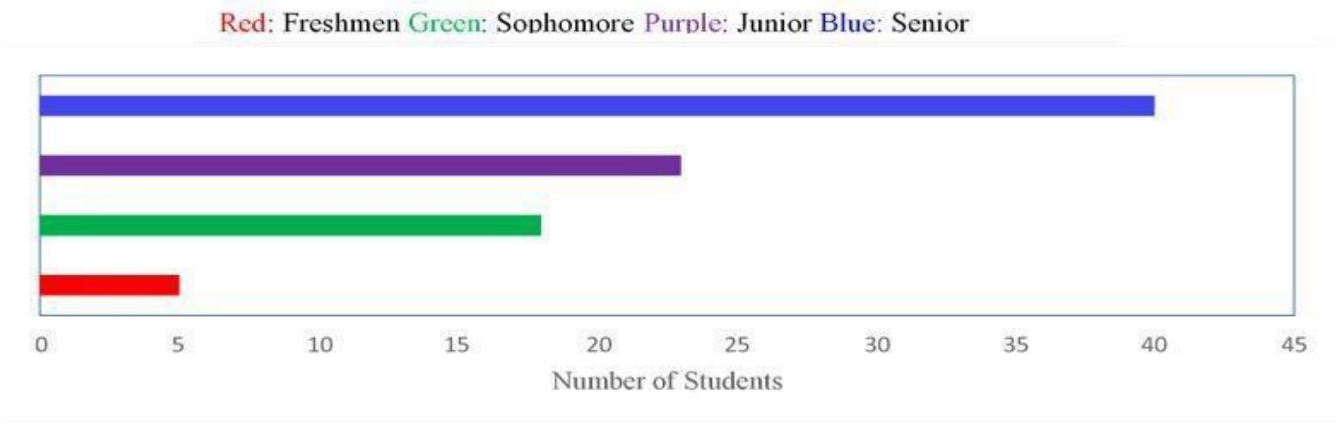

Figure 4. Students' year in college.

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

As seen in **Table 1**, when asked about the person *who* has influenced them to choose engineering as their field of study, more than 50% of the students answered that they were motivated on their own due to their interest and the career research they conducted. However, 29% of the students indicated that they chose engineering due to encouragement/career advice provided by their parents, highlighting the major role parents play in guiding their children toward their future careers proving the authors' hypothesis correct.

Table 1. Distribution of results based on gender for the survey question: "Who influenced you to choose engineering"?

Answer	Male students (%)	Female students (%)
Parents	12	17
Teacher	5	9
Guest speaker	1	0
Guidance counselor	1	2
Others*	19	34

*Others constitute reasons that were 3 militaries, 30 ourselves, 5- spouse, 3 salary/job availability/field, 1-friend, 1-mentor from childhood

Another crucial aspect is *when* (at what grade in school) female students decide their career path. From the data in **Table 2**, it is evident that role models/influencers do play a vital role in shaping female students' career choices. Most of the students made that career decision either in middle school or in high school, and only 20% of students waited until college to make a choice. The survey confirmed the authors' belief that reaching out to female students while they are still in middle and high school and educating them about careers in engineering would help them to consider this field and see themselves as future engineers.

Table 2. Distribution of results based on gender for the survey question: "When did you decide to choose engineering as a career?"

Answer	Male students	Female students
Middle school	10	4
High school	17	19
College	12	8
Others	9	6

Aside from stereotypes, another key barrier is the negative perception of the difficulty of engineering subjects. Research has shown that female students/teachers/parents are aware of the importance of engineering, yet the negative perception around related course difficulty, often beginning at the high school level, dissuades women from pursuing the major. When asked about the barriers they faced while choosing engineering as their field of study, nearly 50% of the students listed self-doubt in their abilities and anxiety about the rigor/difficulty of the courses they need to take in the major.

Female students link engineering to problem-solving, analytical thinking, innovative thinking, creative thinking, decision-making, and teamwork. Not surprisingly, the top reason listed (75% of respondents) for their friends not choosing engineering as their field of study was their lack of confidence in their abilities, especially in courses requiring advanced knowledge of mathematics. Past research shows that for female students, the key drivers of

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

subject choice are how good they are at the subject (94%), the subject syllabus (92%), and whether the subject teacher is knowledgeable (91%), while 87% believe whether the teacher is fun is also important.

Some respondents mentioned that female students were intimidated by the sheer number of men taking engineering courses and presumed that "it is not for them." There is a stigma that women who choose engineering will struggle in their careers since the jobs would be mostly filled by male counterparts. This stigma/fear about their job and career prospects form a major hurdle for female students contemplating engineering as a field of study. Parents and teachers are significant influencers of school subjects chosen among female students and conversely influence career aspirations.

Parents continue to struggle to make informed decisions and give guidance to their daughters. When asked about the possible reasons for choosing engineering (**Table** 3), 72% of students said that they were interested because they were good at math and science, 57% listed high salaries and career opportunities, 24% listed influence by someone employed in engineering, and 28% mentioned encouragement by parents as a reason for choosing engineering. Table 5 shows the distribution by gender to the question: "What made you interested in engineering?".

Table 3. Percentage distribution of gender-wise responses to the question: "What made you interested in engineering?"

Answer	Male students (%)	Female students (%)
Someone I know was in the field	9.06	3.08
Career opportunities	17.14	11.18
A relative was an engineer	7.24	4.32
Other	8.42	3.72
Good at math and science	25.34	10.5

Today's youth have limited understanding, or potentially flawed perception of engineering. Their understanding often lacks clarity about engineering, and they may mistake it for trade school occupations (e.g., mechanic, repairman). Many people mistakenly perceive an "engineer" to be someone who works with machinery. This misleading "grease behind your fingernails" image can discourage pupils, especially female students, and promote an inaccurate image of a profession that has changed radically over the last 20 years (Seymour 2002). High school students, including females, and the people who influence them—teachers, school counselors, parents, peers, and the media—largely do not understand what a career in engineering is like and therefore do not consider it as a career option. Undeniably, misconceptions regarding exactly what engineering is about to constitute a real barrier to understanding the profession.

It is observed from the survey that the major factors that contribute to this underrepresentation include inadequate curriculum content and delivery, biased teaching materials, lack of role models, lack of understanding of what engineering is and what engineers do, and negative socio-cultural attitudes and practices. To address these shortcomings, the authors of this article propose to develop specific strategies to attract and retain women in engineering. The approaches/methodologies used in these strategies are formulated as a series of activities and events designed to encourage female students in middle/high schools to understand what engineering is and what an engineer's work looks like, break the illusion of engineering being a "man's field," educate parents on how they can

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p- ISSN 2775-6793 e- ISSN 2775-6815

encourage their female children to consider engineering, and organize activities to motivate female students to study engineering.

The primary goals of this research are to (1) verify the hypothesis that having familial influence, exposure to engineering role models early in schooling, and teaching what engineering is and what engineers do are factors in career choice; (2) propose methods to attract and retain women in engineering. First, the authors focused on the importance of engineering and how gender parity and the factors listed above play a significant role in the number of women in engineering. Second, the authors focused on assessing the views of male and female students with regards to why they chose engineering and the barriers they faced. The survey results support the conclusion that young women do not shun engineering careers just because of laziness or inability—they simply do not see it as attractive, comparatively, due to *non-familiarity with the field* and psychological and financial signals sent by society and the *business world*. A combination of negative stereotypes about engineering and apprehension about enrolling in mathematics-based courses may contribute to the current state of women in engineering.

4.4. What can be (and need to be) done to improve the recruitment and retention of women in engineering? Capacity-building activities

For the efforts to attract and retain women in engineering to be successful, both the perception and apprehension about engineering should be challenged and changed. Stereotypes are embedded in us: in our families, in our beliefs, in our culture, in our media, and our society at large, hence it is extremely difficult to change our perceptions. However, the war against stereotypes should start, and it should start with all the stakeholders. In the future, the change should be initiated and achieved in a consistent and targeted manner, supported by sufficient resources and practical policies.

Engineering educators need to increase public awareness by addressing deep-rooted misconceptions about the field of engineering and emphasizing the importance of the field through public forums. If the role of engineers is more visible and better understood, more young people (both females and males) would be attracted to engineering as a career.

To initiate capacity-building strategies that focus on women in engineering, the authors considered community and social development approaches that reflect cycles of human interdependence and healthy and dynamic transactions. Examining the "common human condition," rather than individual development on its own, assists in laying aside the false impressions of resilience or capacity.

Therefore, focusing on "the common human condition," one can view individual advancement in the context of communities that form their reference groups. According to Sacha (2004), *Sustainable development can be achieved only through an approach that considers everything from geography to infrastructure, to family structure*. In this context, Dr. Martin Luther King Jr.'s saying is indeed germane: "I can never be what I ought to be until you are what you ought to be. This is the way our world is made. No individual or nation can stand out boasting of being independent. We are interdependent." This saying has implications for the field of engineering, as it is exploring an interdisciplinary approach to advancing women in engineering.

A developmental approach informs that when resources and services supplement people's capabilities, they live productive and fulfilling lives. Thus, a developmental approach to community-level interventions and its relevance in increasing awareness and bringing about attitudinal changes toward the field of engineering would require that we work with multiple

DOI: http://dx.doi.org/10.17509/xxxx.xxxx
p- ISSN 2775-6793 e- ISSN 2775-6815

stakeholders, including high school female students, academic counselors, school administrators, high school student science clubs, parent-teacher associations, faith groups, an association of women engineering students, practicing women engineers, women faculty, and women entrepreneurs. Although community organization and other forms of macro practice are usually associated with developmental interventions, conventional community practice approaches (such as neighborhood building, social services planning, and social action), it could be effectively utilized as investments that address peoples' material needs.

To increase the number of women in engineering, we must view these strategies as a social investment and aim to enhance participation through robust funding. Funding areas could include creating opportunities for employment, self-employment (microenterprise), focus on asset-building strategies, and creation/funding of programs to remove barriers. Consequently, these policy and practice interventions can be used to help remove dated perceptions that women are not good in math and science and to demystify the field of engineering with the potential for increased economic participation. With this contextual ethos, the following interventions could be initiated, and their efficacy could be evaluated:

(i) STEM summer camp programs for middle school girls at the University
(ii) After-school tutoring programs for math and science (middle school)
(iii) Events for families with middle school-aged girls to interact with women engineers and UWF engineering students to learn about engineering and its relevance to society, and their motivations to pursue engineering
(iv) Organize presentations by women engineers and women engineering students at science clubs in middle schools
(v) Meet and Greet middle school teachers and staff with UWF engineering faculty and students
(vi) Engineering fair at local churches

Having summer camps at the University will help to introduce middle school girls to their first engineer role models. Mentoring has been positively linked to women's representation in engineering programs in the past (see http://arec.oregonstate.edu/diversity/diversity3.html). "Formal and informal events and having dedicated physical space are all highly correlated with women's representation" in engineering programs (see http://arec.oregonstate.edu/diversity/diversity3.html). Parents, immediate family, other relatives, and friends are all contributors to these decisions. Unfortunately, some students enroll in programs because their parents are in that industry or a related one, have an endowment to a school's program, or contribute money, or even because of the infamous "because I said so".

5. CONCLUSION

In the US, all the computer science and engineering colleges have been exploring and putting forth efforts to recruit and retain more women in these fields. This research paper describes the authors' hypothesis, findings from a survey, and a series of capacity-building activities for actively recruiting and retaining female students in engineering programs at the University of West Florida. Such recruitment and retention of female students is crucial to the country's efforts to increase the number of women in the engineering workforce and is a priority for the University of West Florida. Our research findings have significant implications for the recruitment and retention of female students in engineering.

Our survey results show that parents/siblings/friends and their support and encouragement are particularly important for female students' choice of engineering as a career. Female students can be influenced to choose engineering by factors like intrinsic

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p- ISSN 2775-6793 e- ISSN 2775-6815

motivation, knowledge about what engineering is and what engineers do, excitement in the subject matter, desire to use math and science skills, participation in technological innovations, and aspire to have a societal impact as a career goal. They still must overcome considerable stereotypes to undertake engineering as their career and should not feel excluded or not accepted in the workplace. Interventions that could provide more support and educate parents and peers to encourage female students will be very beneficial in increasing the representation of women in engineering. The authors are initiating a plan to achieve our recruitment and retention goals.

(i) STEM summer campy that include mobile robotics camps for middle and high school students by coordinating with local Girl Scouts council and public schools to assist with recruitment

(ii) After-school tutoring programs for math and science (middle school) by our SWE, AWIS, and IEEE sections through their outreach programs

(iii) Expansion of our undergraduate mentoring program by professional engineers working in local industries/air force laboratories.

The future scope of this research would include documenting and analyzing the activities that were conducted along with pre and post surveys reflecting the high school students' shift in attitude towards choosing engineering as a major/career, parents' awareness and knowledge about engineering as a profession, impact of hands-on activities that encourage female students to pursue engineering in college.

6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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