WOMEN IN ENGINEERING: PAST, PRESENT, & FUTURE

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Abstract *—Historically, engineering has been thought of as a field of study predominantly best-suited for men. In fact, the masculine face that engineering often assumes has overshadowed, and in some respects, continues to overshadow the concept of the engineer in many people's minds. While this conception has prevailed historically, in recent decades, the feminine face of the engineer has slowly emerged. This paper will explore the historical underpinnings of engineering as a career choice, with a focus on the emerging contributions of women to the profession. This exploration will include an examination of some of the barriers common to women considering a career in engineering along with a discussion of how these barriers have been, and continue to be surpassed. The role that professional societies have played in terms of recruitment of women to the profession will be presented.*

Index Terms —Engineering as a career choice, professional engineering societies, women in engineering, women's leadership in engineering.

INTRODUCTION

Throughout much of the past century, the contributions of women to the field engineering (and science, in general) were largely absent in the literature. As a result, the common perception was that engineering was a field best-suited for men. Within the academic setting, women slowly began populating the college-level science and engineering classrooms in the 1950s and 1960s. Compared to their male counterparts, the number of women enrolled in engineering classes was disproportionately small. Today the number of women choosing to major in engineering remains far less than the number of men. In the U.S., over the past 20 or so years, the percentage of women choosing to major in engineering has hovered around 14 – 18 % [1, 2]. The discussion that follows presents a brief overview of the historical underpinnings of engineering and engineering education within the U.S. In addition, the emerging voice of the female engineer will be described, with emphasis on historical connections.

HISTORICAL UNDERPINNINGS

Larkin [3] suggests that the predominance of male engineers is due in large part to the public's image of what an engineering is and what an engineer does. Oftentimes, the public's image of an engineer often involves someone who wears a hard hat, sturdy work boots, and routinely gets their hands dirty. This rugged image most often conjures up a male persona in most people's minds.

Women tend to pursue careers in which they can make a tangible contribution to helping other people and/or to society as a whole. Engineering has often not been a popular career choice among women due in large part to the masculine image of the engineer. This masculine image has become somewhat more opaque in recent decades, but unfortunately, remains quite vivid for many. In addition, engineering has not been seen as a profession through which an individual can make a difference by helping others. Historically, more "traditional" career choices for women were within the nursing or teaching professions. These professions were often viewed as much more appropriate for women, and; ones for which the opportunities to be of help to others were much more obvious. Perhaps the misconceptions regarding engineering as a career choice are due in large part to the fact that most people don't understand what engineers do. This misunderstanding begs the question 'What DO engineers do?'

Certainly engineers solve problems. However, engineers do so much more than simply solve problems. It might be said that doctors and nurses are the people that help people recover from illness. Engineers, on the other hand, are responsible for the development of the technologies that enable doctors and nurses to treat people as well as to help prevent people from getting sick in the first place.

Prior to the women's movement in the 1970s, little research had been done to evaluate the contributions of women to the fields of science and engineering. Furthermore, Kass-Simons & Farnes suggest that it was practically impossible to find women scientists and engineers who were willing to carry out such research [4]. Kass-Simons & Farnes further intimate that the reasons that it was difficult to find women willing to conduct this type of research were:

> First, it was very difficult in some areas to locate practicing women scientists (women's organizations in a number of fields were just then being formed).

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> Secondly, most women scientists were too busy trying to stay afloat in their own fields to take time out to write about nontechnical subjects. And thirdly, many women shared the general attitude that matters concerning women, even scientific matters, could never be considered worthy of scholarly endeavor. (pp. ix – x)

The following section briefly highlights some of the noteworthy contributions of women to the fields of science and engineering over the past century. Within this discussion, a more feminine persona of the engineer will emerge.

The Emergence of the Female Engineer

Emily Warren Roebling and Kate Gleason are two of the first and most notable females to make their mark on the engineering profession in North America [5]. While having no formal engineering training, Roebling played a significant role in the construction of the Brooklyn Bridge. Her husband and father-in-law, Colonel Washington Augustus Roebling and John Augustus Roebling respectively, are typically given credit for its construction. The plans for the construction of the bridge were approved in 1869 [6]. However, a serious accident occurred early in its construction which crushed both of John Roebling's legs. Shortly thereafter, a crippling illness permanently disabled her husband, and it was Emily Warren Roebling that spent the next 11 years supervising the completion of the bridge.

Kate Gleason was the first woman to take a mechanical engineering course at Cornell's Sibley School of Engineering, the first university in the eastern U.S. to accept women [7]. Gleason did not graduate with a degree in engineering and she eventually went on to pursue other fields, one of which was banking. She later went on to be the first female president of a U.S. bank.

The first woman to graduate in the U.S. with a degree in engineering was Elizabeth Bragg [8]. Bragg graduated with a degree in civil engineering from the University of California in 1876. A few years later, in 1892, Emma Wilson graduated from the then Iowa State College, also with a degree in civil engineering [9].

While the presence of women in engineering was sparse during the 1800s and early 1900s; there were brief periods, such as war times, where the female face did emerge in engineering in larger numbers [10]. As there were fewer and fewer men available on the home front during World War I (WWI), the opportunities grew for women to work in factories and other venues, including engineering, that were directly related to the war effort. Alice Goff was one of the first women to benefit from the shortage of male engineers during WWI [11]. In 1915, Goff graduated from the University of Michigan with a B.S. in civil engineering. After graduation she went to work in the steel industry and was involved in all aspects of the development of applications for the use of concrete in large buildings. For example, one of her most notable projects related to the war effort involved the creation of a bomber assembly plant in Texas.

Also within this same time frame, there were a small number of women in other engineering or engineering-related programs at a handful of schools throughout the country. For example, in 1919, the University of Wisconsin conducted a mechanics class for women. In 1920 seven women were accepted into the co-op program to study either commercial or chemical engineering at the University of Cincinnati [12].

Following WWI and with the crash of the stock market in 1929 which marked the beginning of the Great Depression, the world saw economic disasters of enormous proportions. As a direct result of these disasters, unemployment was rampant during the depression years, and jobs that were previously held by women were sacrificed in order to allow them to be filled with men. This was particularly common if the woman was married. The prevailing notion of the time was that the man was the "breadwinner" and the woman the "domestician."

Lillian Gilbreth was one of just a few resilient career women of that time, who, along with her husband Frank, managed to continue to operate Gilbreth & Co., a consulting firm that helped companies improve management, efficiency, and production techniques. Gilbreth received the B.S. and M.S. degrees in literature from the University of California, Berkeley prior to marrying Frank in 1904. In 1915 she received her Ph.D. in psychology from Brown University. While known as the mother of modern management, throughout history, Gilbreth has primarily been considered her husband's assistant, even though he never earned a college degree [13]!

The war was responsible for the direct correlation between wages and the quantity of finished product. As a result, manufacturers quickly sought the help of engineers to aid them in such areas as quality and cost control. When manufacturing efforts expanded, so did the need for greater productivity. Industrial engineers quickly began to develop strategies to improve overall efficiency. During this time period, the Gilbreths worked to develop time and motion studies related to manufacturing issues and quality control [14]. After her husband's death, Gilbreth took over the couple's company and she remained professionally active for nearly fifty years until her death in 1972 [15]. In 1926, Gilbreth became the first female member of the American Society of Mechanical Engineers (ASME). In 1935, Gilbreth became a member of the full time faculty at Purdue University. She was the first female engineering professor at Purdue [16]. In 1965, nearly 40 years after becoming a member of ASME, Gilbreth became the first woman to be granted membership in the National Academy of Engineering (NAE) [17 – 18].

After the start of World War II (WWII) in 1939, women once again returned to the workplace. Some U.S. universities and colleges developed special training courses

in engineering exclusively for women. For example, women at the University of Cincinnati were trained to be airplane factory supervisors for the Goodyear Aircraft Corporation. In addition, the University of Idaho offered women a course in auto mechanics. Further, at the Colorado State College of Agricultural and Mechanic Arts (now Colorado State University) women learned how to remodel Curtis-Wright engines [19].

Similar to the end of WWI, when WWII drew to a close and men again began to return home from the war, employers were quick to tell women to return to their domestic responsibilities at home. Many of the special training programs for women that had been created during wartime were quickly dismantled and the educational opportunities for women in engineering became severely limited. Many universities with engineering schools or programs did not accept women. Professional societies would also either exclude women entirely or offer them some sort of crippled membership [20]. The Society of Women Engineers (SWE) was created in 1950 as one mechanism for dealing with this unmitigated discrimination of women in engineering.

As noted earlier, the strongly masculine connotation of the engineer stems, in part, from the distinctive origins of the engineering profession. Throughout most of the 19th century, it was rare to receive a formal degree in engineering; rather, the skills and training required for the job were acquired through hands-on experience in male-dominated work environments. Railroad yards, machine shops, and surveying crews prepared men for a career in which they could design and create problem-solving technologies. These types of work environments were physically demanding and often dangerous, which often deemed them to be inappropriate workplaces for "respectable women" of the time [21, p. 46]. Many years would transpire before women were given the chance to work in male-dominated professions.

Despite the rigorous physical demands of the previously mentioned occupations, these jobs provided incredibly useful technical training and experience to the people that worked them. Manipulating materials, erecting buildings, and constructing and repairing machines provided an excellent foundation upon which an engineering career could be built. Given that it has been long deemed more acceptable for men to work in hands-on, technical jobs than women, greater numbers of men have been prepared in the workplace for a career as an engineer. However, the changing composition of the workforce during the world wars offered women a chance to shift social conventions and earn their turns as the "tinkerers" rather than the "nurturers".

The following section addresses some of the barriers women have historically faced when making career decisions. Barriers most prominent to women considering careers in engineering and the sciences will be described. These barriers are also prevalent for many women seeking career advancement within their chosen profession.

BARRIERS AND THE "GLASS CEILING"

It has been historically observed that women are recruited to and retained in the sciences and engineering in lower numbers than men. Research is emerging about the barriers that have prevented women from pursuing careers in engineering in the past, and about the glass ceiling that women face when entering leadership positions in the field of engineering. The gendered disparity observed in the academic, professional, and leadership realms of the field of engineering exists as a result of historical and institutional factors.

The educational and professional worlds of engineering have historically been viewed as somewhat hostile environments for women. Tobias (1990) has investigated the environment of introductory science courses in colleges and argues that typical classrooms are "...competitive, selective and intimidating, and designed to winnow out all but the 'top tier'... there is little attempt to create a sense of 'community' among average students of science" [22, p. 9]. Therefore, the typical lecture-based science classroom may actually inhibit the learning of some students, particularly females who may already feel intimidated as a minority group. Larkin (2009) proposes that the use of diverse teaching styles in the classroom is necessary to accommodate the different learning styles of science students. For instance, conducting portions of a class in the laboratory gives students the opportunity to work in groups. "A group approach to learning often reduces competitiveness among students" (p. 18), and reduced competitiveness may lessen or eliminate the hostility and intimidation sometimes encountered in upper level science classes [23]. Employing various teaching styles may help foster a welcoming environment for women within the academy of engineering.

While there are a great number of women who express an interest in engineering and an even greater number who are well qualified to work as engineers, there is only a small proportion of female engineers within the American workforce. Over the past 35 years, Jacqueline Eccles and a group of her colleagues have been studying the causes behind the low enrollments of women in engineering programs [24]. She found that the major gender differences in science-related careers are due to the value that women place on various occupations. Women have been observed to value altruistic careers that have a direct, beneficial impact to society or other people, leading them in huge numbers to fields such as nursing and education. Unlike in medicine and education, the link between engineering and societal amelioration has been less clear and widely known to the general public. This fact may help explain the low female enrollment in engineering.

The small number of women in engineering can be viewed as both an opportunity and a cautionary forewarning. Because there are so few women active in this discipline,

there is heightened visibility. This heightened visibility draws attention to successful performances; and, as a result, great achievements made by women in engineering do not go unnoticed. However, visibility also spotlights errors, which may perpetuate the view of engineering as an intimidating field for women [25]. Simply because of their lower numbers in this field, women are guaranteed a place in the spotlight, whether it reflects upon their successes or their failures.

Barriers on the Path to Engineering

Because engineering is still viewed as a relatively unconventional career choice for women, it seems as though female engineers face additional obstacles to achieving their career goals. McIlwee suggests that men and women have distinctly different paths to becoming an engineer [26]. In most cases, the path to engineering seems more "natural" to men than to women, given the societal and historical contexts of this profession.

Gender socialization has given men an advantage over women in the realm of engineering. Typically during childhood, boys are given toys to tinker with while girls are given toys that imitate household duties. By having toys to take apart and reassemble, boys are engrained with a love for mechanics and technology early in life, preparing them for the professional aspects of an engineering career. Women have historically been offered fewer opportunities to toy with mechanical things during childhood. Their path to engineering is more commonly dependent upon their strength in mathematics and science, allowing women to academically succeed in engineering. However, as with many disciplines, it can be observed that the study of engineering differs in many ways from its practice in the professional world. Women may feel more challenged in the engineering workplace due to a lack of a mechanical and technological background, which men often excel in due to gender socialization [27].

McIlwee concluded that the different paths that lead men and women to engineering helps in part to explain the gendered disparity in the field. Women are most often drawn to engineering if they are markedly talented in mathematics and science. Given strong skills in mathematics and science, engineering emerges as a practical career choice for some women. In fact, 80% of the women sampled pursued engineering because it was a practical career choice; in contrast, only 17% of men took on a career in engineering because of its practicality [28, p. 24]. Men are more often drawn to engineering because of hobbies and skills established early in life, or because of tradition. The path toward engineering may feel more "natural" to men whose families have a deep-rooted connection to scientific or mechanical careers. Alternately, engineering may seem like a challenging, bold, and unnatural endeavor for a woman whose family did not have any female role models in science or engineering.

Leveling the Playing Field - Second Tier Students

Tobias [29] describes a group of students populating what she terms the "second tier." She suggests that the term second tier is a "… loose hypothetical construct, which includes a *variety* of types of students not pursuing science in college for a *variety* of reasons" (p. 14). Tobias cautions that second tier is not to be confused with second rate; these second tier students are fully capable of doing science, yet choose not to. A woman who makes the choice to pursue engineering as a career knowingly faces several challenges. In addition to overcoming workplace gender stereotypes, the female engineer must overcome hostility in this discipline by not only keeping up with the men, but by exceeding them in her skills and capabilities.

Female engineers may feel pressure to prove their merits, lest they be overlooked in a sea of predominately male colleagues. It can be noted that currently, only the most exceptionally bright and persistent women will tend to move on to a career in engineering. Women who may be well qualified, yet insecure in their abilities might deter from a path to engineering because they feel that the challenges and obstacles in the workplace are insurmountable. "The lower levels of self-confidence and assertiveness displayed by women" describe why there are a larger proportion of mediocre men in engineering than mediocre women: only the most talented and dedicated women have been willing to tolerate the challenges and inequalities in the engineering discipline to pursue their passion [30, p. 109].

Leveling the playing field, so to speak, would necessitate that more female second tier students give engineering a try. This could involve the implementation of better recruitment techniques, or could involve drastic changes to the engineering environment in general. These "environmental changes" might include shifting the attitudes and stereotypes towards women in the sciences; changing societal views of the engineering profession; and reducing the intimidation and competition of engineering within academia. Professional engineering societies may be the most promising way for women to change the environment of the field, increase female representation, and work towards equality with men in the workplace.

CONTRIBUTIONS OF PROFESSIONAL SOCIETIES IN THE AMERICAS

Regardless of the geographical scope of their activities, professional engineering societies act as an invaluable asset to any person, male or female, who seeks to advance their career in engineering. In this section, the activities and aspirations of several of these societies in the Americas are explored.

North America

In North America, numerous opportunities for female engineers have been made possible in recent years through the efforts of several professional societies and organizations. The following discussion provides highlights of the efforts of three organizations in regards to the recruitment and retention of women, and women as leaders in science and engineering. These organizations include the Society of Women Engineers (SWE), the Women in Engineering Division (WIED) within the American Society for Engineering Education (ASEE), and the Women in Engineering Proactive Network (WEPAN).

Founded in 1950 by several female professionals and engineering leaders, the SWE is a nonprofit service and educational organization that enables women to attain jobs and advance to higher positions in the field of engineering. Additionally, SWE recognizes women who have made significant contributions to the discipline as both engineers and leaders [31]. SWE acts as a driving force that aims to establish engineering as a desirable career choice for women through its various efforts: training and development programs, scholarships, professional networking opportunities, and outreach and advocacy programs. This society directly addresses the issue of female recruitment and retention by running an educational outreach program called Aspire. This particular program aims to inform K-12 girls about the functions of an engineer, the opportunities in such a career, and various scholarships, camps, competitions, and activities that would accelerate their success in engineering. At the core of SWE's vision is the desire to empower women, further enabling them to succeed and advance in engineering careers.

The ASEE currently consists of 50 divisions and constituent committees that are specific to various disciplines or topics. For instance, ASEE has divisions geared toward aerospace, agricultural, civil, chemical, computer, electrical, mechanical, and physics engineering, to name a few. Divisions including minorities in engineering, new engineering educators, and women in engineering also exist within the ASEE structure to address the difficulties faced by some of those who enter the field. It is a core belief at the ASEE that the quality of engineers dictates the quality of life within a society. In having so many divisions, the ASEE can touch upon every manifestation and permutation of the field of engineering so that when every division is connected through the overall efforts of the society, there will be a widespread and systemic enhancement of engineering and, in turn, society. The Women in Engineering division of the ASEE was established in 1978 to address issues common to women within all fields of engineering education [32]. There is a particular emphasis placed on the recruitment and retention of female students to the field of engineering. Also, the Women in Engineering division focuses on facilitating the re-entry of women into the profession (e.g. perhaps after taking time off because of a pregnancy or to raise a family).

In 1990, WEPAN was formed as a collaboration of leaders at several major universities who were focused on supporting women in engineering. This organization's focus is on the development of a diverse and highly prepared engineering workforce. Since its creation, WEPAN has grown to include over 600 members from engineering schools, large research institutions, smaller technical or liberal arts colleges, Fortune 500 corporations, and non-profit organizations [33]. The WEPAN strives to enhance the success of women in the engineering profession by focusing on research-based issues and solutions. Through a grant given by the National Science Foundation and the support of corporate sponsors, the WEPAN website hosts the digital Knowledge Center, accessible to both members and visitors. The Knowledge Center is a database that provides access to digital resources relevant to women in science and engineering, including reports, statistics, agendas, policies, bibliographies, conference proceedings, and best practices. This organization also takes part in outreach activities that prepare non-members for their entry into the engineering workforce.

The opportunities to interact with other female engineering professionals such as those provided by SWE, ASEE, and WEPAN play an important role during the educational and professional development of aspiring women engineers and leaders. These organizations provide excellent networking opportunities for women at all stages of their careers. Without the programs and initiatives mobilized by these organizations, opportunities for women in engineering careers and leadership positions in North America would be greatly stunted.

As in North America, there are several professional organizations in South America that provide opportunities for professional growth in engineering. In the sub-section that follows, opportunities for women engineers (and for all engineers, in general) through professional organizations in South America are presented. This discussion is not intended to provide an all-inclusive list, rather, to provide an overview of some of the prominent engineering organizations and societies.

South America

The challenges faced by women in the sciences and engineering are not limited to North America. The disparity between men and women spans workforces across the entire globe. Propitiously, South America is also the host to several professional societies that enable women and men to succeed in engineering academia, the engineering workplace, and in leadership positions. These societies include the Brazilian Society for the Progress of Science (SBPC), the Brazilian Federation of Engineering Associations (FEBRAE), Region 9 of the Institute of Electrical and Electronics Engineers (IEEE), and the Latin American and Caribbean Consortium of Engineering Institutions (LACCEI). The two former organizations are

centered in Brazil, while the latter two have a broader scope that encompasses all of Latin America.

The Brazilian Society for the Progress of Science, known in Portuguese as the Sociedade Brasileira para o Progresso da Ciência (SBPC), is a nonprofit civil entity that aims to promote science, culture, and education in Brazil. Since its foundation in May of 1948 by a group of scientists and science advocates, the SBPC has played an important role in the expansion and development of Brazil's national system of science and technology, as well as the popularization and diffusion of science throughout the country. Some of the society's ongoing activities include annual conferences, regional meetings, promotion, and political action regarding policies that affect funding directed toward the sciences and engineering [34]. Additionally, BSPC has published its own scientific journal, *Ciência e Cultura*, since 1949. This publication shares the same focus as the parent society, striving to diffuse scientific, technological, and cultural knowledge to the Brazilian public.

During the 1930's, Brazil underwent a revolution that ushered in great social reform, as well as economic and governmental shifts. Thus, it seemed imperative at that time to create an organization that could represent Brazilian engineers for the betterment and advancement of the society as a whole. On December 30, 1935, the Brazilian Federation of Engineering Associations, or as it is called in Portuguese, the Federação Brasileira de Associações de Engenheiros (FEBRAE), was created with the task of representing Brazilian engineers in international forums. FEBRAE does more than act as the voice for Brazilian engineers. Similar to many of the previously mentioned professional societies, FEBRAE promotes the advancement of science, technology, and engineering in an effort to increase public interest in these fields. The federation also focuses on improving engineering education and providing adequate training for potential entrants to the field of engineering. FEBRAE acts as a forum for communication and coordination between private, public, and governmental engineering associations. Additionally, the federation promotes Brazilian engineering through congresses and conventions, and facilitates the exchange of professional, technical, and social contacts within the organization [35]. Currently, FEBRAE is comprised of over 170 Brazilian associations, universities, and societies.

The Institute of Electrical and Electronics Engineers (IEEE) is the world's largest technical professional association with over 375,000 members in 160 countries. Its name may be misleading, for this society's focus and membership is not limited to electrical and electronic engineers; the IEEE has maintained this abbreviation to preserve the worldwide recognition it has achieved over time. In fact, the organization welcomes professionals and experts in nearly every area of technology, including biotechnology, computation, design, industrial control, social implications of engineering, robotics, etc. The organization's roots date back to 1884, when a small group of electrical professionals met in New York to form the American Institute of Electrical Engineers (AIEE). With the discovery of radio technology in the early 20th century, a new society called the Institute of Radio Engineers (IRE) was formed in 1912 that devoted itself to the advancement of professions related to radio and increasingly, electronics. On January 1, 1963, the AIEE and the IRE merged to form the IEEE [36]. In the decades that followed, the IEEE expanded its presence globally. Currently, it is divided geographically into 10 regions, with Latin America and the Caribbean corresponding to Region 9. Region 9 has over 16,000 members and is considered one of the more dynamic regional areas within the organization [37]. Members in Latin America have access to this region's newsletter, cleverly entitled *NoticIEEEro*. The IEEE provides countless benefits to all its members, including access to journals, newsletters, technical books, textbooks, online educational programs, conferences, and a seemingly limitless potential for professional networking. Its extension to Latin America is a promising step towards the advancement of the sciences and engineering education in the region.

Another professional organization that represents engineering within the broader Latin American scope is the Latin American and Caribbean Consortium of Engineering Institutions (LACCEI). This nonprofit entity unites technical and engineering institutions in Latin America, including businesses, colleges, and universities. The LACCEI provides academic and training programs to its members, and connects member institutions to technical or engineering organizations from other parts of the world. The consortium provides numerous opportunities and advantages to students of engineering, including academic programs at all educational levels, industry internships, and distance or online learning. LACCEI is also of great assistance to teachers of engineering through their fundraising for research endeavors, laboratory and curriculum development efforts, and through the transfer of new technologies and teaching methods [38]. This organization stands apart from previously mentioned professional societies in that it primarily focuses upon the enhancement of engineering education, and focuses to a lesser degree on the professional and leadership aspects of the discipline.

It is important to note that these organizations differ from the North American entities mentioned in the previous sub-section in that they have a generalized scope, focusing on the overall betterment of the educational, pedagogical, and professional landscapes for both men and women in technology and the sciences. At present, the authors are not aware of any professional organizations based in South America that focus exclusively on the advancement of women in technical and scientific fields, or whose main focus is on reducing the disparity in the gendered composition of engineers.

The following section provides a brief look at how female engineering professionals have began to bring down

barriers and put a crack in the "glass ceiling." A profile of Eleanor Baum, the first woman Dean of Engineering in the U.S. will be shared. Efforts to break down barriers and put a crack in the glass ceiling will be summarized.

CRACKING THE GLASS CEILING

While the number of women choosing to study engineering in the U.S. seems to have reached a plateau in recent years, the number of women attainting leadership roles in the academy has increased. Startlingly, the number of female engineering deans in the U.S. was zero just over 20 years ago! Presently, there exist 339 engineering colleges in the U.S. [39[. Of this number, 24 engineering colleges are led by female deans. In 1983, Eleanor Baum, an electrical engineer by education and training, became Dean of Engineering at Pratt Institute, and in 1987 she became the Dean of Engineering at Cooper Union, a position she still holds today. Notably, Baum was the first woman to achieve a leadership position as dean of an engineering program in the U.S. Her achievement simultaneously opened a new chapter in the history books and put a crack in the glass ceiling.

Baum decided to become an engineer in the mid 1950s when she was just 17 years old, in part, as a rebellious act [40]. Her parents and teachers told her she "couldn't do it" and she found her choice "enormously discouraging for a long time." Baum's academic path wasn't a smooth one nor was she immediately accepted by several engineering schools because of the fact that she was a woman. In one instance, she recalled not being accepted because the school said that it didn't have any women's bathrooms! Eventually she was accepted by City College of New York (CCNY) and may have been its only female engineering student. If there was another female engineering student at the school, she and Baum never crossed paths. Baum earned the B.S. and M.S. in Electrical Engineering from CCNY in 1959 and 1961, respectively. In 1964 she received the Ph.D. in Electrical Engineering from the Polytechnic Institute of New York. Baum credits her perseverance to stubbornness and her genuine interest in engineering.

In addition to her distinction as the first woman dean of engineering, Baum became the first woman president of the ASEE in 1994. Not only were her achievements a significant advancement for her own career, they also represented a noteworthy message to all women engineers throughout the U.S. and beyond. Baum has tirelessly demonstrated that is was possible to put a crack in the glass ceiling, sending the message that it is no longer impenetrable.

Baum has suggested that women still tend to view engineering as being very hostile, male-dominated, and competitive. As a result, perhaps engineering needs an "image overhaul," stressed Baum. The stereotypical image of the engineer still prevails in the public's mind which makes it appear to be incompatible for women to become engineers [41]. In many respects, engineering is a strongly people-oriented profession, yet this fact often remains hidden from the public view. As a whole, the engineering profession might better develop ways to collectively present to the world its many branches that have had such a positive impact on society in a multitude of ways.

SUMMARY & FUTURE DIRECTIONS

Lebold & Lebold (1998) have argued the need to enhance and expand efforts to increase the number of tenured female faculty at colleges and universities [42]. They have further purported the development of engineering awareness programs for elementary schools along with programs targeted to help make parents aware of what engineering is all about.

The chilly, and often unwelcoming climate women still face when considering a career in engineering needs some adjustment. In terms of the relatively low numbers of women in science and engineering fields, Zoli, et. al. (2008) have suggested that rather than conforming to the existing climates in science and engineering within an academic setting, a more formal transformation of these climates may be in order [43]. Perhaps the global model of the engineering field needs to be adjusted and expanded in order to become a better fit for women.

Globally, engineers are involved with so many areas that help make life better for society as a whole. Agricultural engineers, for example, work to address the problem of global hunger. Other engineers work to improve elements that are vital to a sustainable society such as air and water quality, transportation, communications, energy-efficient buildings, and so much more. The historical conception that engineering is a male-only profession has taken a long time to overturn. Over the past three decades, the feminine persona of the engineer is shifting from the outside edges towards the center of the arena. This shift has added a significant strength to the very core and foundation of the engineering profession.

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