WOMEN ENGINEERS -- A 100 YEAR LOOK BACK AND HOPE FOR A LEAP FORWARD

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Abstract

The role of women in engineering during the period 1893-1993 is examined with special emphasis on the increasing representation of women in undergraduate and graduate education and in the academic and engineering workforce. These changes are the result of women demanding greater equity in education and employment, accompanied by a greater acceptance and recognition of their capabilities.

During the first half of the century, womens' roles in engineering were fraught with discrimination, rejection and inequity. The few women who did study engineering were true pioneers who defied conventions of the day and received little encouragement from family or teachers. These highly gifted women were driven by the intellectual and social challenge of engineering.

The second half of the century brought almost exponential changes in engineering and engineering education for women. The womens' movement, civil rights, affirmative action, and greater acceptance in the technological workplace resulted in improved opportunities for women in engineering. Industry, government, and education recognized the potential of women which produced a plethora of special pre-college, college, and post-college programs to recruit and retain women in engineering.

Introduction

In 1893 when the *Society for the Promotion of Engineering Education* was founded, only one woman had been awarded an engineering degree in the United States. In 1993 when the *American Society for Engineering Education* celebrated its Centennial, over *10,000* women will have received U.S. engineering degrees in over fifty engineering and engineering technology fields. This paper focuses on the educational changes and progress of this equity struggle and on some of the pioneers that have led the way.

There were a significant number of women who were doing engineering work prior to 1893; some women had degrees in math and science fields, but most of them did not have college degrees. The Brooklyn Bridge might not exist had it not been for Emily Warren Roebling. For eleven years she assisted with the construction after her father-in-law, a master bridge builder, became incapacitated when his leg was crushed by the bridge's timbers. Additional responsbility was given to her when her husband contracted a dread disease leaving him paralyzed. Under her husband's guidance she studied higher mathematics, the calculations of catenary curves, strength of materials, bridge specifications, and the intricacies of cable construction. The drama of this situation increased when the enemies of the bridge, and many who were opposed to the building of it, wanted Washington Roebling removed from the project due to his physical disability. However, through Emily's presentation at a meeting of the American Society of Civil Engineers, the backing of the engineering profession was secured. In May 1883, tens of thousands thronged the streets with bands playing and banners waiving. The bridge had taken thirteen years to build and twenty men had lost their lives. There is a memorial tablet on the Brooklyn Bridge commemorating master bridge builders John A. Roebling, Washington Roebling and Emily Warren Roebling.[1]

The first woman to study engineering in the United States was Kate Gleason whose accomplishments were so tremendous that she is thought of as the real "trail blazer" and the leading spirit of all women engineers. She began as an apprentice engineer with her father at the tender age of eleven. She entered Cornell in 1884 as the first of the "Sibley Sues" to take a mechanical engineering course. She was a friend and warm admirer of Susan Anthony who saw Kate as a woman forging her way into the field of engineering, a shining example of her own theories that women needed but the opportunities to succeed in fields hitherto closed to them. The first woman elected to membership in the American Society of Mechanical Engineers was an honor she richly deserved. Her design of a worm gear brought her recognition and acceptance. She attributed her success to "a bold front, a willingness to risk more than the crowd, determination, some common sense, and plenty of hard work." This formula for success is apparent in all of the women engineers during the period of 1893 to 1913.[1]

According to Iowa State College, in 1892, the first woman to receive a U. S. engineering degree was Elmina Wilson,. She was the first woman on their instructional staff until 1905, when she withdrew.[2] But the University of California states that Elizabeth Bragg was the first woman to graduate from engineering in 1876.[3]

Five twenty year periods from 1893-1993 are examined in this paper with a view toward highlighting the evolutionary changes that have taken place in this remarkable century of progress. In view of the 1993 ASEE Centennial, we have chosen 1893 as the starting point of this paper that focuses on US women in engineering.

1893-1913: A Few Pioneers or Who's On First?

One of the first women to earn a B.S. degree in engineering was Bertha Lamme, the sister of Benjamin Lamme, the namesake of ASEE's most distinguished Lamme Award. She studied electrical engineering at Ohio State with her brother "for the fun of it" and with no plans for an engineering career; however, she received a surprise offer of employment from Westinghouse. She contributed significantly to the mathematics of machine design. But typical of the times, her engineering career ended with marriage to an Ohio State-Westinghouse peer.[4]

In 1895, Marion Sara Parker completed a four-year engineering course in three years at the University of Michigan. As a structural engineer, the complete calculations, foundation and framing plans for a large office building were put under her sole charge. Her work was excellent--neat, quick, accurate. She held her own with engineers and draftsmen. A remarkable woman! Alas, her career ended after only ten years -- with marriage![4]

About 1900, Marshall Keiser pursued her formal education at the Agriculture and Mining College in Kentucky, Ohio Mechanics Institute and the Institute of Technology in Munich, Germany. She was compared to another famous Kentucky pioneer, Daniel Boone, who was a civil engineer. Ms. Keiser taught chemistry for five years; she then worked as a chemist on the Island of Java. Her short career was temporarily interrupted by, *you guessed it*, marriage. After her husband's death, she returned to the work force holding many executive positions, writing, and publishing engineering articles. She also holds the dubious honor of being a first in the dual career category for she adopted and educated six children, in addition to her many activities in the field of engineering.[4]

1913-1933: World War I Opportunities and the Discriminatory Depression

It is ironical that women are generally opposed to violence and war but it has done the most to advance their careers. In 1914, World War I began and with the shortage of male engineers women were given the opportunity to take their places, that is until the war ended and they were again displaced by *men.*

One of the first women to benefit from the war and the shortage of males was Alice Goff who graduated from the University of Michigan in 1915 with a B.S. in civil engineering. Her employment with a steel company consisted of appraisal, design and estimating reinforced concrete for large buildings.

One of her most impressive projects was a $15,000,000 bomber plant in Texas during the second world war.[4]

Lydia Weld attended Bryn Mawr and continued her studies at MIT in naval architecture and graduated in 1903. Her initial employment was with a shipbuilding company in Virginia where she had charge of drafting plans for naval ships. It is interesting to note that in 1915, Ms Weld became an associate member of ASME but not until 1935, twenty years later, did she become a full-fledged member. A great example of the fortitude of the early engineering pioneers, Ms. Weld was forced to retire due to ill health in 1917; however, the literature reveals that she was running a 400-acre alfalfa, hog and pear ranch in 1952.

There are many "firsts" accomplished by the women engineering pioneers. For example, in 1918, Edith Clark entered MIT and one year later was awarded the degree of Master of Science in Electrical Engineering -- the first woman to earn an EE degree from that institution. Ms Clark became a professor and tauught engineering at the University of Texas. Being a member of the academic environment was unique then and still is for women in engineering.[4]

Another major breakthrough for women in engineering and science was the passing of the 19th Ammendment to the U.S. Constitution in 1920 which gave women the right to vote; only 20 U.S. engineering institutions had granted their first engineering degrees to women and 90 women had received U.S. engineering degrees.[1]

1933-1953: World War II Emergencies and the Post-War Decline

This period reflects the differential demands that plagued and characterised the growth of women in engineering. The depression resulted in a retrenchment in the demand for women engineers. During a time of massive unemployment, it was believed that women "should sacrifice personal ambitions and accept a life of economic inactivity." Congresswoman Kahn spoke for most of her colleagues when she said that a woman's place is not in the business world competing with men who have families to support but in the home. Secretary of Labor Perkins denounced the rich "pin money worker" as a menace to society. Employers refused to hire women, especially married women.[5]

A dissenting opinion most surely would have been that of Dr. Lillian Gilbreth - "America's first lady of engineering." With her "Cheaper by the Dozen" children, pin money was non-existent. After her husband's untimely death, she took full charge of Gilbreth & Co., and pioneered in time and motion studies, and the psychology of management. After serving for a number of years as a lecturer and adviser to Purdue students, faculty, and administrators she became a Purdue faculty member in 1935-6 teaching outstanding seniors and graduate students industrial engineering and management; she continued her annual visits as an annual academic advisor to women students at Purdue University long after her 1950 retirement until just before her death in 1972.[6] She was recognized world wide for her contributions to industrial engineering and scientific management. In contrast, Amelia Earhart chose the technical route; she too was a counselor to women students at Purdue but opted for flight training instead of college. Her final and still mysterous plane flight was sponsored by the Purdue Research Foundation. These quite different role models might account in part for the fact that from 1892-1953 Purdue granted more engineering degrees to women (103) than any other U.S. institution -- the University of Colorado (47), Michigan (45) and Cornell (43). This Purdue tradition still prevails although more precariously today as a number of institutions now enroll over a thousand women in engineering every year.[1]

World War II provided another impetus for increasing women in engineering. Many engineering schools set up special training courses in engineering for women. They were sponsored by the War Department, the Signal Corps, the Ordinance Department and the Air Force; aircraft companies inaugurated special programs for engineering aides and engineering cadettes. Although WWII again provided new opportunities for women in engineering, the end of the war brought increased pressure for women to return to the home, not only "Rosie the Riveter" but "Sibley Sues" were pressured to return to their rightful place "in the home."[7] Indeed, many women looked forward to resuming their roles as homemakers and mothers and there was strong support for veterans who enrolled in engineering in

unprecedented numbers and proportions under the GI Bill; their wives focused on the trials of overcrowded temporary housing, nurturing small children and putting "hubby thru."

After the Depression and WWII, women engineers and working women had clearly demonstrated their ability to do engineering and technical work including activities that involved physically taxing jobs and mental creativity. However, the argument against women engineers took a more dramatic turn; working women now threatened mens' jobs; threatened family structures, interfered with the socialization of children and the time-honored tradition of the male as the primary breadwinner. Indeed, the role of women was again, "A woman's success is measured by her husband's achievements." Within engineering there still existed significant overt discrimination. Most engineering honoraries did not allow women to become members. Tau Beta Pi awarded "Badges"[1] instead of membership to women. Many engineering schools still did not admit women; Georgia Tech's Rambling Wreck boasted, "And if I have a daughter sir, I'll tell you what I'll do, I'll dress her up in blue and gold and send her to Purdue."

Women engineers, however, were no longer willing to be complacent. In view of the fact that many engineering societies would not admit women and recognizing that they had similar aims and problems, women from diverse groups banded together in1948 and organized the Society of Women Engineers which was incorporated in 1952.

1953-1973- Stagnation and Affirmative Action

The values and beliefs expressed during this time period resulted in a curious paradox. Women were being encouraged to move back to the home, give up their careers and accept their traditional domestic role. At the same time, there was the greatest expansion in the twentieth century of women in the labor force. However, it was a different labor force that was expanding. Women in the lower socioeconomic classes entered the work force to enlarge their family's purchasing power. Middle-class, educated women were getting married and raising their children rather than accepting employment. Thus, the increased labor force consisted of blue and white collar workers rather than college educated and professional women.[5]

This period also marks significant social changes including the civil rights and womens' movement and federal legislation demanding equal educational and employment opportunities with the teeth of affirmative action. These social movements set the stage for meaningful change. Women were enrolling in and returning to college in unprecedented proportions. Girls were encouraged to consider non-traditional fields, including engineering and science and to take the subjects required for admission into those fields. Engineering colleges began to look with favor on women as engineering enrollments plummeted in the early seventies.

Naomi McAfee ,whose early and mid-career spans this period, describes herself as pro-women, however, she believes that "if a woman first thinks that the reason she did not get ahead was her sex, then she is probably trying to cop out." She also believes that a woman has a better advantage than a man because of equal employment opportunity and affirmative action. However controversial her views may be, Naomi achieved much success throughout her Westinghouse career: as an infrared researcher, and subsequent promotions to assistant, associate, full, and fellow engineer; then into technical management as supervisory engineer, manager of quality and reliability engineering, director of corporate strategic resources, manager of design assurance and systems, and research and development divisions. "In my own career I was discriminated against, but I liked what I did and with whom I did it. Now I have achieved a level where I can prevent a lot of discrimination."[8]

1973- 1993: Growth and Fairness

A number of factors seem to have contributed to the rapid almost expotential growth of women in engineering during this period. The rapid decline in undergraduate engineering enrollments were viewed almost with alarm by engineering colleges and employers of engineers. In reponse, most engineering schools became actively engaged in recruitment programs; women once again as had been the case in WWI and WWII were viewed as an untapped resource The civil rights and women's movement also encouraged women to seek non-traditional careers and engineering as the field with the lowest representation of women became both a goal and a target. Meanwhile, employers of engineers were under

affirmative action and equal opportunity pressures to account for the small number and proportion of women engineers. In response to claims that there were too few women engineers available, many employers began to support engineering college out-reach efforts.[9] The National Science Foundation supported a number of studies to identify the factors associated with the low representation of women in science and engineering. These studies tended to put to rest the idea that women were not suited for engineering on the basis of ability, emotion, or drive. What was needed was action-oriented programs that focused on the cultural norms that could breakdown these barriers. The low percentage of women taking math and science in high school and junior high school was a major barrier to access to admission into engineering. Emphasis also focused on improving retention, encouraging graduate study, recognizing women engineering achievers, improving and expanding in-college and post-college work experiences. Women in engineering and science support groups became international in scope including the biennial Girls and Science and Technology (GASAT) international meetings and the newly NSF supported Womens Engineering Program Advocates Network (WEPAN).[9] Current agendas include expanded efforts to increase the number of tenured faculty, elementary school and parent programs, closer cooperation with under-represented minority groups, and real breakthroughs in the engineering management glass ceiling. The appointment of Dr. Eleanor Baum as the first U.S. Dean of Engineering and the election of Dr. Martha Sloan as President of IEEE are encouraging signs that women are finally arriving as truly equal partners in engineering.

1993-2013: True Equity and Parity

As engineering moves into the 21st Century, the goals remain the same; the achievement of true equity will surely eliminate most of the overt discrimination that was blatant a century ago, but it will be challenging to remove the more subtle forms of conscious and unconscious covert discrimination that are still prevelant in admissions, e.g., use of SAT Math scores, instruction; e.g., computer competency and employment; e.g., promotion to technical management and academia. More emphasis will be needed to address some of the back-lash problems associated with special programs for women and minorities that exclude and give special privileges and access to these groups.

Dr. Irene Peden, NSF Division Director, Electrical and Communication, on leave from the University of Washington documents so well the early overt discrimination she suffered as an engineering student and graduate in the late 1940s and her struggles as a productive woman faculty member and administrator, "In spite of the war stories I've told you, I would do it all over again. If I have a regret, it is only that it is too late to start over, and to be a *young* faculty women in the 1990s."[11] True equity therefore is a real possibility and certainly a goal for the year 2013.

What will be true equity 35% or 51%? In some areas we have already approached these goals - close to 35% in Bio-Engineering, CHE and IE, but still trailing in ME, CE and EE. Other goals approaching 12% parity within women engineering populations is the representation of African Americans. African Americans now include equal (50%) percentages of men and women in some institutions and in some fields, but much remains to be done with the international students attending U.S. engineering institutions. They now constitute about one-half of the engineering graduate students; this population is still predominately male and has become the major source of new U.S. engineering faculty. Parity in the next two decades is a possiblity within some of the engineering education sub-populations, but not likely within the engineering workforce and engineering academic community.

However, we can assure Simone de Beauvoir who sighed in her Memoires *" What a pity that Simone was not a boy: she could have gone to the Ecole Polytechnic."* ***Simone, you do not have to be a boy, you can enroll in the Ecole Polytechnic.and any one of 350 U.S. Engineering institutions.***

Except for WWI and WWII, representation and growth of women in the engineering workforce was minimal. The 1970's represented a turning point not only in the number and proportion of women studying engineering, but significant growth of women for equal educational and employment opportunities. The 1980's and 1990's showed significant growth in beginning and middle level engineering positions. The 21st Century promises steady growth and recognition in both education and employment at all levels.

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