2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #32262

Women In Engineering

Dr. Raymond Edward Floyd, Northwest College

Raymond E. Floyd (M'63 – SM'85 – LSM'03) He has a BSEE from Florida Institute of Technology, Melbourne, FL – 1970, an MSEE from Florida Atlantic University, Boca Raton, FL – 1977, and a PhD in Engineering Management from California Coast University, Santa Ana, CA - 2009. He spent 26 years with IBM, retiring as a Senior Engineer in 1992. He is currently a Visiting Lecturer at Northwest College in Powell, WY. He has published over 200 papers on a variety of topics. He most recently co-authored a text, Perspectives on Engineering (2011), an IEEE eBook, Shaping an Engineering Career: Book 2: Dual Career Ladders (2013), and another text, So You Want to be an Engineer? (2015).

Prof. Astrid K. Northrup P.E., Northwest College, Powell WY

Astrid Northrup earned her B.S. degree in petroleum engineering from the Montana College of Mineral Science and Technology (Montana Tech) in 1984 and her M.S degree in petroleum engineering from Montana Tech in 1986. She also earned a Certificate in Land Surveying from the University of Wyoming in 2005. She is a registered Professional Engineer in Colorado and Wyoming. She worked in the petroleum industry as a reservoir engineer and as a private consultant before moving into a teaching career at Northwest College in Powell WY, where she is Professor of Engineering Science and Mathematics and Division Chair of Physical Science. She is pursuing a Ph.D in Science Education at the University of Wyoming in Laramie. She is married to David and has three adult sons.

Women In Engineering

Abstract

There has been a major effort in the past few years to provide more emphasis on STEM related careers, especially in terms of women entering STEM fields. It has been gratifying to see positive results from educational efforts to open opportunities for women, with many more young women entering the classes previously believed to be reserved for men. The numbers are still small in contrast to men in engineering classes. This paper will examine some of the efforts being made in industry and education to achieve a greater number of women in engineering for a lifetime career and discuss some women who have been instrumental in getting more women into engineering careers.

Introduction

From an early age, most girls are told they are not good at math, physics, mechanics, chemistry, and other technical subjects. In many cases, they may also be advised to not become interested in business, again the subject being too technical for girls. They are told they could have careers in sales (non-technical of course), home economics, nursing, or teaching in non-technical subjects, all matching their areas of strength. It can be as discouraging as being told, “Women are supposed to stay home and have children!” as experienced by one author. In the career of nursing, it is often overlooked that the nature of such a career can be technically and emotionally challenging. While human relations are a large part of the work, the technical aspects are frequently overlooked. It is particularly interesting to note that 75% of the teachers in elementary and secondary schools are women [1]. Of course, the women teachers are typically only teaching non-technical subjects. From this history of rhetoric, is it any surprise that we continue to have such a small number of women entering the world of engineering? There has been a major effort in the past few years to provide more emphasis on STEM related careers, especially in terms of women entering STEM fields. In the United States, approximately 18% of engineering students are females, compared to 64% of humanities students [2]. In the case of one of the authors, it was less than 5% of the engineering students were women. A review of the literature reveals that social, cultural, interpersonal, and personal factors all influence females’ college major choices and career aspirations. Many of these factors can be traced to family

origin and early childhood, not just to experiences in school. To this end, this paper explores gender-related factors relevant to females' college major choices [3].

Females and males view the desirability of a major using different criteria. Notably, this is true for other demographic groups as well. In one study, researchers analyzed the extent to which occupational segregation by gender, race/ethnicity and family of origin affect patterning of individual college choices [4]. It is far beyond time to break this mold, this myth about what a woman can and cannot hope to achieve! The only true limits are those women wish to place on themselves, not the untrue limits impressed on them in their youth. The option remains for women to pursue those subjects they enjoy, looking for a career in engineering.

Mathematical ability is essential for successful engineers with such course offerings as calculus and differential equations, and a common misunderstanding is that males are better at mathematics than females. The fact is females do as well or better than males in mathematics by most

measures [5]. For example, in high school, female average performance and participation in mathematics and science have improved over time and, in some cases, surpassed that of males. High school females, on average, graduate with higher math and science grades than their male classmates, and since 1990, females have earned more high school credits in mathematics and science than males [6]. Again, in the case of one author, she proved her technical skills through acceptance to Pi Epsilon Tau and Tau Beta Pi, both engineering honor societies [6].

Despite the overall positive trends in high school mathematics scores, females are less likely than males to declare engineering as their major in college [7]. In 2006, about 15% of first-year female college students planned to declare a major in all STEM fields combined; but if biological and agricultural sciences are removed, only about 5% of first-year female college students intend to major in a STEM area of physical sciences, including engineering [8]. At the same time, more than a quarter (25%) of first-year male college students declared a physical science major [8].

Discussion

For many years there were few women engineers and even fewer female managers. For example, in 2018 women occupied only 6% of the CEO positions in the Fortune 500 corporations [9]. The rationale has been that from an engineering perspective, women were not technically oriented. In the management case they were too emotional to handle personnel situations such as

reprimanding, counseling or firing of problem employees. Things are slowly changing from the past. The National Association for Female Executives (NAFE) [4] publishes a list of the top 70 companies where females have made great inroads in their careers, both technical and management. In that list, with the 70 companies having more than two million employees, almost half are female, with almost 40 percent of the senior managers being women. Such numbers are an excellent illustration of the progress that has been, and continues to be, made over the years.

NAFE also publishes an annual list of Women of Excellence [10] which identifies women in a variety of industries having displayed success in their work, support in the community, or other positive ways during the prior year. It is interesting to note that while many have educational accomplishments in business, education, and similar backgrounds, there are few detailing educations in industrial engineering, chemistry, mechanical engineering, computer science, or electrical engineering. What? Women with all these accomplishments but so few in technical subjects? How can that be? Could it be these few simply did not accept the stereotype impressed on most young girls? They believed in what they could do, set their goals to succeed, and then have achieved their dreams.

While there are many examples of women being successful in STEM related careers, there are some that illustrate the importance to their industry success where the woman's contribution has been important. The first example involved the team in the United States space program. There were several women mathematicians that worked quietly in the background, their contributions not coming to light until the release of a book detailing their contribution (and a movie to bring it to the attention of current day viewers). This is documented in the book by Margo Shetterly, *Hidden Figures* [11]. Without their mathematical skills, the Freedom Seven, Gemini, and Apollo space programs may not have had the success they did.

A second example is from the development of what we know today as word processing. The concept and first commercial units were developed by Evelyn Berezin in the late 1960's – a woman! She began her education as a major in economics although her favorite subject was physics. Since physics was not considered a proper topic for women, she did not show her true ability for some time. At the end of the Second World War, there were many new opportunities for women. She was able to fulfill her true desire to study physics and received her BS in

physics. Her primary interests were in the field of computer use in industry. Her early contributions include banking systems and airline reservation systems. She founded a company, Redactron, and developed a system referred to as the "Data Secretary", the first computerized word processor to aid the work of typists worldwide. At the time of her death, she held nine patents centered on word processing systems [12].

A third example is Rear Admiral Grace Murray Hopper [13]. She received her Master of Science and Doctorate degrees from Yale in the field of mathematics. She was best known for her contributions to computer science, especially in the field of programming languages. While many people worked on the development team for the Common Business Oriented Language, better known as COBOL, she heavily promoted the use of the language in both business and military application. COBOL is a business language based on a language developed by Dr. Hopper, CODASYL, and released in 1959. It is still in use by corporations today.

The final example is Edith Clarke [14]. She got her undergraduate degrees in mathematics and astronomy, and taught mathematics for several years before enrolling in an electrical engineering program at MIT earning the first ever engineering degree awarded to a woman by that department. She worked for General Electric (GE) as a "computer" for several years, providing mathematical solutions for power grid problems. She was the first woman to present a paper to the American Institute of Electrical Engineers (later to become the IEEE). During this period, she received two patents related to electric power distribution lines. When she left GE she became a professor at the University of Texas with the distinction of being the first female EE professor in the United States. As a final point of recognition, she became the first female to be elected to the position of Fellow in the IEEE. She is a truly remarkable example of the achievements a woman can accomplish.

These four examples are a small segment of the women who have accomplished great things during their lifetime. Their progress was often blocked by the lack of opportunity and, more importantly, support from their male counterparts. In some cases, the original career choice was not in STEM related fields, but when they decided that something beyond their current path was there, they took the chance and pursued that new dream – to the success they found. In most situations the young girl must be taught and counseled that technical subjects are a choice, even for her. Such counseling and teaching cannot wait until she enters college. The preparation and

academic support must start in grade school and continue through college. Beyond that, the support must come from her management and other engineers. Some may call it favoritism, but it should not be viewed as such. We need to provide the opportunities and support for young women to gain the self-reliance to choose engineering as a career and be successful in that choice. To do otherwise is wasting national resources and, perhaps, even a loss to humanity due to the loss of some possible great achievement that might otherwise have been accomplished. We should not accept such a possible loss simply due to the lack of support and action that could ensure success.

Beyond a college degree, or degrees, women have the opportunity to become Professional Engineers (PE), opening career opportunities as consultants if they so desire.

Conclusion

There has been a major effort in the past few years to provide more emphasis on STEM related careers, especially in terms of women entering STEM fields. It is far beyond time to break this mold, this myth about what a woman can and cannot hope to achieve! The only true limits are those women wish to place on themselves, not the untrue limits impressed on them in their youth and even into their choices of a possible career choice discussion with a student counselor. It has been gratifying to see positive results from such efforts, with many more young women entering the classes previously reserved for men. It is fantastic to see the number of young women in engineering classes. In one author's experience there were less than 3% of the students following engineering as a career. Today that number is approximately 18% [2]. While such numbers are still small, the growth is obvious and welcome. These young women can be found in calculus, physics, programming, and similar courses, each preparing to pursue a career in engineering of one sort or another. It is so gratifying to see their interest and work effort in classes that even boys find challenging but are fundamental to an engineering career. Such growth in women in engineering careers bodes well for the future. There should be no glass ceiling for these young people. There is no magic formula that ensures success, each person must determine what they will accept, and work to meet the demands placed on them. Unfortunately, there remains some barriers, mostly simple acceptance of the fact that these young ladies are, or will be, excellent engineers. Inroads are being made by women engineers today, and more success stories are there to be told. We have heard the expression before, not

original with us, but we believe the statement "Accept No Limits" applies, and, if followed, will see young people, men, and women, succeed in an engineering career. The key to their success is knowing and understanding; intelligence is helpful, but hard work is essential!

References

1. *"The Condition of Education*", National Center for Education Statistics, *May 2020.*
2. Wang, M., & Degol, J. L. (2017). *Gender Gap in Science, Technology, Engineering, and Mathematics (STEM): Current Knowledge, Implications for Practice, Policy, and Future Directions*, EducPsychol Rev 29, 119-140, https://doi.org/10.1007/s10648-015-9355-x.
3. Northrup, A. & Burrows, A. *"I'm not good at math," she said: Gender and Engineering Majors*, 2020 ASEE Virtual Annual Conference, 6/22/2020, https://peer.asee.org/33962.
4. *NAFE Women of Excellence*, http://www.nafe.com/tags/women-excellence.
5. Hill, C. (2010). *Why so Few?: Women in Science, Technology, Engineering, and Mathematics*. Washington, D.C. : AAUW.
6. Northrup, A. (2016). "*On Being a Petroleum Engineer",* IEEE Potentials, 35(3), 21-22.
7. Riegle-Crumb, C., King, B., & Muller, C. (2016). *The more things change, the more they stay the same. Prior achievement fails to explain gender inequality in entry into STEM college majors over time*. American Educational Research Journal, 49(6), 1048-1073. http://doi.org/10.3102/0002831211435229.
8. Shettle, C., Roey, S., Mordica, J., Perkins, R., Nord, C., Teodorovic, J., Brown, J., Lyons, M., Averett, C., & Kastberg, D. (2007). *The Nation's Report Card: America's High School Graduates*. NCES 2007-467. U.S.Department of Education, National Center for Education Statistics. Washington, D. C.: U.S. Government Printing Office.
9. Warner, J., Elimann, N., Boesch, D. 2018. "*Women's Leadership by the Numbers*", American Progress, 11/20/2018.
10. *NAFE Top Companies*, http://www.nafe.com/tags/top-companies

11. Shetterly, Margo (2016). "*Hidden Figures: The American Dream and the Untold Story of the Black Women Mathematicians Who Helped Win the Space Race*". Harper-Collins, New York.

12. Berezin, Evelyn. https://www.invent.org/inductees/evelyn-berezin.

13. Hopper, Grace. "*Grace Murray Hopper (1906-1992): A legacy of innovation and service*", https://news.yale,edu/2017/02/10/grace-murray-hopper-1906[1992.

14. Brittain, J. (1999) "*From Computer to Electrical Engineer – the Remarkable Career of Edith Clarke".*

About the Authors