Towards Gender Balance in Engineering for an Expanding Global Market Place

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Abstract

A global economy requires that engineers understand the importance of both cultural and gender diversity to be more efficient in solving problems in our world of technology and communication. Nearly four decades ago, Unites States engineers led one of the greatest accomplishments of all time by successfully landing men on the moon and returning them safely to America. Four subsequent crews followed the first crew in successful triumphs. If we recall the picture of those engineers they were all white men in white shirts, most with plastic pocket protectors to hold rows of pens and pencils. This picture is slowly changing, as the field of engineering progresses and evolves. Recent studies showed that there are more women engineers joining the workforce every year, but still not enough to fulfill the gap. Engineering classrooms remains to be dominantly consisted of male students with a national ratio of six to one. The female ratio at the college of engineering in Texas Tech University is much lower than national statistics.

Influential factors of lower interest in women preceding engineering careers are known as "environmental" factors, such as isolation, exclusion from networks, and lack of role models. All of such are a major source of discouragement for girls and women in the field of science and engineering. If engineers are capable of solving complex problems of the world, then they surely can figure out how to improve the enrollment of women into engineering-specific careers. This paper presents possible solutions for revamping the recruitment and retention of female students in untraditional engineering careers.

Keywords: Globalization, gender balance, women in engineering

Introduction:

Globalization reshaped the world with the increasing interaction of cultures and economies to conduct business and commerce including the field of engineering. The economies of the world are increasingly becoming interdependent as companies expand their operations and marketing throughout the world. In this global corporate environment, technical professionals are required to work as part of international teams and devise solutions, which will be implemented across national and cultural boundaries. This new environment requires that engineers understand the importance of both cultural and gender diversity to be more efficient in solving problems in our connected, and technological world.

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Despite high unemployment, companies are persistently looking to fill engineering positions with a lacking pool of qualified workers to do the jobs. The shortage of women candidates for those positions is even more apparent. Many fewer women pursue engineering degrees and those who do often end up working in other fields. The NSF Engineering Task force, established in 2005, reported that student's interest in engineering careers declines from high school to college especially among the female students. Even though the number of women in engineering is growing, men continue to outnumber women in the engineering profession. According to the National Center for Education Statistics[1], the number of male engineering graduates rose by 11% from 2004 to 2009, while the number of female engineering graduates actually fell by 5.2% over the same period. In 2009, the percentage of undergraduate degrees from engineering schools that went to women hit 17.8%, a 15-year low, according to the American Society of Engineering Education[2]. In order to create interest in engineering there is a need for change in preparation for engineering study and in the culture of engineering schools. Diversifying the professoriate proceeds slowly, leaving students without role models.

What is Wrong with Education Today?

Education is fundamental to development and is the most important parameter for countries' vitality and growth. In order to have an understanding of why so few females pursue engineering fields, one must examine the paramount problems associated with education in globally. We are in an era that is rapidly moving from an industrialized model of education to a more global, information-age technologically driven education.

Although these changes are observed by society and most industries, it's not that easy to implement changes in schools because the changes require the rethinking of school systems, curricula, and to know what we must expect from students. Schools need reformation as to better introduce science-technology-engineering and math (STEM) young age to students both inside and outside the classroom. Families, teachers, and counselors must inspire and motivate female students as well as the males to show how engineering can be fun and exceptional career choice.

Preparation of Girls in STEM related Fields:

According to the U.S Department of Education National Center for Educational Statistics[3] in elementary, middle, and high school, girls and boys take math and science courses in roughly equal numbers, and about as many girls as boys leave high school prepared to pursue science and engineering majors in college[1] see Figures 1 and 2. Yet fewer women than men pursue these majors.

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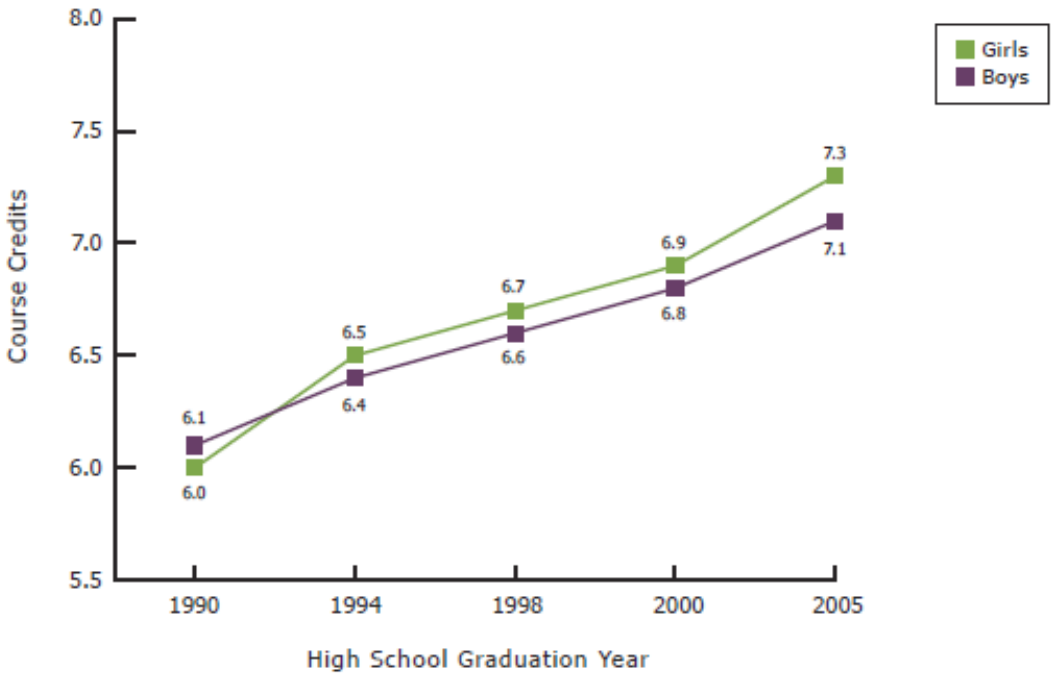

Figure 1. High School Credits Earned in Mathematics and Science by Gender, 1990–2005[1]

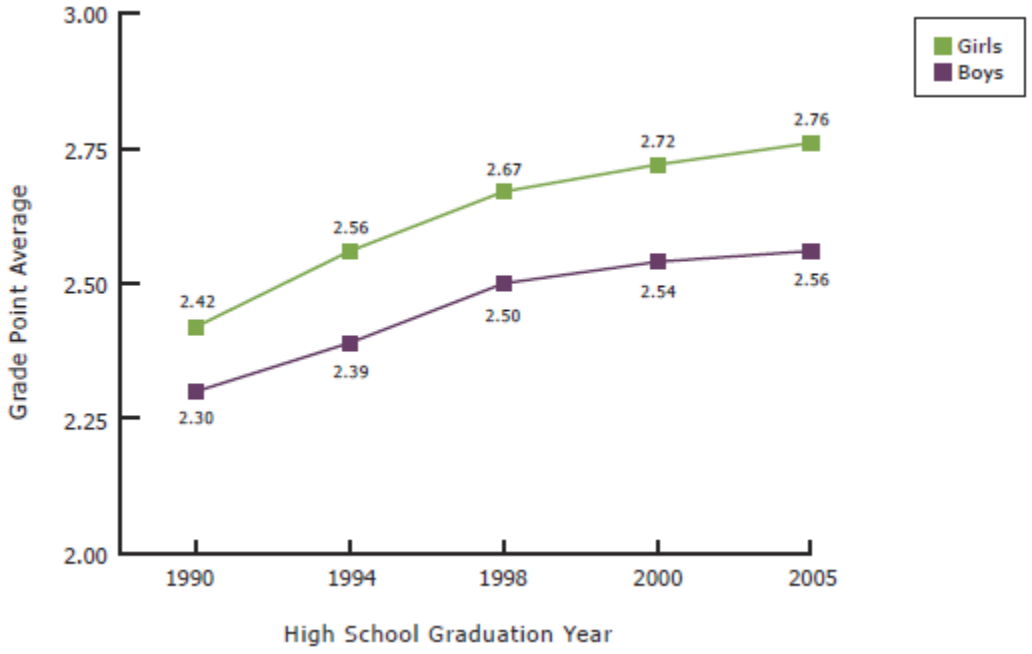

Figure 2. Grade Point Average in High School Mathematics and Science (Combined), by Gender, 1990–2005[1]

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Historically, boys have outperformed girls in math, but in the past few decades the gender gap has narrowed, and today girls are doing as well as boys in math on average[4].

Women in Engineering Colleges

Among first-year college students, women are much less likely than men to say that they intend to major in science-technology-engineering and or math (STEM). See Figure 3. By graduation, men outnumber women in nearly every science and engineering field. In some fields, such as physics, engineering, and computer science, the difference is dramatic, with women earning only 20% of bachelor's degrees (see Figure 4 and Tables 3, 4, and 5) Women's representation in science and engineering declines further at the graduate level and yet again in the transition to the workplace.

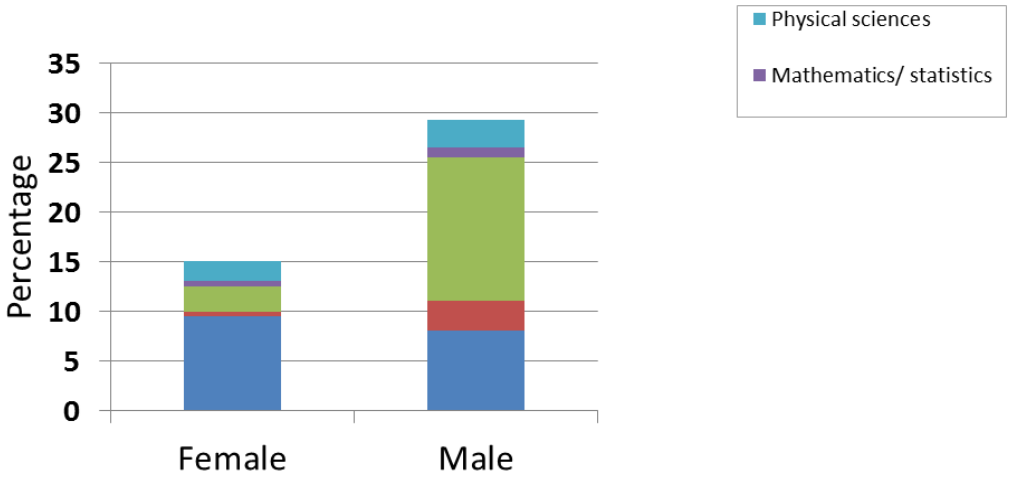

Figure 3. Intent of First-Year College Students to Major in STEM Fields, by Race-Ethnicity and Gender, 2006[5]

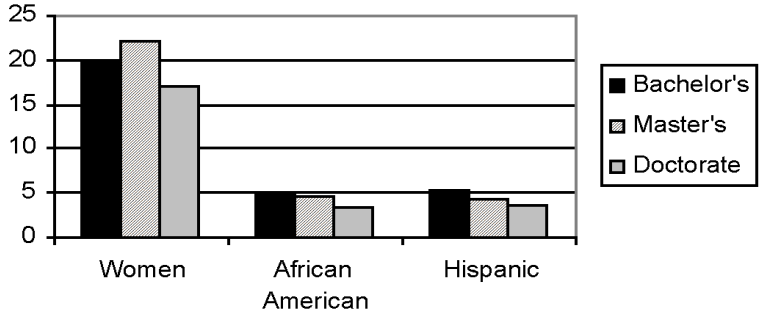

Figure 4. Percentage engineering degrees earned by women, African Americans, and Hispanics in 2003 (source NSF, 2007)

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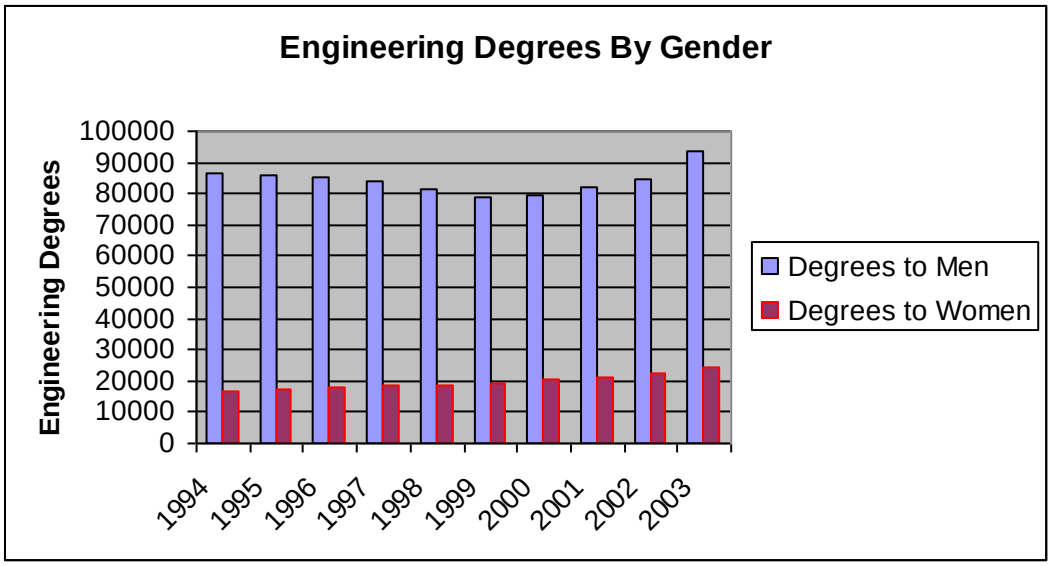

Figure 5. Engineering degrees by gender (Source: Engineering Workforce Commission)

Women in Engineering Workforce

Engineering is still a male dominant career and women in these jobs encounter similar mechanisms related to their minority status as an engineering student, as an engineering faculty or as an engineer working within the private sector. The historically accepted view of technological competence with masculinity is extremely persistent and a result is the slow implementation of change. Stereotype influences the engineering profession's image of engineers, such as engineers being serious and not emotional, unempathetic, and tough on the job. Usually those qualities connected to the engineers are attributed to males while any lacking qualities are attributed to the women[6]. Women don't see pregnancy as a debilitating factor for future hires, a factor men don't have to deal with, but this can be seen as a hindrance to potential employers. Sometimes hostile environments are created so as to limit the successes of women engineers (student, faculty or company engineer). The potential strengths of women for the field of engineering carries positive factors, such as stronger communication skills and a more empathetic, engaging persona. A negating outlook is that women are perceived to have weaker technology skillsets, which makes them ineligible as engineers. Therefore women engineers have to deal not only with regular job pressures, but must attempt to overcome stereotyping as well. In most cases, women engineers end up working longer hours and with less pay than their male counterparts[7]. Their glory is in the merit of their work, one that does not seem fiscally justified.

Industry's view of why few women engineers

Companies often see the main factor for a lower number of female engineers as a dilemma that starts at home. Families, elementary to middle school and universities are where the number of women engineers drops sharply. Some engineering fields have much fewer females than others such as construction engineering. The company view is universities must hire more female role models to recruit more female students so they can hire. Primarily, universities believe companies must provide the role model for students and also competitive salaries to attract more

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female students to pursue engineering degrees. Wächter (2005) explains this view as hot potato that is thrown from one responsible party to another (See Figure 6). As if no particular group wants to accept blame or even attempt a reasonable solution.

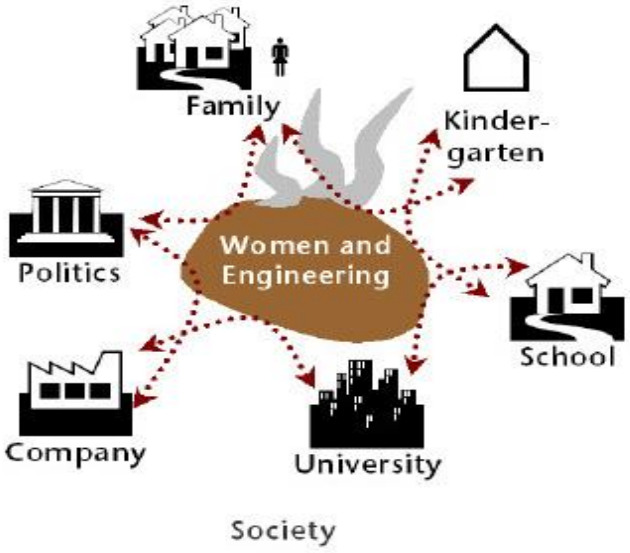

Figure 6. Hot potato model[8]

While the number and proportion of women earning science and engineering graduate degrees has increased dramatically, the need for additional focused steps to increase the representation of women in science and engineering faculties is obvious and persistent. See Figure 7.Universities and colleges play central roles both in the education of scientists and engineers and in the conduct of research and development. Progress towards equality on their campuses is crucial if we are to optimize the productivity of the nation's science and engineering enterprise.

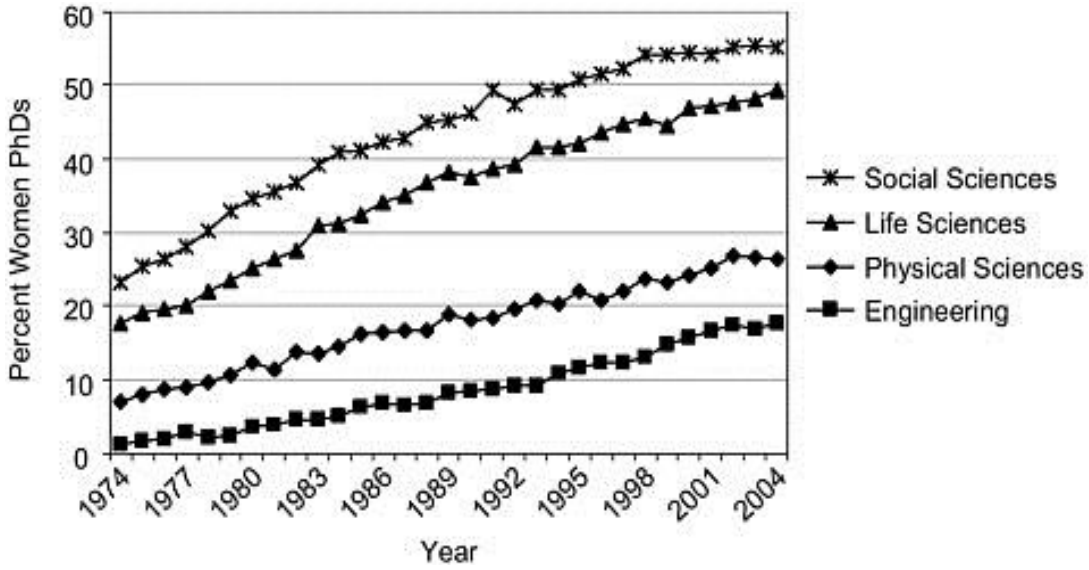

Figure 7. Ph.D Degrees earned by Women, 1974-2004[2]

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Why Women Leave Engineering Careers More Than Other Fields

Preston[9] reported that all engineers leave the field at a rate of four times that of doctors, three and a half times that of lawyers and judges, and 15-30% more than nurses or college teachers. Specific to engineering, the Society of Women Engineers (SWE) recently reported that one in four women who enter engineering have left the profession after age 30, compared to one in ten male engineers[2]. However, while these studies have documented that women have left the field of engineering, they have not focused on the psychological processes involved in making their decision to leave the profession. Their decision could be related to concerns with work/family balance or lack of advancement opportunities. It could be for several factors, many of which have become the focus of retention studies. Fouad and Singh[10] researched the reasons why women leave engineering careers and their studies showed that despite women comprising more than 20% of engineering school graduates, only 11% of practicing engineers are women. 80% are working full time in another field. After surveying 3,700 women who had graduated with an engineering degree they concluded that the organizational climate was a factor in not entering engineering. The lack of flexibility, a disdain for the culture, and management seemed unappealing. A lack of interest was also cited as a reason not to enter engineering. Around 20% of the women never planned to enter and pursued other post-graduate degrees. Table 1 and 2 summarizes Fouad and Singh's findings on the percentage of women engineers who never enter engineering based on graduation years and what these women are doing now.

Table 1. Percentage of Women who never enter Engineering Based on college graduation year[10]

year	**Prior to 1993**	**1984-1989**	**1990-1994**	**1995-1999**	**2000-2004**	**2005-2010**
Percentage	7	13	14	17	24	24

Table 2. Primary Activities of women who never entered engineering workforce (for different years of graduation)

Primary activity	**Before 1993**	**1984-1989**	**1990-1994**	**1995-1999**	**2000-2004**	**2005-2010**	**Total**
Working on non-engineering Jobs	154	150	42	92	36	2	535
Family care	32	60	42	37	7	3	171
Retired	26	3	0	1	0	0	38
Volunteer	12	3	2	1	0	0	18
Other	18	7	3	7	1	0	36

Furthermore Fouad and Singh's (2011) studies showed that women currently working in engineering did not differ from women who left engineering or never entered the work force on technical knowledge, types of interests, levels of self-confidence and outcomes they expected

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from performing in certain tasks. These findings were related to the post-graduate women from engineering colleges. Naturally women were more likely to be committed to the field of engineering if they received opportunities for training and development, opportunities for advancement, and believed that the time demands were reasonable. Women were more likely to be committed to their engineering job when their supervisors and co-workers were more supportive of them overall.

Texas Tech University comparison

As previously discussed, the proportion of women entering many traditionally male-dominated professions has increased substantially in recent years. However, gender ratios in the field of engineering have remained highly unbalanced in the United States, with women constituting only about 20% of engineering majors and holding only about 9% of engineering jobs (National Science Foundation, 2000). Gender balance in engineering is a hot-topic issue in the US and many other countries. The cause of the imbalance has been extensively studied and primarily viewed as a result of the historical patterns of institutionalized gender discrimination, which plays a key role on issues of gender balance in Engineering [11, 12]. However, there is evidence that achievement-related beliefs are also involved[13]. Texas Tech University College of Engineering shares this gender imbalance in student enrollment as well as the faculty male to female ratio. In Texas Tech University College of Engineering, as seen in Tables 3, 4 and 5 by graduation, men outnumbered women over the last three years. The Graduate degrees held by women are slightly higher given the fact that a majority of the graduate students in the College of Engineering are foreigners. The male faculty to female faculty ratio does not stray too far from the national facts listed in table 6. Of the total number of engineering faculty, only 17 are women.

Table 3. Texas Tech University Degrees Conferred by Gender Years 2009-2010
December 10

College	Gender	Bachelors	Masters	Doctoral	Total
Engineering	Female	63	44	8	115
Engineering	Male	469	168	35	672
Engineering	Not reported	1			1
Engineering	Total	533	212	43	788

Table 4. Texas Tech University Degrees Conferred by Gender Years 2010-2011
December 11

College	Gender	Bachelors	Masters	Doctoral	Total
Engineering	Female	67	45	6	118
Engineering	Male	504	151	37	692
Engineering	Not reported				
Engineering	Total	571	196	43	810

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Table 5. Texas Tech University Degrees Conferred by Gender Years 2011-2012 December 12

College	Gender	Bachelors	Masters	Doctoral	Total
Engineering	Female	78	33	8	119
Engineering	Male	569	201	32	802
Engineering	Not reported				
Engineering	Total	647	234	40	921

Table 6. Texas Tech University College of Engineering. Faculty Demographics by departments 2012-2013 (Tenure & Tenure Track)

	Chemical Eng	Civil Eng	Computer science	Construction Eng	Electrical &Computer	Industrial	mechanical	petroleum	Total
Female	3	3	2	1	4	2	4	1	17
Male	12	20	13	7	20	12	29	5	121
Total	15	23	15	8	24	14	33	6	138

Global Demand and need for Gender Balance for Engineers

The demand for engineers is spread across globe. In the United States alone, in the month of September, there were more than 184,000 jobs advertised online for engineering professionals according to Wanted Analytics, a business intelligence firm. The volume of listings was up 12% compared with those a year earlier and 27% against the same time period in 2010[14]. Therefore, the role of the academia educating engineers to fill this need is great. We cannot bring a real solution to the problem unless the issue of gender equality is addressed and achieved in a positive manner. The universities role is that of attracting and retaining the female students and more importantly than attracting the female faculty is to provide positive role models for female student. The issue of female faculty is another issue that needs to be addressed. Removing the structural barriers to gender equality in engineering government academic institutions, industry and private corporations as well as global collaborations might be necessary.

Recommendations at Glance:

Education starting early age in the SMET in and out of the classrooms fostered and supported by family and teachers
Mentoring programs for female students in K-12 programs
Encourage students to have more flexible grown mindset about intelligence.
Providing role models to girls very early age
Summer SMET related fun and educational activities for girls
Educate male and female students to be self-confident to break peer pressure issues.
Training school counselors and advisors in gender sensitive issues to be supportive to girls

In Academia: recruit and retain more female students
Provide mentoring and support to female students

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Provide scholarships
Facilitate and encourage International exchange opportunities for female students and faculty
Recruit and retain more female faculty,
Provide female faculty equal startup and support as male counterparts
Provide mentors and networking opportunities
Prevent gender biasness and change negative work climate
Create supportive gender sensitive academic culture

In companies and Organizations: recruit and retain female engineer
Implement gender sensitive recruitment policies
Create clear path toward advancements of women.
Provide in service training
Prevent gender biasness and change negative work climate
Create organizational women friendly culture
Provide mentoring and networking opportunities
Implement Diversity programs will lead to non sexist work culture
Provide family friendly support.
Government, academia and industry collaboration is a necessity.

Conclusions:

It's not just the U.S. that's suffering from a critical shortage of engineers. Many countries are experiencing a decline in the number of young people, especially women, studying engineering. Globalization and new economic development requires including engineers to be functional in more diverse work environments. Given the fact that half of the population is women and most technology related jobs, including engineering, women are seen as minorities is not beneficial. It seems women appear not to play an important role in engineering and technology. However, it is not a deficit of women that provides a gender in balance but rather is the result of biases rooted in stereotypical education systems, teaching and working climate, content, and the context in the engineering fields.
To fulfill global economic needs we need to educate and push more graduating engineers with an emphasis on closing the gap between women and men in engineering fields. There is a big role for government, academia, and the private sector in aiding to fill these gaps and improve upon the enrollment of women into engineering specific careers.

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