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**AC 2007-2250: WOMEN IN SCIENCE AND ENGINEERING: POLITICS OF GENDER**

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# Women in Science and Engineering: Politics of Gender

## Abstract

Because they are fewer than men in science and engineering, women are generally said to prefer arts and humanities. But to some analysts, the reason for the low percentage of women in science and engineering may be due to innate mental and psychological differences between them and men. Others contend that women have the capacity to excel in any profession and that their fewness in science and engineering can be attributed to other factors. They urge educational institutions and employers to develop programs and specific policies that would allow women to strike a better balance between the demands of work and those of family.

One may then ask: was the absence of equitable programs and policies responsible for the predominance of men in certain professions in the past? Or is it a genetic difference that prevents many women from specializing in these professions? This paper examines the gender gap in science and engineering; the proposed theories that exist and the validity of the theories. The questions that will be addressed include: Are women underrepresented in science, mathematics and engineering? Why is this so? What are the competing theories and how valid are they? If women are truly underrepresented, what efforts are being made to correct the phenomenon? Do women in science and engineering reach the top in their fields? If not, why? For the purpose of this paper, women in academia and in the industry will be the focus.

## I. Introduction

The statistics of education show that women outnumber men in college enrollment. Women represents sixty percent of the undergraduate population and in 2001-2002, women earned more doctorates in the United States than men. However, women are underrepresented in science and engineering (S&E) fields. Science and engineering education in the United States has a gendered history. In a study for the National Science Foundation, Jon Miller<sup>1</sup> found that while 9 percent of adult men are scientifically literate, only 6 percent adult women are<sup>2</sup>. (To be scientifically literate is to have a basic understanding of the terms, processes and impacts of science and technology). Among college educated men and women, 23.6 percent of adult men are scientifically literate, while only 17.1 percent of women are<sup>3</sup>. Other large scale surveys of national trends show that there were consistently smaller percentages of female science majors compared to men. Women continue to be underrepresented in science and engineering fields, both in terms of the number of bachelor's degrees they earn and their presence in the science and engineering workforce<sup>4</sup>. The degrees awarded in S&E fields in 1996 show some disparities between men and women:

18 percent of engineering degrees (11,316 women and 51,798 men);

33 percent of earth, atmosphere, and ocean science degrees (1,485 women and 2,972 men);

34 percent of mathematical and computer science degrees (12,764 women and 24,857 men);

37 percent of physical science degrees (5,702 women and 9,694 men);

50 percent of biological and agricultural science degrees (39,369 women and 39,100 men);

51 percent of social science degrees (56,834 women and 54,955 men); and

73 percent of psychology degrees (53,863 women and 19,965 men).<sup>5</sup>

As late as 1960's women made up only 1 percent of students studying engineering in the United States. A review of national surveys of college students in 1988 showed women constituted 33 percent of computer and mathematical scientists, 24 percent of natural scientists and chemists, but only 7.3 percent engineers.<sup>6</sup>

Throughout the last half of the 20th century, activists fought to change that situation. There were attempts to win acknowledgment of women's ability to become good engineers. American Association of University Women<sup>7</sup> highlights how women are being left behind in the technology revolution.<sup>8</sup> In a qualitative study, 70 middle school and high school girls on the East coast and 900 teachers nationwide were interviewed. For the same study, AAUW Educational Foundation convened a Commission on Technology, Gender and Teacher Education to make recommendations for research practice, and policy that might address the gaps.

Until recently, the inequality has been explained as being consistent with the natural differences between the sexes. One school of thought believes that women's innate capability limits them to those disciplines or careers seen to be more attuned to female characteristics. The other school of thought believes that there is no difference between female and male intellectual capability and women can be as successful in the hard sciences as men. The difference, they say, only exists in individuals and not tied to sex. The history of the general belief that engineering is not for women could be traced back to the late nineteenth century and early twentieth century. After the Second World War, enrollment in science and engineering programs skyrocketed as federal government pumped money into research. How did women fare then and now?

### Theories

Several theories have been proposed as to why there are few women in Science, Mathematics & Engineering (SM&E) fields. I will discuss four in this paper.

## **II. Theory of discrimination and denial of access**

One is the theory of discrimination, denial of access. Engineering was perceived as a masculine career and consequently, women were denied access. Studies of elementary, middle and high school science reveal a persistent pattern in which teachers paid more attention to boys' scientific interests and provide them with more science experiences. Girls, on the other hand, develop more negative attitudes towards science and by the end of high school take fewer science and mathematics courses, also scoring low on science achievement tests.<sup>9,10</sup> In a recent study, Baker and Leary interviewed forty girls in grades 2,5,8 and 11 using semi-structured protocol. The interview focused on feelings about science, science careers, peer and parental support, and how science is taught. All of the girls asserted that women can and should do science. In this report,

Baker and Leary<sup>11</sup> stated that teacher-student interactions are biased in favor of boys as early as in elementary schools. In the face of failure, boys are encouraged to try again, and girls are allowed to give up.<sup>12</sup> Pedagogy is often based on male learning styles especially when competition is emphasized. Under all forms of instructions, girls have less access to science equipment, hands-on activities and computers than boys.<sup>13</sup>

Many studies indicate that schools fail to provide environments conducive to girls' learning. Textbooks lack positive female role models and often include sex-role stereotypes.<sup>14</sup> According to Eisenhart and Finkel,<sup>15</sup> the increasing use of new technologies in educational settings has widened the gap even more. In a study of a technological- powered classroom, Yates and Finkel<sup>16</sup> found that while girls were skilled at and interested in using computers, they were not encouraged to bring those skills into the classroom. As a result, girls used computers far less than their male counterparts in their science classes, and learned less about the new technology. In 1992, The American Association of University Women (AAUW) published a report, *How Schools Shortchange Girls*.<sup>17</sup> This report provided evidence that girls were often ignored in the classroom and neglected in the curriculum. In 1998, a follow-up report was published titled, *Gender Gaps: Where Schools Still Fail Our Children*.<sup>18</sup> Based on an analysis of over 1,000 research documents published between 1990 and 1998, *Gender Gaps* reveals that girls have made some strides, but gaps still remain in the areas of science and mathematics (AAUW, 1998). Cumulatively, these experiences logically lead to lowered educational and career aspirations in science and engineering for girls.

Stepping out of the school system, higher education presents its own obstacles. Until the twentieth century, almost exclusively, men populated science and engineering, and, until recently, the profession prevented women from creating a niche for themselves in the male dominated technical world. For several decades, society treated the study of technology, "men's territory."<sup>19</sup> Until World War II and beyond, many leading engineering schools, including Rensselaer Polytechnic Institute, Georgia Institute of Technology, and California Institute of Technology, remained closed to women. The few women admitted to Massachusetts Institute of Technology (MIT) struggled against a hostile intellectual and social environment. Women studying engineering were perceived as odd exceptions, outcasts and defying normal gender norms.<sup>20</sup>

The reason for the gender exclusion was found in the origin of the profession. Throughout the 19<sup>th</sup> century, it was rare for practitioners to have earned a formal engineering degree. They acquired their credentials through on-the-job experience such as in the railroad yard, or machine shop. Such work environments excluded women. In addition, engineering chores involved hard, sometimes dangerous and physical encounters. These were perceived as inappropriate for women. Other forces that reinforced the masculinity of the profession were that makers of model trains and other technological toys marketed them only to boys as a way to make them into future engineers. Girls who expressed technical interests were often steered instead into the science side of home economics.<sup>21</sup> In the late 1800s and early 1900s, a handful of women ventured into engineering studies, primarily at land-grant institutions.<sup>22,23,24</sup> For instance, Olive Dennis earned her civil engineering degree in 1920 from Cornell, and then worked more than 20 years at the Baltimore and Ohio railroad. Women such as Dennis attracted attention since they were a rarity. Commenting on that female presence, a 1920's newspaper headline read "Three

Coeds Invade Engineering Courses and Compete with Men at Cornell University: Stand Well in Their Studies."<sup>25</sup>

The issue of venturing into strange space came to a head when, with the outbreak of World War II, the United States suddenly faced a manpower crisis. Men were called up to service, and industry needed people with technical expertise at drawing boards and engineering shops to produce planes and tanks for the war. So, companies sought to hire female engineers. But they could not find enough female engineers. Companies like General Electric hired women with knowledge of Math and Science, gave them emergency crash courses and turned them into wartime engineers' aides.

One of the most elaborate of such plans, in 1942, was the Curtiss-Wright airplane company's initiative for training "Curtiss-Wright Cadettes." Seven colleges--Cornell, Iowa State, Minnesota, Penn State, Purdue, Rensselaer Polytechnic Institute (RPI), and the University of Texas--agreed to work with the firm and teach its specially prepared curriculum to more than 600 women. Program representatives recruited sophomore, junior, and senior coeds through advertisements in college papers, calling especially for those with training in mathematics at least through algebra. The students went through a 10-month immersion in classes on engineering mathematics, job terminology, aircraft drawing, engineering mechanics, airplane materials, theory of flight, and aircraft production. After that intensive exposure, Curtiss-Wright assigned Cadettes to plants to work in airplane design research, testing, and production.<sup>26</sup>

Two of the institutions in the Curtiss-Wright project already enrolled women majoring in teaching or home economics prior to the project. By contrast, at all-male RPI, the arrival of "engineeresses" created a culture shock. Local newspapers carried giant headlines, "RPI Opens Doors to Women: Institute Breaks 116 Year Old Rule Due To War Need ... Curtiss Wright Women ... Invade RPI Campus" (Rensselaer Polytechnic 1943). Soon RPI discovered advantages to having "Katie Kaddettes" on campus.<sup>27</sup> Cadettes threw themselves into the school culture. They were cheerleaders, and actresses in the act troupe. They proved temptingly photogenic and added glamour to the campus. Life magazine published a special feature titled: "The 'engineeresses' were a curiosity, but acceptable as a temporary war measure".

As World War II drew to a close, returning male veterans flooded American engineering programs, and the wartime emergency rationale for encouraging women to develop their technical talents vanished. Also, conservative gender modes of the postwar decades brought a prevailing expectation that the goal of marrying and raising children should take precedence over women's career ambitions. Young girls who did express technical interests were often deliberately discouraged by negative remarks from family or teachers.<sup>28</sup>

At Georgia Tech, talk of women engineers was unheard of. The issue of coeducation came to the fore when there was a rumor that Atlanta women were raising funds to go to the courts and compelled the regents to start admitting women. The Atlanta Attorney General said if they did, they were certain to win.<sup>29</sup> Soon there was a test case. A technically talented high school woman wished to study engineering at Georgia Tech. To this the school president Van Leer commented:

"My personal feelings sway me in one direction, whereas my official

position influences me another way. I have been associated with coeducational institutions practically all of my life, and I have always felt it was wrong to discriminate against a student because she happened to be a woman. I feel that way about Miss Bonds. She is obviously a Georgia citizen and a qualified and responsible engineering student; this makes it seem wrong ... for her to be denied an engineering education in her native state simply because she is a woman. On the other hand, Georgia Tech is traditionally a man's school. The majority of students, faculty, and alumni are opposed to coeducation.”<sup>30</sup>

Under the influence of his wife and daughter (who both had technical interests of their own), Van Leer followed his personal inclination and started advocating for women's admission. After a series of attempts and failures, the board passed measure, admitting women under limited conditions.<sup>31</sup>

The gender gap in S&E induced the attention of government agencies. A study by the National Center for Education Statistics examines gaps related to gender in entrance, persistence and attainment of postsecondary science and engineering (S&E) education.<sup>32</sup> The study examined two sets of data. First the report examined the link between high school experience and entrance into S&E postsecondary programs to explore the extent to which women and underrepresented minorities continue to have lower entry rates into S&E programs at the postsecondary level. This is an analysis of the National Education Longitudinal Study of 1988.<sup>33</sup> To give an overview of NELS 88, a nationally representative sample of eighth-graders were first surveyed in the spring of 1988. Four follow-ups resurvey of the respondents were done in 1990, 1992, 1994, and 2000. On the questionnaire, students reported on a range of topics including: school, work, and home experiences; educational resources and support; the role in education of their parents and peers; neighborhood characteristics; educational and occupational aspirations; and other student perceptions.

The second analysis addresses issues relating to persistence and degree attainment by women in postsecondary S&E study. It traced a cohort of postsecondary students who began their S&E education in their first post secondary year (i.e. as freshmen) through a five-year time frame (1989-90 to 1993-94) using data from the ‘Beginning Postsecondary Student Longitudinal Study (BPS)’. Initial findings showed that the gender gap is mainly among Asians and whites. Further examination showed that students of whatever race/ethnicity or gender will likely major in S&E in postsecondary if:

- they have taken advanced science sources
- they were self motivated to study science
- they had parents with relatively higher levels of educational attainment
- they had parents with high expectations for their children’s college education.<sup>34</sup>

With the experience of exclusion, women have low self-ratings of their ability in analytical fields that have traditionally been male-dominated. This, added to perception of competition and difficulty with majoring in the sciences kept women away from SME. Cases of math anxiety and instructors’ lowered expectations have also been shown to hinder women from

participating.<sup>35</sup> During the 1970's and 1980's the percentage of women receiving engineering degrees increased dramatically. Women's share of bachelor's degree in engineering rose from about 1 percent to more than 10 percent.<sup>36</sup> However, Jacobs<sup>37</sup> demonstrates that the rate of improvement in gender balance in scientific fields slowed substantially in the late 1980s after increasing markedly in the 1960s, 70s and early 80s. He concludes that women remain segregated from men in all science fields of study at the college level.<sup>38</sup>

### III. Theory of self concept

Another proposed theory is the issue of self concept. Ross & Nisbett.<sup>39</sup> argued that individuals see situations through the lens of their own self views and that individual differences exist in the way situations impact on people. Constructivist posit that humans actively create and construe our personal realities –that each person creates his or her own representational model of the world and that this model does not simply act as a filter through which ongoing experience is perceived, but that the model actually creates and constrains new experience and so shapes what the person will perceive as “reality.”<sup>40</sup>

Indeed research suggests a central role for the self in motivation and behavior.<sup>41</sup> Thus, self views are important for understanding the persistent tendency for male and female students to separate into different academic and career paths and the resistance of many young women to science and technology careers. Self concept in various guises and interaction with the social context, shapes the academic and occupational choices that people make with respect to mathematics and science. For instance, having a positive or negative self schema with respect to mathematics and science, as opposed to having no self-schema or only a weak self-schema for this domain, has been systematically linked to a variety of tangible outcomes: performance on in-lab math tests, past math/science course enrollment, confidence with respect to career possibilities in math and science, intent to take more math/science courses, and the number of math/science courses actually taken for 3 years subsequent to the self-schema assessment .<sup>42</sup>

Female college students, even those who select math-intensive majors, have difficulty associating math with the self if they implicitly stereotype mathematics as masculine.<sup>43</sup> Despite their current self-perceptions as positively inclined toward mathematics and science, women in one study could not , or would not construct possible selves in the realm of engineering and the physical sciences – perhaps because such possible selves were at odds with their notions about femininity, or perhaps because they had no female role models in these areas to help them articulate a possible self.<sup>44</sup>

On the basis of their gender, students may be encouraged or discouraged from certain choices and may learn to view themselves as fitting well or poorly into certain roles (Eagly, 1987; Eccles, 1987; Raty, Vanska, Kasanen & Karkkarnen, 2002). Example will be female university students in male dominated academic areas report higher levels of discrimination and stereotype threat than do women in female dominated academic areas.<sup>48</sup>

The construction of current – and possible self-views is a dynamic process.<sup>49,50</sup> Thus students are actively constructing their futures as they construct their self-views and reciprocally, are actively adjusting their self-views to fit the futures they are envisioning. In the process women

and men may be diverging more and more in their sense of possibility. Ivie & Stowe's examination of U.S. women and men in academic physics showed that although almost half of high school physics students are women, women are poorly represented at bachelor's level and higher and that women's participation in physics decreases with each step up the academic ladder.<sup>51</sup>

Moreover, research on students in a university engineering program designed specifically to be woman-friendly showed that women's academic performance was higher than men's for the freshman and sophomore years, but that men seemed to catch up in the last 2 years. In addition, female students experienced a noticeable drop in confidence in their engineering abilities in senior year, at a time when male students displayed a surge in self-confidence.<sup>52</sup> If there is an increasing divergence, it may be partly because, as they approach academic and career decision points, young women envision future difficulties in science, engineering and technology. Steele et al<sup>53</sup> found that female students in a male dominated area anticipated more future sex discrimination and thought more about changing their major than did their counterparts in traditional fields.

#### **IV. Theory of family connection**

One other theory being proposed as to why fewer women can be found in science, is that women make decisions about their lives differently from men.<sup>54, 55</sup> These decisions are made with the mindset of having multiple life roles, self identity and ways of interacting with people, objects and experiences in the world.<sup>56</sup> Nard<sup>57</sup> found that women make career plans based on anticipated personal and professional roles. Gilligan.<sup>58</sup> found that highly successful women describe themselves in terms of relationships. Their identity rests with their relationship as mothers, wives, lovers and children and not in academic or professional success.<sup>59</sup> Similarly, Arnold<sup>60</sup> found that academically outstanding women tend to judge success in terms of relationships and tend to make decisions that emphasize balance between work and family life.<sup>61</sup> Younger girls and adolescents also describe their world in terms of relationships.<sup>62</sup> Eccles<sup>63</sup> concluded that women may choose less technical occupations because of their popularity which makes choice less challenging than it is for other occupations. Women's choices are based on short and long term goals, self identity and psychological needs that are different from those of men. Women have an inner sense of connection to others.

The failure of the SME fields to highlight connection of subject matter with life applicability has been shown to affect the retention of women in engineering. For many female students, the technical nature of engineering does not suggest life skills of creative thinking and communication. Seymour<sup>64</sup> explains that the image of scientific careers also does not appeal to female students' orientation toward helping others and having a family.<sup>65</sup> Campbell,<sup>66</sup> indicated that those who are talented and academically successful drop out of science majors and change careers at a much greater rate than men, even when they are equally or better prepared. Even when girls do well and like science, they do not necessarily choose science careers.<sup>67</sup> A further refutation of traditional variables comes from studies in the Scandinavian countries where there is legislation against sex discrimination and textbooks must pass inspection for gender inclusiveness. This relatively well-off homogenous population has the same curriculum for all

students, and role models in the form of a female prime minister and female cabinet members. Yet the number of women who choose science and engineering is extremely low and declining.<sup>68</sup>

Baker and Leary<sup>69</sup> conducted a qualitative study mentioned earlier. The goal was to determine what influences girls to choose science. A volunteer sample of 40 girls in grades 2,5,8 and 11 were interviewed, using a semi-structured protocol. They were asked to share their feelings in five areas: science, science careers, peer and parental support, how science is taught, and how they would teach science to girls and boys.

Seven themes emerged from this study and data revealed three threads common to all girls from all the grades. The categories that developed were school science, societal factors and equity. Science was perceived positively by the girls across grade levels. They planned to do more science, they were confident about their ability to do science and many were planning to pursue science related careers. They would like science taught differently. When they expressed positive sentiments about school science it was because it met their needs for relationships and connection. Good teachers and team work are positive themes while independent work separates and isolates, and when topics become decontextualized, they are uninteresting.

The second category, societal factors, showed that the girls did not receive a clear message about who a scientist is and what scientists do. The media often portrayed scientists as weird-looking males doing bizarre experiments. This stereotype is least appealing to girls. In the third category, equity, the girls noted that liking scientific career depends on the individual not on one's gender. They refused to accept that girls can't do science or that they can't be scientists.<sup>70</sup>

## **V. Theory of innate variability**

The fourth and most controversial theory is about women's lack of innate aptitude for science and engineering. In January 2005, Harvard President, Larry Summers<sup>71</sup>, in his address to the National Bureau of Economic Research Conference, stated that the reason women are fewer than men in science and engineering is that there is variability in intrinsic aptitude between men and women. His remarks sparked a lot of controversy across the nation. The success of the Curtis-Wright airplane company during World War II disproves the notion that women lack innate capability. There is not yet an empirical scientific evidence to support this theory.

## **VI. Workforce**

Turning attention to the labor force, women comprise 12 percent of the employed in scientific and engineering fields in industry according to the National Academy of Sciences. This is due in part to the subfields chosen by women and partly due to the attrition rate for women scientists and engineers in industry, which is double that for men and substantially higher than that of other employment sectors.<sup>72</sup> Education is not the only area that marginalizes women in science and engineering; workplace discrimination is a real barrier to women scientists.<sup>73</sup> Science and engineering workforce participation and employment are the ultimate measure of the S&E pipeline outcome. In 1995, women represented 51 percent of the U.S. population and 46 percent of the nation's labor force, but constituted only 22 percent of the S&E workforce. This difference reflects the gender gap in S&E participation at the higher education level. Data from the 1995

Surveys of Science and Engineering College Graduates<sup>74</sup> shows that among employed scientists and engineers (including postsecondary teachers), women make up 22 percent of the total S&E workforce, but 50 percent of the social scientists and 9 percent of the engineers.

### A look at the top of the professions

The rolls of the National Academy of Sciences and the list of Nobel Laureates register very few women. The Academy of Sciences is a private organization chartered by Congress to provide advice to policy makers. Membership in the Academy is considered one of the highest honors. Of its 2,059 members, 187 are women which is about 8 percent. Another reward for excellence is the Nobel Prize. The Nobel Prize is the first international award given yearly since 1901 for achievements in physics, chemistry, physiology or medicine, literature, peace and economic sciences. Only 12 female scientists have received the Nobel Prize so far; of these 12, three share the prize with their husbands.<sup>75</sup> Inquiries into comparative positions show that women tend to occupy lower-prestige positions than do their male peers: 22 percent of women were at schools of 'high' quality compared to 38 of men. On the flip side, 55 percent of women and 30 percent of men were located in institutions of 'medium' or 'low' quality.<sup>76</sup> A look at the graduating rate in higher degrees will give the impression that women outnumber men in academia. Sixty percent of undergraduate population is women and in 2001-2002, women earned more doctorates (51%) than men in the United States. Fewer women though, earned Ph.D.s in the Physical Sciences (29%), Life Sciences (50%), and Engineering (19%), than in Social Sciences (60%) and Humanities (50%).<sup>77, 78</sup> However, the majority of the professors in major research universities are men.

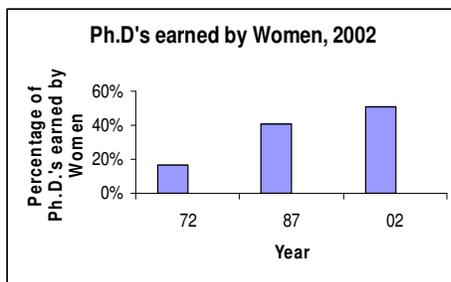


Fig 1. Courtesy of the National Science Foundation

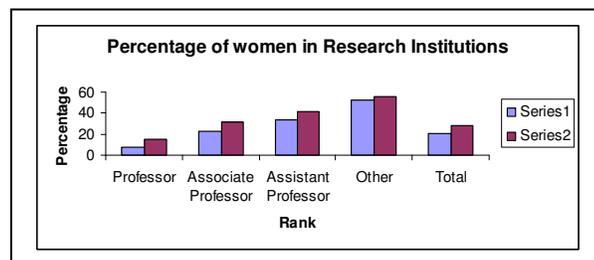
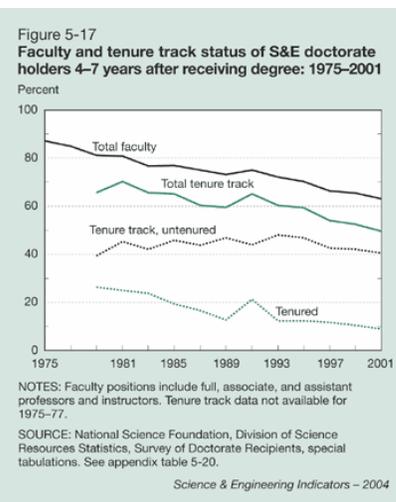


Fig. 2., Percentage of Women at Research Institution  
Series 1- 1989; Series 2- 2001

Even though women earn more Ph.D.s than men, they occupy the low rungs of the ladder in Academia. There are more women in the Assistant Professors and "Other" categories than full Professors and are more in four year colleges than in Research Institutions. This means the attrition rate of women before reaching the top in academia is higher than that of men. Women occupy the majority of the tenure track, and untenured categories.



Courtesy of the National Science Foundation  
<http://www.nsf.gov/statistics/seind04/figures.htm#c3>

“The higher up the academic-prestige ladder a university is, the fewer women it usually has in tenured faculty positions” says Wilson in *The Chronicle of Higher Education*. He stated further, “Other recent research shows that women at doctorate-granting universities advance more slowly on the tenure track than men do, are paid less than their male counterparts, and are more apt to be dissatisfied with their jobs.”<sup>79</sup>

In industry, limited access is the first hurdle faced by women seeking jobs in science and engineering. While progress has been made in this area in recent years, common recruitment and hiring practices which use traditional networks often overlook the available pool of women, according to report of Committee of Women in Science and Engineering (CWSE). Once on the job, the environment is toxic to women. Many female employees find paternalism, sexual harassment, allegations of reverse discrimination, different standards for judging the work of men and women, lower salary relative to their male peers, inequitable job assignments, and other aspects of a male-dominated culture that are hostile to women. Women have limited opportunities for advancement, particularly for moving into management positions. The number of women who have achieved the top levels in corporations is much lower than would be expected, based on the pipeline model.

We must continue to address the many but subtle ways in which women are discouraged from pursuing interest in scientific and technical fields. Society benefits most when we take full advantage of the scientific and technical talent among us. It is time we created a broader awareness of those proven and effective means, including institutional policies and practices that enable women and other underrepresented groups to step beyond the historical barriers in science and engineering.

## VII. Proposed Solutions or Reforms

In 1959, the President’s Advisory Committee issued a major statement on Education for the Age of Science. One of the several premises that were expressed was that:

“No child shall be deprived of the fullest opportunity to develop talents.”<sup>80</sup>

There are four compelling reasons to open doors, removing barriers, and encouraging and enabling the full participation of women especially in science and engineering. First it is equitable treatment of all citizens that emerged in mid century as part of the civil rights and human rights movements. Progress has been made in changing the rules that previously barred women from entry and participation in education and in the workplace. The second is the economic argument. There is a growing need for skilled workers and we cannot afford to leave a sector of our workforce out. Third, women as new entrants to the workforce represent an important source of renewal. Fourth, many challenges that we face will need sustained commitments to make short term sacrifices for long term gain.

“We cannot succeed on many critically important policy matters without the full participation of women.”<sup>81</sup>

## **VIII. Solutions in place**

Over the years, many efforts in educational policymaking and practice have been made to increase underrepresented minority and female participation in S&E areas. Title IX of the Education Amendments of 1972, for example, forbids discrimination on the basis of sex in any education program and institution receiving federal funds. This statute is enforced by the U.S. Department of Education’s Office for Civil Rights. The Women’s Educational Equity Act of 1974 was the first piece of legislation enacted by Congress that has exclusively as its aim the funding of projects to improve the quality and scope of education of girls and women. In addition, one of the goals of the National Science Foundation’s (NSF) human resource development programs is to assure equality in S&E education, and NSF has established a number of programs that prioritize education in science, mathematics, engineering, and technology for students including women and minorities (e.g., National Science Foundation 1997, 1996a). Higher education institutions—public and private sectors alike—have been recruiting women and minorities to study in fields traditionally dominated by white men. Such programs often focus on S&E and professional education.<sup>82</sup> At the K–12 level, states and local schools have come up with various strategies to improve math and science education for girls.<sup>83</sup>

In Florida, since 1989, the School Board of Broward County (SBBC) has taken steps to increase underrepresented students’ participation and success in science, mathematics, and technology. Its aim is to provide students with new understanding and motivation for the sciences. The programs have aimed to increase students’ self-confidence and interest in science and mathematics, which would be reflected in increased enrollment in higher-level science courses at the secondary level, such as Advanced Placement (AP) Chemistry, AP Biology, and AP Physics. These courses provide a stronger intellectual background for students choosing undergraduate science, mathematics or computer science majors at the college level.<sup>84</sup>

In this program the School Board of Broward County has partnered with Broward Community College to provide underrepresented students with targeted educational opportunities to supplement the traditional secondary experience by offering ‘Saturday Science’. Two Saturdays a month between September and May, the program brings together students from across 60 middle and high schools in the district to focus on scientific research, engineering and

environmental issues. Problem solving and hands-on learning are provided by teachers and guest lecturers as well as field activities, mathematical and statistical applications, and laboratory research. Two classes feature guidance activities on scholarships, college applications, technology education, and career awareness for both parents and students. Participants are evaluated using group competitions, individual and group activity logs, and a major project. Saturday Science and district wide students' enrollment in science courses were examined for 1996-97, 1997-98, and 1998-99. Results show that more Saturday Science students enrolled in higher level science courses, that is, AP courses and International Baccalaureate (IB) courses than the district wide students. They also earned higher great point average (GPA) and surveyed students revealed that the Saturday Science participation had improved their grades and positively influenced their decision to attend college.

'Project Lead the Way' (PLTW) is another initiative that is gaining ground for increasing the participation of girls in science and engineering fields. According to Richard Blais, the founder, PTLW seeks to create partnerships with the nation's schools to prepare an increasing number of diverse groups of students to be successful in engineering programs. First started in the 1980's it is now offered in 45 states.

In 1998, the American Association of University Women Educational Foundation announced a 10-year research agenda that includes focus on girls and young women's educational preparation for an increasingly technological, information-driven economy.

At the University of Michigan a new program that is partly supported by NSF gives money to women scientists to hire graduate students and postdoctoral fellows for their laboratories.<sup>85</sup> Michigan and other major research institutions are trying to minimize the negative effects raising small children can have on a female scientist's career.<sup>86</sup> The irony is that the oldest and most generous program to help female professors facing work/family conflict began at Harvard Medical School in 1995. The program awards \$25,000 a year for one or two years to professors just starting their careers. They can buy protected time during the day for academic work, research, writing and grant applications. At the National Institute of Allergy and Infectious Diseases, a new program has just been instituted to help female postdoctoral fellows with young children hire help in the laboratory.<sup>87</sup>

"We finally realize we have a problem. Women aren't succeeding at the same rate as men, but we've decided to make up all of this other stuff instead of re-examining the structure we've built up, which is rigid and unforgiving. There is only one way to be successful, and that means that in science you are available 24/7 to be in the lab, to follow your research wherever it is going on at any given time. For both men and women, that earns you can't have any outside distractions."

-Cathy A. Trower<sup>88</sup>

## **IX. Conclusion**

In this 21<sup>st</sup> century, dependence on science and technology has been steadily increasing. Consequently, the demand for competent scientists and engineers has also risen. But women continue to be underrepresented in the fields of engineering, physical sciences, mathematics,

computer science, and biological sciences. Women are also underrepresented in the scientific and technical workforce. The number of women in science and engineering is neither representative of the population, nor is it representative of the number of women educated in these fields. Several theories have been proposed, but the most compelling one for the high attrition rate is that the policies do not match the current societal demands on women. It is disheartening to know that some young women and girls in their teens are already thinking of giving up having families of their own in order to have a career in the science fields. Women have a crucial role to play in society, that of procreation. Society should not penalize them for satisfying the most natural role for the existence of human kind. Rules are made and in light of present day needs and demands, those rules should change. It is heart warming to see that some institutions or organizations are already taking some positive steps. It is clear that the dearth of women in S&E is not lack of innate aptitude to succeed in those fields, which no one has the power to change. It is a matter of policy. That can change.

Changes in classroom instruction, in teacher and parental expectations and in social perceptions are needed before equality for women in the classroom could be achieved. Through partnerships, school systems and institutions of higher learning can implement cost efficient and educationally effective programs that develop student skills and talents in high schools that prepare them for the rigors of college and university study, and that enable them to be competitive in the workplace. Fewness of women in S&E has nothing to do with genetics but opportunity, access, societal expectations and support.

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