

**BRIDGING THE GAP: GENDER EQUITY IN SCIENCE,
ENGINEERING AND TECHNOLOGY**

REPORT PREPARED BY

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INTRODUCTION

For many years researchers have investigated gender equity in science, engineering and technology educational programs and workplaces. These studies have been used to, among other things, raise awareness of gender discrimination; inform policy discussions; and as an impetus to address instances of gender discrimination. Currently the discussion of gender equity in science, engineering, and technology is being addressed by the New Jersey Council on Gender Parity in Labor and Education. The Council on Gender Parity in Labor and Education is made up of individuals from government, education, and business to investigate issues of gender equity. It is a permanent Council established by the New Jersey Legislature in 1999. The Council finds that gender inequity in science, engineering and technology fields is a workforce problem that inhibits the full utilization of the labor force.

There is a national shortage of computer scientists, engineers, and programmers, the effects of which are felt within our state. This has resulted in approximately 190,000 jobs in Information Technology that are unfilled each year, and this number is only expected to grow. The Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development reports that between 1988 and 1998 the occupations that experienced the most growth were scientists, engineers, and medical workers. These occupations are expected to continue to grow throughout the upcoming decade, creating 5.3 million new jobs to fill

by the year 2008.^{1[1]} However, despite the growth in science, math, and technology jobs, women are vastly underrepresented in both the jobs themselves, and the educational programs and college academic majors necessary for entrance into these fields. The jobs that are growing the fastest are precisely the jobs in which women are not represented.

This report is intended to be used as a resource tool that synthesizes the literature that the Council has reviewed in its investigation of gender equity in science, engineering and technology. In this report we explore the issues surrounding the exclusion of women from science, math, and technology educational programs and jobs. It is important to note that the world of science, math, and technology is one that is rapidly transforming. Indeed, over the past decade women have made strides in some aspects of science, math, and technology. For instance, in 1999, women earned almost half of the advanced professional degrees in medicine, and nearly 59 percent of the undergraduate degrees in mathematics in New Jersey.^{2[2]} In addition, girls and women participate equally with boys and men in their use of computers for email and the Internet.^{3[3]} However, despite such advances, women continue to be underrepresented in these jobs. This report is an attempt to systematically investigate the changing world of science, math, and technology to address the needs of the labor force.

^{1[1]} Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development. 2000. *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology*. Washington, D.C.: National Science Foundation.

^{2[2]} NJ IPEDS. 1999.

^{3[3]} Cook, Jacqui Podzius. 2000. "Girls Reject Tech Careers: Fewer Women Get Computer Degrees." Associated Press.

Overview of The Issue

The Council began its investigation of gender equity in science, math, and technology by reviewing recent reports conducted by the American Association of University Women (AAUW), and the Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development (CAWMSET). From these reports the Council found that women have yet to achieve parity in either the educational or the labor sectors of science, math, and technology. Given the heightened focus on this issue within both our state and the nation, the Council decided to conduct a full investigation of gender equity in science, math, and technology occupations. The Council began by reviewing the work of recent Commissions to help frame the issue of gender equity and technology.

The Council first turned to a 1998 report by the AAUW, *Gender Gaps: Where Our Schools Still Fail Our Children*, that illustrates alarming disparities between boys' and girls' educational attainment in technology, technology related fields, engineering and science. Specifically, girls are less likely to take high level computing classes in high school, and in 1998 comprised only 11 percent of those taking Advanced Placement computer science exams. Girls outnumbered boys only in their enrollment in word processing classes, what the AAUW termed the 1990's version of typing classes. At the college level, while women earned about 25 percent of computer/information science bachelor's degrees, they achieved only 11 percent of the doctorates.^{4[4]}

However, what is perhaps even more important is that these educational inequities are felt within our workplaces. Because girls and women do not receive

^{4[4]} American Association of University Women. 1998. *Gender Gaps: Where Schools Still Fail Our Children*. Washington, D.C.: AAUW Educational Foundation.

educational training in technology areas, they continue to be excluded from science and technology jobs---the professions and occupations that are growing. This is not only a problem from an equity standpoint, it also limits our ability to capitalize on the talents needed for the present and future workforce. These trends in the workplace and educational institutions suggest that in order to increase gender parity in technical occupations, one must examine the relationship of gender and technology from kindergarten classrooms through corporate boardrooms. To frame the problem the Council turned to two main research reports: *Tech-Savvy: Educating Girls in the New Computer Age*, conducted by the AAUW, and *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology*, conducted by CAWMSET. Each report contributed to a framework that the Council used to begin to define the issue for New Jersey.^{5[5]}

Tech-Savvy took as its mission an analysis of girls' educational preparedness for our technologically driven labor market. The AAUW defines being technologically literate as possessing a set of critical skills, concepts, and problem-solving abilities to apply information technology in sophisticated and innovative ways. This allows for problem solving across disciplines and subject areas, and an understanding of the basic principles of computer programming and science. Using this definition, they found that girls usually are not in educational programs where they can acquire these skills.

Further, when they are in technology classes they tend to be concentrated in computer

^{5[5]} American Association of University Women. 2000. *Tech-Savvy: Educating Girls in the New Computer Age*. Washington, D.C.: AAUW Educational Foundation; Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development. 2000. *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology*. Washington, D.C.: National Science Foundation.

“tools” courses--such as learning to use databases, page layout programs, online publishing, and productivity software. As a result many girls do not qualify for the ranks of the technologically literate.

However, exclusion from computer literacy courses is not the only challenge girls face in technology. *Tech-Savvy* also reports that girls face additional barriers to technology such as masculine cultural stereotypes of the isolated male computer geek; computer games that are geared toward boys; and teaching methods that discourage interest in applied computer work. Perhaps one of the most important findings is the link between educational socialization and future occupational choices. *Tech-Savvy* researchers found that often when "gender equity" in computer technology appears in school curriculums many times it translates in practice into programs in which girls master the computer "tools" of PowerPoint, email, Internet Search Engines, word processing, and databases. This has not worked in girls' favor. These skills are demanded in many of the low paying, traditionally female jobs in the service, clerical, and retail sectors. In contrast, women are significantly underrepresented in information technology jobs, systems analyst, software design positions-- all of which demand technological literacy, not simply tool mastery. This continues to highlight the link between education and occupational choice.

The Council also studied the work of CAWMSET to further explicate the experiences of women in science, math, and technology jobs. This federal commission focused on initiatives to increase the numbers of women, minorities, and the disabled in these fields. They focused on education (at the elementary, high school, and college level), professional life, public image of computing, and national accountability. In

addition to focusing on many of the educational equity issues discussed in *Tech-Savvy*, CAWMSET found gender inequity also exists in technological and science fields in such areas as: salary discrepancies between men and women; the funneling of women into low-paying, low-status industries, corporate jobs and academic jobs; and the exclusion of women from informal networks and mentoring opportunities. CAWMSET recommended a national awareness and accountability to achieve gender parity in science, engineering, and technology.

To better summarize the large amount of information collected from secondary research sources, this report will address gender equity within the educational system and the workforce, building on the work of AAUW and CAWMSET. The first section addresses the under-representation of girls and women in the science, math, and technology educational pipeline. This section is divided into two further parts: one in which we address gender inequity at the pre-college level, and a second part in which we address gender inequity at the college level. Each part is subdivided into several subsections that focus on issues of gender stereotyping and biases in the classroom. The final section addresses gender inequity in science, engineering, and technology workplaces.

EDUCATION

Perhaps nothing is more fundamental to a Council on Gender Parity than a core belief that each student has a right to an education that is free of gender bias. Such a foundation is necessary not only for equity reasons but also to prepare workers to enter into jobs that fully utilize their talents and skills. Research has documented that investing in education and training increases worker productivity more than increasing

the hours workers work, or increasing capital stock.^{6[6]} Investing in our educational systems is an investment in our workforce. As such, ensuring that all children and adults receive the same opportunities in science, math, and technology preparatory programs helps to guarantee that we have a skilled workforce that will continue to meet our growing labor force demands.

However, as research continues to document, many students experience inequalities based on both gender and race within our educational institutions. These inequalities are felt throughout the educational system, but are magnified within science, math, and technology preparatory programs at all levels. In this section we discuss the experiences of male and female students throughout the educational pipeline. Overall, we find that girls tend to be underrepresented in preparatory programs in science, math, and technology at all educational levels from elementary school to post-graduate departments. As mentioned earlier, when girls are included in such programs, they are often encouraged toward word processing or database inputting, as opposed to computer programming or systems analysis. This coursework differential is a major predictor of future occupational choice. The gender differences in science, math, and technology course taking are most dramatic at the post-baccalaureate level. For the most part we simply are not preparing girls to enter into jobs involving science, math, and technology skills that are above the clerical level. Efforts then to address the large number of unfilled jobs in New Jersey and the nation, must begin by addressing the inequities within our educational system in an attempt to reform them. In the following

^{6[6]} Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development. 2000. *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology*. Washington, D.C.: National Science Foundation.

sections we define the issues and problems in reaching gender and racial equity in science, math, and technology at the pre-college and college levels.

Pre-College Education

Ninety percent of the jobs today's kindergartners will be working in when they reach adulthood do not yet exist.^{7[7]} These jobs will require flexible analytical skills that have a strong foundation in science, math, and technological studies. It is imperative that all children receive the skills taught in science, math, and technology educational programs in order to be adequately prepared to enter into our workforce. However, research suggests that girls are discouraged from science, math, and technology courses at an early age. Researchers find two main categories of gender barriers that face women in the science and technology classroom: *disabling stereotypes about gender appropriate behavior*, and *explicit and implicit gender biases in the classroom*. Within each category of gender barriers are numerous practices that cumulatively discourage women from entering these nontraditional fields.

Researchers suggest that children internalize belief systems about "appropriate" careers for them to enter at the youngest ages (as early as pre-kindergarten). They then carry these belief systems throughout their educational career and adult job tenure. Each year these beliefs become more ingrained. Therefore, it is imperative that the gender inequities within the current educational system be addressed and removed in order for us to educationally prepare all children to fill our increasing job demands. At the pre-college level *disabling stereotypes* that preclude girls' desires for future careers in science, math, and technology include the following:

^{7[7]} "The Facts About Women and Work" <http://www.academic.org/work.html>.

1. 1. A belief that there is a biological foundation to gender performance in science, math, and technology.
2. 2. An equating of computers, technology, and science with masculinity and male pursuits.
3. 3. A competitive, not cooperative, learning environment that makes it difficult for girls to reconcile their desire to improve society with a future career in science, math, and technology.
4. 4. Gender stereotyped production and marketing of computer games and educational software.

Similarly, we also find that *gender biases* exist at the kindergarten through high school level that contribute to girls' desire to turn away from science, math, and technology courses and careers. We found such biases as:

1. 1. Parents, teachers, and guidance counselors not encouraging girls to pursue science, math, and technology classes, clubs, and careers.
2. 2. Teachers not trained in science and technology.
3. 3. Sexual harassment and sexist behaviors in the classroom.

It is important to recognize that these two categories of inequality are not mutually exclusive. In fact, it is quite the opposite: they coexist within our classrooms. This reproduces and strengthens their presence within the educational system. For instance, stereotypical beliefs that girls do not like math contribute to gender biased behaviors in which math teachers may call on male students more than female students in class. The exclusion of girls' contributions in math classes, in turn, contributes to the stereotypical attitude that girls just do not like math.

The Math Gene: You're Born With It!

There is a belief within our society that men and boys simply do better in science, math, and computer technology fields of study than do women and girls. This belief is so pervasive that studies have demonstrated by the time children enter third grade they believe that “girls just cannot do math.”^{8[8]} Such erroneous beliefs have their roots in both “scientific” studies and the popular media.

On December 15, 1980 *Newsweek* magazine ran the cover story, “Do Males Have A Math Gene?” Their answer was a definitive yes. The magazine based this claim on research that found that boys performed better than girls on quantitative SAT exams, even when boys and girls had taken the same number of math classes. Such biologically deterministic studies took hold throughout the media in the 1980’s and 1990’s, infiltrating everything from news articles to toys. Perhaps the clearest example of this was when Mattel introduced a Barbie Doll, “Teen Talk Barbie,” which told little girls that “math is hard.”^{9[9]}

However, *Newsweek* and other forms of mainstream media did not report that there were flaws in the studies that claimed that math ability was biologically destined. Patricia Campbell, of Campbell-Kibler Associates, Inc., found that studies asserting gender differences in math by using SAT tests have many shortcomings. She argued that these studies assume that simply because girls and boys have been in the same math classes, one cannot assume they had the same experiences in those classes. She further pointed out that the researchers in one study told the girls prior to the SAT

^{8[8]} Crawford, M., Herrmann, D.J., Holdsworth, M., Randall, E., and Robbins, D. 1989. “Gender and Beliefs about Memory.” *British Journal of Psychology* 80: 391-401.

^{9[9]} Gutbezahl, Jennifer. 2000. *How Negative Expectancies and Attitudes Undermine Females' Math Confidence*. Masters' Thesis: University of Massachusetts.

test that girls do not test as well as boys. Such problems cast doubts on the studies' conclusions.^{10[10]}

The conflicting evidence in the media eventually led the British Royal Society to state, "there is no convincing evidence of innate gender differences in mathematical ability." Three years later, in 1989, the National Research Council of the United States, citing evidence from a number of studies, found that "there is almost no difference in the performance of male and female students who have taken equal advantage of similar opportunities to study mathematics."^{11[11]} However these findings did not make the headlines as had the "math gene." As a result, gender discriminating ideas regarding boys' and girls' abilities in math and the related disciplines of science and technology continue to be prevalent within our society.

Beliefs that girls do not do well in science, math, and technology erode girls' sense of self-confidence in their interests and abilities in these areas. CAWMSET found that among high school SAT-takers, 75 percent of students who plan to major in computer science and engineering are boys. Such beliefs are also prevalent among younger students. By eighth grade, twice as many boys as girls demonstrate an interest in science, engineering, and technology careers. Further, by eighth grade girls' interest and confidence in their mathematical abilities have eroded, even though they perform as well as boys. Similarly, fewer girls enroll in computer science classes and feel confident about their abilities to perform in such classes.^{12[12]}

^{10[10]} Campbell, Patricia. "No Virginia, There is no Math Gene."
http://www.tiac.net.users/ckassac/no_virginia.html.

^{11[11]} Campbell, Patricia. "No Virginia, There is no Math Gene."
http://www.tiac.net.users/ckassac/no_virginia.html.

^{12[12]} Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development. 2000. *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology*. Washington, D.C.: National Science Foundation.

Technology: A Male Frontier

Gender discrepancies in science, math, and technology can be attributed, in part, to public media images that ascribe success and interest in these areas to boys. Often these messages are taught to children in subliminal ways. Most commonly children learn the gender message through the use of computer games and educational software. The AAUW found that most computer games and software packages are designed for men by men. They are geared toward traditionally male behaviors and activities. Specifically, these games and software packages are action packed, violent, sports oriented, and aggressive. The AAUW, in reviewing popular mathematics educational software used in kindergarten through sixth grade classrooms, found that only twelve percent of the characters were female or had female gender identifiable characteristics. Since women rarely appear in computer venues, many elementary students find it hard to recall any computer software or games that have female characters. For instance, while elementary students could easily name software with male characters, only six percent of the students could name software with female characters. This is further substantiated by a study of thirty randomly selected software programs used in schools. Researchers found that out of 3,033 characters, only 30 percent were female and 80 percent of all characters involved in adventures or leadership roles were male.^{13[13]}

Not only do women rarely appear in computer games and software, when they do appear they often are portrayed in stereotypical and unhealthy ways. For instance, female characters tend to play passive traditional roles, such as the princess who must

^{13[13]} American Association of University Women. 2000. *Tech-Savvy: Educating Girls in the New Computer Age*. Washington, D.C.: AAUW Educational Foundation.

be saved by the male hero, as opposed to leadership roles. In addition, many female characters are physically portrayed in an unhealthy manner. A recent study of 24 of the top selling video games found that 85 percent of female characters were portrayed as having large breasts and unusually small waists and/or very thin bodies. In addition 38 percent of female characters appeared in video games with a significant portion of their body exposed. Most commonly researchers found that female video game characters tended to expose their thighs, stomachs, breasts and/or cleavage.^{14[14]} This negative and stereotyped portrayal of women in video games may contribute to girls' diminished interest in video games. Research demonstrates that although boys and girls spend close to the same amount of time using their home computers, boys spend nearly 400 percent more time playing video games than do girls.^{15[15]}

Such toys, games, and software help to reinforce the message that technological ventures are male pursuits. The message is clear for girls: they do not belong in science, math, or technology classes and careers. Since computer toys are marketed to boys, girls find that when they choose to go against the "norm," and pursue science, math, and technological classes, they may feel like uninvited guests. The AAUW reports that since girls are usually outnumbered in classes they are unable to form peer support groups. These groups are essential to success in technology as they often encourage participation in advanced computer classes. Without a core group of girls in

^{14[14]} Children Now. 2000. *Girls and Gaming: A Console Video Game Content Analysis*. Oakland CA: Children Now.

^{15[15]} Children Now. 2000. *Girls and Gaming: A Console Video Game Content Analysis*. Oakland CA: Children Now.

classes, female students are at risk for feelings of social isolation within the classroom.^{16[16]}

Not only do girls face social isolation, they also fear that doing well in science, math, and technology will raise questions about their femininity. Research finds that girls will turn away from computer science classes and careers because they are unable to see them as feminine pursuits. Technology, science, and math classes do not take into account the different experiences and perceptions girls bring to them. The AAUW reports, "...it is clear that girls are critical of the computer culture, not computer phobic."^{17[17]} Girls believe that a high-technology career means that one must be a male working alone with a computer for hours on end. This image does not mesh with the view girls have of the world. Many girls approach their work and their place in the world from a cooperative vantage point. The prevailing public image of computing prevents girls from viewing a career in science, math, and technology as helping them fulfill their values and achieve their goals.^{18[18]} Based on these findings the AAUW asserts that "instead of trying to make girls fit into the existing computer culture, the computer culture must become more inviting to girls."^{19[19]}

Girls have specific criticisms of the culture. For instance, they are not interested in the violent games that destroy things, but instead would prefer games that allow them to create things, simulate real life, work through real life problems, role play, and face problems they have yet to experience. Girls are interested in the computer as a tool

^{16[16]} American Association of University Women. 2000. *Tech-Savvy: Educating Girls in the New Computer Age*. Washington, D.C.: AAUW Educational Foundation.

^{17[17]} American Association of University Women. 2000. *Tech-Savvy: Educating Girls in the New Computer Age*. Washington, D.C.: AAUW Educational Foundation.

^{18[18]} American Association of University Women. 2000. *Tech-Savvy: Educating Girls in the New Computer Age*. Washington, D.C.: AAUW Educational Foundation.

^{19[19]} American Association of University Women. 2000. *Tech-Savvy: Educating Girls in the New Computer Age*. Washington, D.C.: AAUW Educational Foundation.

that allows them to accomplish something else, while boys tend to experience the computer as a toy that is an end in and of itself. As such, girls are more likely to view the computer as a means to a greater good. For example, they may use the computer to promote human interaction through the Internet and email. On the contrary boys are more likely to use the computer to play games, and focus on the hardware aspects. It is then imperative that we begin to create and market computer games and software that focus on the aspects of computer life that appeal to girls. Until we move away from viewing technological pursuits solely from a male perspective, girls will continue to be excluded from the frontier.

Gender Bias in the Classroom

Cultural stereotypes about appropriate gender behaviors are not the only barriers that girls face. Often these stereotypes are evidenced in the gender biases practiced in the classroom. Gender discrimination in the classroom can be defined as “patronizing behavior and assumptions that women are less qualified and/or committed than men, regardless of whether these assumptions are conscious or unconscious.”^{20[20]} Such discrimination continues to exist within our elementary and high school classrooms. Perhaps the most prevalent manifestations of these biases are the conscious and unconscious actions of parents, teachers, and guidance counselors to discourage girls from entering science, math, and technology fields, as well as sexual harassment and sexism in the classroom.

Teachers: Role Models in the Trenches

Teachers' expectations can have a direct influence on students' class work and scholastic achievement. Children live up to the expectations teachers provide for them.

^{20[20]} Hitchcock, Corey. 1998. “Testing 1,2, 3; Technology to Girls: Hello?” <http://www.sfgate.com/>

Teachers do not just teach academic content, they also serve as sources of guidance, role modeling, and mentoring. However from the outset, teachers often expect different behaviors from their students, based solely on gender assumptions. The AAUW found that 71 percent of male teachers believe that their male students are more interested in the mechanics of computer technology, while only one percent of male teachers feel their female students are more interested. Over one-third of male teachers further believed that their male students enjoyed applied uses and experiences with computers more than their female students would enjoy such pursuits. Female teachers were more likely to consciously state that sex did not influence students' interests in science, math, and technology. Sixty-six percent of female teachers find boys and girls about equal in their uses of technology.^{21[21]}

However, even such conscious statements about non-gendered thinking do not always translate into non-gendered behavior in the classroom. For instance, the *Scholarly Communication Project* found growing evidence of sexism in the classroom. In this study researchers observed classroom interactions and then interviewed teachers and students on their interpretations of the events. Researchers found that “on two occasions during classroom observations, the boys monopolized the computer tools. In focus groups [conducted after the class], girls complained that boys often rushed to get supplies and made fun of girls trying to use the equipment. Further, the teachers allowed the boys to get away with it. Boys would criticize girls, resorting to

^{21[21]} American Association of University Women. 2000. *Tech-Savvy: Educating Girls in the New Computer Age*. Washington, D.C.: AAUW Educational Foundation.

stereotypes about girls' lack of skills."^{22[22]} Such discriminatory behaviors, whether conscious or unconscious, create an environment in which girls feel unwelcome.

In addition to stereotypical expectations, the AAUW found that often teachers have a good deal of anxiety about technology and little knowledge about how to use it themselves. Many teachers do not possess the technical skills necessary to fully integrate technology into the classroom. Nationally there is a lack of attention to teacher training and certification in technology and science. For instance, during the 1999-2000 school year, approximately 5.67 billion dollars were spent in American schools on technology. Of that money only 17 percent was spent on teacher training.^{23[23]} If teachers do not possess the skills in technology and science, they cannot encourage them in their students or act as role models in that respect. In part, teachers' lack of training in technology and science is particularly troublesome when one considers that the majority of teachers are female. Female teachers' disinterest and anxiety about technology may be communicated to girls in the classroom. For instance, each time a teacher defers to a boy in the classroom to help with the computers or audio-visual materials, a negative message is sent to the girls in the room. In order to address girls' discomfort with the science and computer culture, we must ensure that teachers are adequately trained in technology.

Sexual Harassment

Title IX of the Education Amendments of 1972 states that no individual may be discriminated against based on sex in educational programs that receive federal funding. Included under Title IX are prohibitions against sexual harassment. This

^{22[22]} Hitchcock, Corey. 1998. "Testing 1,2, 3; Technology to Girls: Hello?" <http://www.sfgate.com/>.

^{23[23]} "More Technology Training for Teachers." November 22, 2000. *New York Times*.

includes unwelcome sexual advances, requests for sexual favors, and other verbal and/or physical conduct of a sexual nature. The New Jersey Gender Equity Task Force, a forerunner to the Council, recognized sexual harassment as a gender barrier in education.^{24[24]} In their report, *Balancing the Equation: A Report on Gender Equity in Education*, they found that sexual harassment significantly affects girls' experiences in all educational programs, but is particularly destructive in the nontraditional programs, such as science, math, and technology. Sexual harassment contributes to an environment of intimidation in these classrooms. After incidences of sexual harassment, girls often report that they will choose not to participate in science, math, and technology classes, clubs, after school activities, and eventually careers.^{25[25]}

In their report, *Hostile Hallways: The AAUW Survey of Sexual Harassment in Schools*, the AAUW found that girls experience educational, emotional, and behavioral impacts from sexual harassment. Girls who have been sexually harassed report that they do not want to attend school, or actively participate in classes (for example, they are less likely to talk in class or answer questions). In addition, those girls find it harder to concentrate in classes, study, and prepare for the classes in which they experienced harassment. As a result, they often find that their class performance has declined. These effects are critical in science, math, and technology classes. Girls may associate the sexual harassment they experience in such classes with their pursuit of

^{24[24]} In 1993 the New Jersey State Employment and Training Commission created a Gender Equity Task Force to identify and address the barriers facing women in the workforce readiness system, and make recommendations to address those barriers. One of their recommendations was the creation of the Gender Parity Council. The Gender Equity Task Force still meets.

^{25[25]} New Jersey State Employment and Training Commission's Gender Equity Taskforce. 1997. *Balancing the Equation: A Report on Gender Equity in Education*.

nontraditionally female classes. As a result they may drop out of the classes, believing that they do not belong in them.

In addition to educational impacts, girls often experience emotional disturbances as a result of sexual harassment. The AAUW found that girls who have experienced harassment tend to feel embarrassed, self-conscious, and experience lowered levels of self-confidence. Clearly, sexual harassment contributes to an environment in which girls feel that they are not legitimate or welcome members in nontraditional classes. Further, girls often alter their behaviors as a result of sexual harassment. Most commonly the AAUW found that girls will avoid both the person who harassed them, and the classrooms and activities associated with the harassment.^{26[26]}

In 1993, New Jersey researchers conducted a large-scale research project in which they investigated incidences of sexual harassment among male and female middle and high school students in the state. They found that 97 percent of girls and 70 percent of boys experienced some form of sexual harassment in school. However, while incidences of sexual harassment were high among both boys and girls, there were gender differences in the effects of the harassment. Fifty-two percent of the girls were very or somewhat upset by the harassment, as compared to only 19 percent of the boys. These emotional effects also contributed to an overall climate of fear for girls. Forty-four percent of the girls worried about sexual harassment, while only 11 percent of the boys voiced such concerns. As a result of the harassment, one in three girls reported experiencing lower self-confidence, as opposed to only one in ten boys.

^{26[26]} American Association of University Women. 1993. *Hostile Hallways: The AAUW Survey of Sexual Harassment in Schools*. Washington, D.C.: AAUW Educational Foundation.

Interestingly, boys were most concerned with harassment in which they were teased about being gay, and/or called homosexual.^{27[27]}

Such teasing and name-calling points to a form of harassment recognized as gender harassment. This refers to acts of verbal or physical aggression, intimations, and hostility, based on sex, but not involving sexual activity or language. The most prevalent forms of gender harassment include teasing and bullying.^{28[28]} For instance, boys may make fun of girls or put down girls' abilities in science and technology classrooms. The AAUW found that boys often will refer to girls' femininity and appearance in computer science classrooms. This has the effect of making girls uncomfortable and distracts them from their work.^{29[29]} As such, gender harassment in addition to sexual harassment must be addressed in elementary, secondary, and high schools.

The Impact of Race and Ethnicity

These problems are further intensified for students of color, who face greater educational barriers than white students. Racial and ethnic minorities in the United States face a serious lack of access to high quality education during the K-12 years; this includes science and mathematics education as well as education in other subject areas. Many African American and Hispanic students attend urban schools that are predominantly minority. For example, 32 percent of African American students and 25 percent of Hispanic students attend

^{27[27]} Trigg, M. and Wittenstrom, K. 1996. "'That's the Way the World Really Goes': Sexual Harassment and New Jersey Teenagers." *Initiatives* 57: 55-65.

^{28[28]} Stein, Nancy. 1999. *Classrooms and Courtrooms: Facing Sexual Harassment in K-12 Schools*. New York: Teachers College Press.

^{29[29]} American Association of University Women. 2000. *Tech-Savvy: Educating Girls in the New Computer Age*. Washington, D.C.: AAUW Educational Foundation.

schools in the central city.^{30[30]} Data on the distribution of resources in schools including high-quality curriculum, qualified teachers, expenditures, and computer equipment demonstrate that inner city, high minority, and high poverty schools consistently receive fewer and poorer resources than do schools that serve a predominantly white population.^{31[31]} This impacts the desire to stay in school; standardized test scores; mathematics, technology, and science knowledge and skill development; and the likelihood of attending college.

If we consider Latina/os in the United States' educational system, for example, data shows that they are at a greater risk of not finishing school than any other ethno-racial group and tend to leave school at an earlier age than members of any other group.^{32[32]} The graduation rate for Latinas is lower than for girls in any other racial or ethnic group. In 1995, Hispanic females made up 30 percent of high school dropouts, compared to African American females, who made up 12.9 percent, and white females, who made up 8.2 percent.^{33[33]} On the positive side, women are slightly more likely to graduate from high school than men (90 percent of women versus 87 percent of men.) Minority groups, including Hispanics, African Americans, and American Indians have lower high school graduation rates than whites.^{34[34]} Latina/o high school students are much less likely to be enrolled in college preparatory classes than are their white

^{30[30]} Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development, 2000. *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology*, Washington, D.C.: National Science Foundation.

^{31[31]} Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development, 2000. *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology*, Washington, D.C.: National Science Foundation.

^{32[32]} American Association of University Women, 2001. *Si, Se Puede! Yes, We Can: Latinas in School*. Washington, D.C.: AAUW Educational Foundation.

^{33[33]} American Association of University Women, 2001. *Si, Se Puede! Yes, We Can: Latinas in School*. Washington, D.C.: AAUW Educational Foundation.

^{34[34]} Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development, 2000. *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology*, Washington, D.C.: National Science Foundation.

counterparts. In 1992 Hispanic high school graduates were less likely than white graduates to have taken geometry, Algebra II, chemistry, trigonometry, physics, or a combination of biology, chemistry, and physics; they were much more likely to have taken remedial mathematics.^{35[35]} It is unclear whether this pattern is equally pronounced for both male and female students.

Secondary schools with high minority enrollment offer less extensive and fewer advanced science and mathematics courses and programs. This impacts decisions to major in science or mathematics in college, as well as admission to college. Minority students are more regularly “tracked” in lower tier courses at all levels of pre-college education, even when their schools offer high level courses. Latina/o and African American students are underrepresented in Advanced Placement (AP) courses that give students the opportunity to earn college credit for high school work and play a role in admission to the nation’s most selective colleges. Advanced Placement candidates in 1996 were at or under 10 percent minority on all of the following categories: computer science, calculus, physics, chemistry, and biology.^{36[36]} White and Asian girls overenroll in AP Science and Mathematics in relation to their representation in the school population nationwide. Caucasian girls make up 31 percent of high school students in the United States, and make up 35 percent of AP Math students; Asian girls are 2 percent of high school students in the United States, and make up 6 percent of Advanced Placement Math students. In comparison, Latinas and African American girls

^{35[35]} American Association of University Women, 2001. *Si, Se Puede! Yes, We Can: Latinas in School*. Washington, D.C.: AAUW Educational Foundation.

^{36[36]} Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development. 2000. *Land of Plenty: Diversity as America’s Competitive Edge in Science, Engineering and Technology*. Washington, D.C.: National Science Foundation.

underenroll by almost half.^{37[37]} This trend undoubtedly reflects the lack of AP courses available in predominantly Latina/o and African American high schools.^{38[38]}

College and Post Graduate Education

For those women and members of minority groups who do go on to college and post-graduate education, inequities and challenges still face them. Data show that white women, American Indians, and African Americans and Hispanics of both sexes receive a disproportionately low percentage of science and engineering degrees. White males and Asians earn a disproportionately high percentage. 1997 figures reveal that women earned a little over one-third (37 percent) of all bachelor's degrees in science and engineering fields. This is a positive trend, with the exceptions of computer science, physics, and engineering.^{39[39]} Women make up only 15 to 20 percent of undergraduate computer science majors.^{40[40]} These percentages have actually decreased from the 1980's when women made up around 37 percent of computer science majors.^{41[41]} Many experts attribute this decline to a change in the content of the computer science curriculum during the decade. Simply put, there was a movement away from word processing in the 1980's to computer programming and systems analysis in the 1990's. This movement shifted women out of the academic major, and men into it. The trend in physics and engineering

^{37[37]} American Association of University Women, 2001. *Si, Se Puede! Yes, We Can: Latinas in School*. Washington, D.C.: AAUW Educational Foundation.

^{38[38]} American Association of University Women, 2001. *Si, Se Puede! Yes, We Can: Latinas in School*. Washington, D.C.: AAUW Educational Foundation.

^{39[39]} Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development. 2000. *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology*. Washington, D.C.: National Science Foundation.

^{40[40]} Margolis, J., Fisher, A., and Miller, F. *Caring About Connections: Gender and Computing*. <http://www.cs.cmu.edu>.

^{41[41]} Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development. 2000. *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology*. Washington, D.C.: National Science Foundation.

Is more positive, but progress towards gender parity has still been very slow. In 1985, women earned 14 percent of the bachelor's degrees awarded in physics; this had risen to 18 percent by 1996. Women earned 15 percent of the bachelor's degrees given in engineering in 1985, and still only 18 percent in 1996.^{42[42]} Latina, African American, and American Indian women lag behind white and Asian women in earning bachelor's degrees in science, engineering, and technology.^{43[43]}

There seem to be two main points where women are likely to drop out of the educational pipeline: first, when choosing a major, and second, during graduate school. Fifty percent of qualified undergraduate males choose a scientific major, whereas only sixteen percent of undergraduate women choose such a major. For women who do major in science, engineering, and/or technology, many women stop at the master's level, never completing the highest graduate level. For example, in 1997 women earned only 31 percent of science, engineering, and technology master's degrees. The challenge in higher education is to attract women in science, math, and technology majors, and then retain women throughout undergraduate and graduate levels.^{44[44]} This is particularly relevant as trends indicate that the number of white males entering college will decrease throughout the early part of this century.^{45[45]} Thus, the traditional source of educated and skilled labor for these jobs is decreasing, just as the number of these jobs is rapidly increasing.

^{42[42]} Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development. 2000. *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology*. Washington, D.C.: National Science Foundation.

^{43[43]} Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development. 2000. *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology*. Washington, D.C.: National Science Foundation.

^{44[44]} Leveson, Nancy. "Educational Pipeline Issues for Women." <http://www.ai.mit.edu>.

^{45[45]} Carnevale, A. and Fry, R. 2000. *Crossing the Great Divide: Can we Achieve Equity When Generation Y Goes to College?* New Jersey: Educational Testing Service.

Research demonstrates that some of the main barriers to women in higher education are:

1. Decreased level of confidence and self-esteem for some women.
2. Lack of role models and mentors for women.
3. Gender discrimination and sexual harassment in the classroom.

The Chilly College Climate: Diminished Self Esteem and Confidence

One of the greatest gender challenges in higher education is trying to increase women's presence in science, math, and technology undergraduate and graduate degree programs. Connected to this problem is the fact that women seem to experience a greater lack of self-confidence throughout their college years, than do men. For instance, the *Illinois Valedictorian Project*, which followed 46 female and 34 male high school valedictorians through their college years found that although the women graduated from college with a slightly higher grade point average than male students (3.6 and 3.5 GPA, respectively), they experienced a greater loss of self-esteem during those years. In high school, about 20 percent of both male and female subjects ranked themselves as "far above average intelligent," and about 45 percent felt they were "above average." As the students proceeded through college, gender differences in these confidence rankings began to surface. As college sophomores, 20 percent of the men continued to consider themselves "far above average." Yet the comparable percentage of women fell to three percent. By senior year, 25 percent of the men and none of the women considered themselves as having far above average

intelligence. While the self-confidence level of men slightly increased during college, the self-confidence level of women dramatically decreased.^{46[46]}

The annual American Freshmen Survey, a joint project of the American Council on Education and UCLA's Education Research Institute, found that women students entering college in the fall of 2000 expressed far less confidence in their computer skills than their male peers did. Based on the responses of 269,413 students at 434 four-year colleges and universities, the study found that women are only half as likely as men to rate their computer skills as above average or in the top 10 percent. Only 1.8 percent of the women surveyed, compared to 9.3 percent of the men, stated they intended to pursue computer programming as a career. "This is an area where the gender gap has done nothing but grow larger," stated Linda Sax, the survey's director.^{47[47]}

Women's lack of self-confidence can be attributed in part to the "chilly climate" in science, math, and technology classrooms and academic departments.^{48[48]} Dianne O'Leary^{49[49]} notes that among other things, the college climate is chilly toward women because:

1. There are few women teaching or lab assistants and faculty members to serve as role models.
2. Programming projects are designed for male students.

^{46[46]} Pearl, A. Riskin, M. Thomas, B. Wolf, E. and Wu. 1990. A. "Becoming a computer scientist: A report by the ACM committee on the status of women in computing." *Communications of the ACM*, 33:47-58.

^{47[47]} "Women Students Found Lacking in Computer Confidence," *Wired*, January 29, 2001. <http://www.wired.com>.

^{48[48]} Sandler, Bernice Resnick. 1986. *The Campus Climate Revisited: Chilly for Women Faculty, Administrators, and Graduate Students*. Washington, D.C. : Project on the Status and Education of Women, Association of American Colleges.

^{49[49]} O'Leary, Dianne. 1999. "Accessibility of Computer Science: A Reflection for Faculty Members." <http://www.sc.umd.edu>.

3. 3. There is a general devaluing of women's contributions by professors, especially attributing them to male students.
4. 4. There is a friction between women coping with the chilly climate by being "one of the boys" in work habits, socialization, and competitiveness, and those seeking alternate paths.
5. 5. Hostile attitudes from a few male students.
6. 6. Expectations from the instructor that female students will do poorly.
7. 7. Classes that overwhelmingly use male language (for instance, "the user...he," or "suppose your wife"), and gender stereotyped examples.
8. 8. Sexual harassment.

The chilly climate is infused with subtle forms of gender discrimination that affect women's choices about enrolling in and completing science, math, and technology degree programs. Indeed a body of research finds that the cumulative effects of the subtle discrimination at the undergraduate and graduate levels may be more harmful than the relatively infrequent cases of overt discrimination. *The Project on the Status of the Education of Women* found that subtle differential behaviors toward women can have critical and lasting effects. The study notes that this is especially true when these biases involve gatekeepers---individuals who teach required courses, act as advisors, or serve as department chairs. These cumulative behaviors have negative effects on women's academic and career development by influencing women's decisions to switch out of science, math, and technology majors or subspecialties within majors; minimizing

the development of students' relationships with faculty members; lowering career aspirations and/or undermining confidence.^{50[50]}

While women experience confidence gaps in undergraduate education, similar problems exist at the graduate level. Indeed researchers believe that confidence issues may in fact be greater in graduate school because students receive primarily subjective feedback from advisors, as opposed to more "objective" measure of tests and course grades.^{51[51]} Low self-esteem has the effect of lowering women's career ambitions. Women believe they will not succeed in science or technology careers. The relationship between women's self-confidence and their subsequent career choices is integral to the development of our workforce.

Women's self esteem is also affected by the continual referencing of what experts call the "boy wonder icon."^{52[52]} The boy wonder icon associates male traits with science, math, and technology. Perhaps the most prominent cultural manifestation of the icon is the young, male computer hacker, an image a college female student cannot achieve. The effects of this belief are similar to those of the math gene in the elementary schools. The boy wonder icon helps to reaffirm male students' legitimacy in technology classes. Individuals believe that men just are better at using computers than are women. This is clearly evidenced in the 2000 American Freshmen Survey, as well as in interviews with male and female college students. Both male and female college students report that men are better at computing than are women.

^{50[50]} Pearl, A. Riskin, M. Thomas, B. Wolf, E. and Wu. 1990. A. "Becoming a computer scientist: A report by the ACM committee on the status of women in computing." *Communications of the ACM*, 33:47-58.

^{51[51]} Pearl, A. Riskin, M. Thomas, B. Wolf, E. and Wu. 1990. A. "Becoming a computer scientist: A report by the ACM committee on the status of women in computing." *Communications of the ACM*, 33:47-58.

^{52[52]} Margolis, J., Fisher, A., and Miller, F. "The Anatomy of Interest: Women in Undergraduate Computer Science." <http://www.cs.cmu.edu>.

However what is interesting is that researchers find that there are many male college students who do not identify with the hacker image. These male students, unlike female students, are not distressed by their lack of identification. Instead these men tend to graduate from computer science majors, whereas women frequently drop out. Unlike female students these men do not feel that they must conform to the hacker image; they do not question their abilities to become computer scientists; and they do not report being discouraged by teachers or other peers who do identify with the hacker image.^{53[53]}

Experts posit that female students experience more discouragement from the hacker image than do non-hacker male students because the computer science culture assumes that men will succeed. As stated earlier, technology and science are viewed as masculine pursuits. If success is marked for one gender, individuals of that gender will experience increased confidence levels and a sense of belonging. Alternatively, women, who are not marked for success in science and technology classes, will experience discouragement and feelings of inferiority. For example, as one female student in computer science states, “they [male students] have the pressure to do well, but they don’t have the excess pressure from us saying ‘you know you’re pathetic, you just got in because you are a guy!’^{54[54]}

The atmosphere in college classrooms is peppered with comments that are sexist, and whether intentional or not, have the effect of making women feel undervalued and unwelcome. In her study, *Why are There So Few Female Computer*

^{53[53]} Margolis, J., Fisher, A., and Miller, F. “The Anatomy of Interest: Women in Undergraduate Computer Science.” <http://www.cs.cmu.edu>.

^{54[54]} Margolis, J., Fisher, A., and Miller, F. “The Anatomy of Interest: Women in Undergraduate Computer Science.” <http://www.cs.cmu.edu>.

Scientists?, Ellen Spertus reports that female undergraduate and graduate students majoring in science, math, and technology face an onslaught of sexist comments throughout their college experience. Often the sexism is masked under the guise of humor. For instance, a female graduate student recounts the following experience in which a professor stated during a lecture, "pretty soon we will have robots that are sophisticated enough to wander around shopping malls and pick up girls." Other women share similar stories. One female graduate student stated that:

the professor in an automata theory class introduced the topic of decomposition by saying 'machines are like women, many forms of the same function' (wink, wink). As the only women in the class you can imagine I felt terrific. And all of a sudden the guys sitting next to me sort of tensed up. Instead of seeing me as a fellow student, his comment made them see me as something else- something kinda dirty.^{55[55]}

Perhaps some of the most damaging comments relate to the belief among some male students that female students were accepted into science, math, and technology departments solely because of their gender. Over a quarter of the women interviewed for a project conducted at Carnegie Mellon University reported having heard such comments from their male peers.^{56[56]}

The chilly climate is a reality in many science, math, and technology classrooms. The atmosphere undermines female students' self-confidence and feelings of legitimacy in nontraditional fields. Not only does the environment affect women's choices of major, but women who choose to major in science, math, and technology are more likely than

^{55[55]} Spertus, Ellen. 1991. *Why are there so few female computer scientists?* <http://www.ai.mit.edu>.

^{56[56]} Margolis, J., Fisher, A., and Miller, F. "The Anatomy of Interest: Women in Undergraduate Computer Science." <http://www.cs.cmu.edu>.

their male counterparts to switch to a nonscience major.^{57[57]} This “leak” in the pipeline is attributed to such factors as poor quality of teaching, inflexible curriculums, lack of role models and faculty advice, the competitive nature of science, math, and technology classrooms, and feelings of isolation.

Role Models Wanted

Advocates for Women in Science, Engineering and Math (AWSEM) report that when asked many women scientists can point to a single individual whose support and encouragement enabled them to pursue their careers in science.^{58[58]} The presence of female mentors and role models can indeed temper the chilly climate of university life. However since women are underrepresented on science, math, and technology university faculties, it makes it difficult for female students to locate positive role models and mentors. The same is true for members of racial and ethnic minority groups.

Researchers find that the relationship between faculty members and students is very significant for female students.^{59[59]} Many female students leave math and science majors because they are not able to form mentoring relationships with faculty members. This relationship is especially critical at the graduate level, where faculty mentors share with their students information on research funding, avenues for publication, conferences, networking with other professionals, and potential opportunities for research collaborations. Such information is essential for success in graduate school and in helping to land a professional job.

^{57[57]} Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development. 2000. *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology*. Washington, D.C.: National Science Foundation.

^{58[58]} Advocates for Women in Science, Engineering and Math. 1997. “Gender Equity and Mentorship in Science, Engineering and Mathematics”. <http://www.awsem.com>.

^{59[59]} Margolis, J., Fisher, A., and Miller, F. “The Anatomy of Interest: Women in Undergraduate Computer Science.” <http://www.cs.cmu.edu>.

However, in addition to future professional benefits, the mentor relationship provides a female student with the sense that she can see herself as part of the profession.^{60[60]} This helps to encourage and foster a self-image in female students that they are legitimate members of the community of science, math and technology scholars. This legitimacy is essential in countering some of the effects of the chilly climate. Despite the evidence that mentoring relationships are beneficial for female students, many universities do not have formal policies in place to ensure that mentoring occurs, and perhaps more importantly, that female students receive mentoring opportunities before they drop out of the pipeline.

However, mentors are only part of the equation. Research shows that female students also benefit from exposure to female role models. Role models serve as evidence that a successful career in science is not only a possibility, but a viable option for women. For instance, female faculty members prove by their very existence that obtaining a doctorate degree and a faculty position are possible. Similarly, gaining exposure to successful women in science and technology careers outside of academia increases female students' knowledge of the opportunities available to them in science, math, and technology fields.^{61[61]} Of course, the largest barrier to female role models is that women are simply missing from science, math, and technology faculties and jobs. As noted, women make up a small proportion of faculty in technical disciplines throughout the country, as well as in New Jersey. Thus, the potential pool of mentors and role models is quite small.

^{60[60]} Spertus, Ellen. 1991. "Why are there so few female computer scientists?" <http://www.ai.mit.edu>.

^{61[61]} Pearl, A. Riskin, M. Thomas, B. Wolf, E. and Wu. 1990. A. "Becoming a computer scientist: A report by the ACM committee on the status of women in computing." *Communications of the ACM*, 33:47-58.

In addition to mentoring and role model opportunities from female “success stories,” many students find that student peer groups provide a powerful source of encouragement and development during undergraduate and graduate years. There is a growing body of evidence that female students are unaware that peers (both male and female) could be struggling with similar problems within their courses or departments. Once students begin to interact with each other they begin to associate their struggles with factors besides their own individual failings. Peer support also helps provide entry for women in to many of the informal structures that occur within the halls of academic preparation. This helps women to gain entrance into these networks early in their careers.

Female Faculty Members

The chilly climate endemic to university life also affects the workplace experiences of female faculty members in science, math, and technology academic departments. CAWMSET found that among full-time ranked faculty Ph.D.’s, 50 percent of men and 23 percent of women were full professors. Even more telling is that 29 percent of women in science, engineering, and technology were tenured, compared to 58 percent of men.^{62[62]} Female academics in science, engineering, math, and technology departments have yet to achieve parity with their male colleagues.

Paying attention to the situation for female faculty members is vital to help keep women in the educational pipeline. As noted, female professors play the important role of mentor and role model. Their lack of representation alone has drastic effects. In

^{62[62]} Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development. 2000. *Land of Plenty: Diversity as America’s Competitive Edge in Science, Engineering and Technology*. Washington, D.C.: National Science Foundation.

addition, the status of female faculty members provides clues as to how women are treated in science, math, and technology careers. Until recently, the experiences of women in these academic departments were not well documented. However, that was changed in March of 1999 when Massachusetts Institute of Technology (MIT) publicly released the pioneering report, *A Study on the Status of Women*.

Perhaps the most interesting finding in MIT's study was that the researchers found, as of 1994, the percentage of women faculty in the School of Science had not significantly increased since 1974. The percentage of women faculty had consistently remained around eight percent. In raw numbers that means that in 1994 there were only 22 tenured women on the faculty, as opposed to 252 tenured men in the six schools that make up MIT's School of Science. The chances of a female student coming in contact with, and receiving mentoring from, the small number of women professors is quite low. Indeed it is unrealistic to assume that the 22 women faculty would be able to provide mentoring to the hundreds of female undergraduate, graduate, and postdoctoral students.^{63[63]}

In addition to invisibility, the MIT study demonstrated that female faculty members experience marginalization and exclusion within their departments. This marginalization actually increased as the women progressed through their academic careers. Women experienced discrepancies in salary, research laboratory space and resources, amount of salary received from grants, departmental power, leadership, distinguished professorships, and teaching assignments. It is not surprising that women students, observing the treatment of female faculty in the sciences and engineering,

^{63[63]} Massachusetts Institute of Technology. 1999. "A Study on the Status of Women Faculty in Science at MIT." <http://wen.mit.edu>.

would seek other disciplines where mentors and resources were more equitably allocated.

WORKFORCE

Peter Freeman and William Aspray in *The Supply of Information Technology Workers in the United States* state that if the number of women in the information technology workforce increased to equal the number of men, the huge demand for labor in these jobs could be met.^{64[64]} Women make up approximately 46 percent of the total American workforce. However women fill only 19 percent of the science, engineering, and technology jobs,^{65[65]} and women hold only 10 percent of the highest level information technology jobs.^{66[66]} Attracting women to jobs in science, math, and technology is only part of the problem however. Studies find that women leave science, math, and technology careers twice as frequently as men.^{67[67]} As such, we also need to address issues of retaining women once they choose these jobs.

As a center for high-tech companies, New Jersey is unable to fill the large number of jobs in telecommunications, pharmaceuticals and other technical fields. Although the state's colleges and universities handed out more than 13,000 degrees and certificates in high-tech fields in 1999—which represents an 18 percent increase over the decade—it is not nearly enough to keep up with the demand. According to the New Jersey Commission on Higher Education, the 13-member board that oversees the

^{64[64]} Freeman, P. and Aspray, W. 1999. *The Supply of Information Technology Workers in the United States*. Computing Research Association: Washington, DC.

^{65[65]} Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development. 2000. *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology*. Washington, D.C.: National Science Foundation.

^{66[66]} Sandy, M. and Burger, C. 1999. *Women and Minorities in Information Technology Forum: Causes and Solutions for Increasing the Numbers in the Information Technology Pipeline (The White Pages Report)* NSF:Virginia.

^{67[67]} Advocates for Women in Science, Engineering and Math. 1997. "Gender Equity and Mentorship in Science, Engineering and Mathematics". <http://www.awsem.com>.

state's colleges, the labor force shortage in the state is caused in part by the low numbers of women, Blacks and Hispanics entering careers in technology, engineering, and science. "New Jersey's continued economic prosperity is dependent upon a strong workforce, and this report highlights a critical need for high-tech graduates that must be addressed at all levels of the education system—by the K-12 community, the colleges and universities and the state," said James Sulton, the commission's executive director.^{68[68]} The Commission's 1999 report highlighted the fact that, while African Americans and Hispanics earned less than one percent of the doctorates in computer science, non-resident aliens in the state were earning 60 percent of the doctoral degrees in computer science and 52 percent of the doctoral degrees in mathematics. "If the state and the nation are to prosper in the new knowledge-based economy, all segments of the population need to be encouraged and prepared to participate in high-tech fields," the report's authors concluded.

"The current practice of looking abroad for workforce talent is not a long-term solution."

^{69[69]}

Clearly, it makes good business sense on the parts of workers and companies for women and minorities to enter into science, math, and technology jobs. Women who choose non-traditional careers can expect lifetime earnings of 150 percent more than women who choose traditional careers.^{70[70]} Corporations also realize that attracting women and members of diverse racial and ethnic groups to careers in high-technology fields helps to create a competitive market advantage. A survey of Fortune

^{68[68]} "Jersey Colleges Can't Fill Need for High-Tech Workers." January 27, 2001. *The New Jersey Star-Ledger*.

^{69[69]} "Jersey Colleges Can't Fill Need for High-Tech Workers." January 27, 2001. *The New Jersey Star-Ledger*.

^{70[70]} "The Facts About Women and Work" <http://www.academic.org/work.html>.

100 human resource executives found that diversity in the workplace brings about better utilization of talents, creativity, team problem solving, and increased marketplace and leadership understanding.^{71[71]} This sentiment was echoed by William Wulf, president of the National Academy of Engineering, during a talk in which he clearly referenced the positive role women and diverse employees play in engineering jobs. As he states, “every time we approach an engineering problem with a pale, male design team, we may not find the best solution. We may not understand the design options or know how to evaluate the constraints...there is a real economic cost to that. It is measured in design options not considered, in needs unsatisfied...It is that a product that serves a broad...customer base may not be found.”^{72[72]}

With such benefits to both women and companies it is necessary to explore why women and racial minorities continue to be underrepresented in these careers. The CAWSMET report argues that the glass ceiling that serves as a barrier to women attempting to enter the higher levels of corporate management, is being reinforced by the silicon ceiling. This “new” ceiling keeps women out of the high paying and high skill jobs in the science, math, and technology sector. This silicon ceiling is made up of such factors as:

1. 1. An environment that is not experienced by women as female-friendly.
2. 2. An inability to integrate work and family demands.
3. 3. A lack of female role models and mentors.

^{71[71]} Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development. 2000. *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology*. Washington, D.C.: National Science Foundation.

^{72[72]} Wulf, W. 1998. “Diversity in Engineering”. *The Bridge*. 28:1-11.

4. A lack of attention to retraining female workers and displaced homemakers for science, math, and technology jobs.

Female Friendly Worksites: The Value of a Woman

There is a great deal of research that demonstrates why women choose not to enter science, math, and technology jobs, and why they often leave those jobs. As we know women make up approximately 19 percent of the science, engineering, and technology workforce. However even if women do enter these jobs, they are not likely to remain in them. CAWSMET reports that women who work in science and technology industrial jobs are more likely to leave these jobs than are their female counterparts in other industrial sectors. As stated earlier, women are twice as likely to leave science and technology jobs than are similarly placed men.^{73[73]}

Catalyst's *Women Scientists in Industry: A Winning Formula for Companies*, among other studies, reports that women often leave science and technology jobs (and similarly may not enter them at all) because of the cultural climate of their workplaces.^{74[74]} Many of the science, math, and technology workplaces do not provide an environment that is "female friendly." Central to a female friendly environment are formal and informal practices that promote a feeling among female workers that they are respected and valued within the company. These practices include policies that support family life, provide mentoring opportunities, and help in career development. What is essential to a female friendly worksite is an overall feeling of value for the women scientists and engineers. Without a cultural backdrop that promotes the value

^{73[73]} Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development. 2000. *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology*. Washington, D.C.: National Science Foundation.

^{74[74]} Catalyst. 1999. *Women Scientists in Industry: A Winning Formula for Companies*. Catalyst: NY.

of the female employees, women will leave the companies, and often the fields of science, math, and technology all together.

Female friendly worksites do not exist in many science and technology organizations. A report conducted by Women in Technology International entitled *Business Impact by Women in Science and Technology*, documents interviews and focus groups with women in science and technology jobs. Consistently women report that they do not feel valued in many of the science, engineering, and technology jobs that they hold. This lack of value contributes to these women leaving their jobs. For instance, as one woman reports, “I left a department because I didn’t feel valued. The male manager was shocked when I didn’t want to stay after they demoted me a job grade with no explanation.” Another woman noted that she left her previous job for similar reasons. “In my last job I was consistently reminded that I had no value in the group and if they worked at it enough, perhaps I could just disappear. One of my male managers literally told me not to worry my little head about how the project I was managing would be handled technically.”^{75[75]}

Often women assert that many science and technology organizations operate under the “old boys network.” Many women in the Women in Technology International Society felt that they were left out of the important decision making meetings and opportunities. They felt that these decisions occurred in very informal and exclusionary settings, such as in hallway conversations, on the golf course and tennis courts, and in “invitation-only” meetings.^{76[76]} Women felt they were not part of the organization and

^{75[75]} Women in Technology International. 1997. *Business Impact by Women in Science and Technology*. WITI.

^{76[76]} Women in Technology International. 1997. *Business Impact by Women in Science and Technology*. WITI.

that their input was unimportant. This mentality of the “old boys club” is a long-standing tradition in science and technology jobs that has served to minimize women’s roles in these organizations and justify their exclusion and marginalization. An interesting historical case that documents this trend occurred in 1946. Six women, led by Adele Goldstine, programmed the first electronic digital computer (the ENAIC computer).^{77[77]} They first accomplished this by mechanically reprogramming the computer for each calculation. They then wrote programming instructions that converted their manual work in a stored computer program. However their accomplishments, although groundbreaking, were attributed to the male hardware designers, and these women were portrayed as “assistants” or simply, “the girls.” Clearly related to the undervaluing of women is that they do not fit into the image of the technical expert. Often, for example, female computer scientists are mistaken for secretaries or marketing personnel.^{78[78]} The 1999 documentary, *Valley of the Boys*, demonstrates that women do not fit into the work culture of many science and technology firms. This culture stresses competitive games, sports, and other male oriented activities. Often women are left feeling very alone and isolated.

In addition to exclusion, women’s feelings of value are also diminished by the fact that women continue to earn less than do comparable men. For instance, in 1999, women earned on average only 85 percent of men’s salaries in the field of information technology.^{79[79]} The gender wage gap contributes to women’s overall feeling that their work effort is being undervalued. Furthermore the MIT report found that women have

^{77[77]} Koch, Melissa. 1994. “Who are the Role Models?” *TECHNOS Quarterly*. <http://www.technos.net>.

^{78[78]} Kalson, A. 2000. “The men of silicon valley.” <http://www.siliconsalley.com>.

^{79[79]} American Association of University Women. 2000. *Tech-Savvy: Educating Girls in the New Computer Age*. Washington, D.C.: AAUW Educational Foundation.

differential access to laboratory equipment, space, and resources. As women experience fewer labor market rewards because of their gender, they are more likely to leave these fields in pursuit of more equitable work environments.

Work and Family Life: Reaching a Balance

Much research has demonstrated that women are most concerned with ways to integrate work and family. Women work a “second shift” each day.^{80[80]} That is, women work full-time in the paid labor force, and they continue to bear primary responsibility for the family and home. This double burden of home and work puts women at a disadvantage in all forms of paid labor. However this second shift can be highly detrimental to success in science, engineering, and technology jobs.

The report, *Women and Minorities in Information Technology Forum*, found that women perceive that the greatest barriers to their success in information technology careers are long work weeks (50-60 hours per week), expectations to work late hours, and a high stress job environment.^{81[81]} In short, IT jobs, along with science and engineering jobs, still tend to operate on the male model of work. That is, the typical worker is a man who works full-time and has a wife at home to supply the domestic labor. Although that image is inaccurate for women (and many men), it still holds. Since women still perform a good deal of the domestic labor, even when they work full-time, this inequity falls squarely on their shoulders.

Integrating family and work is a significant aspect of women’s lives. Fifty-four percent of mothers with infants under the age of one are in the workforce. In addition,

^{80[80]} Hochschild A. 1989. *The Second Shift*. New York:Avon.

^{81[81]} Sandy, M. and Burger, C. 1999. *Women and Minorities in Information Technology Forum: Causes and Solutions for Increasing the Numbers in the Information Technology Pipeline (The White Pages Report)* NSF:Virginia.

an estimated 85 percent of women in the workforce will become pregnant at some point during their tenure. However pregnancy and infant childcare are not the only family issues facing women. Women are twice as likely to stay home with a sick child than are men. Along with childcare responsibilities, many women provide care to older relatives and parents. Only five percent of people 65 years of age and older are in nursing homes. An estimated 75 percent of senior citizens are living with or nearby their families. These family responsibilities affect the work lives of countless women. Furthermore, this situation is only expected to get worse. By 2040, as baby boomers age, 19 million people will be dependent on care. It is estimated that it is women who will bear the burden of providing care for both their children and aging parents/relatives. A woman can expect to spend at least 17 years caring for a child, and 18 years caring for an older person.^{82[82]}

As a result of these factors women report that they often leave IT careers because the long hours that they are expected to work are detrimental to their family lives. In addition, women find that if they stay home for one to two years to take care of family responsibilities, they cannot easily return to their jobs because of changes in the technology used. Finally, women feel that managers are reluctant to allow part-time work. Often women may reduce their work hours to try to integrate family and work responsibilities. As a result of their new part-time status, women find that they are

^{82[82]} New York State Alliance for Girls and Women in Technology. 1995. *Girls and women in technology: A call to action: preparing girls and women for a technological workforce*. NYS Alliance for Girls and Women in Technology: New York.

assigned to less desirable projects, causing their careers to stall or prematurely end.^{83[83]}

Family and work life integration must be addressed for women to be full participants in the workforce. However, in order to address this we must begin by dispelling the overriding cultural belief that married women with children cannot fully participate in the workforce. CAWSMET found that even in science, engineering, and technology firms that have family friendly policies, women are concerned that they cannot pursue their careers and take family leave without risking the perception that they are less committed to their careers than are comparable men.^{84[84]} New research focusing on work and family integration in science, engineering, and technology firms will help shed light on how the structure of work at these firms and the impact that working in these industries have on the family and community lives of the women and men professionals in them. The Radcliffe Public Policy Center is conducting a study of work and family integration in biotechnology firms.^{85[85]} Similarly, the Rutgers Center for Women and Work is beginning a research project on work, family, and community integration in the lives of mid-career women professionals in information technology, among other fields.^{86[86]} Through studies like these as well as innovative workplace policies and changed social assumptions about gender roles in the home, work-family integration may be achieved for both men and women. Work-family integration not only

^{83[83]} Sandy, M. and Burger, C. 1999. *Women and Minorities in Information Technology Forum: Causes and Solutions for Increasing the Numbers in the Information Technology Pipeline (The White Pages Report)* NSF:Virginia.

^{84[84]} Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development. 2000. *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering and Technology*. Washington, D.C.: National Science Foundation.

^{85[85]} "Opportunities for Work and Family Integration for Professionals: A Study of Biotechnology Firms," <http://www.radcliffe.edu/pubpol/Sloan.html>.

^{86[86]} "Re-imagining Work and Community: Perspectives from Professional Women in Dual-Earner Families," research project in progress, Center for Women and Work, Rutgers University.

requires companies to provide flexible work arrangements, on-site childcare, and parental leave policies, but also a movement away from the cultural belief that women should be the primary caregivers in the family. Once we espouse such a cultural mindset, we can then see both men and women as legitimate participants in the home and work spheres.

Role Models and Career Development

The Catalyst 1998 *Census of Women Corporate Officers and Top Earners* found that only eleven percent of all corporate officers were women. Looking in more detail illustrates that of the corporate officers who held senior titles in research, there were only two women and 38 men.^{87[87]} Clearly women are underrepresented at the highest levels of industrial management. The glass ceiling that still operates in corporate jobs not only prevents women from reaching the top tiers of management, but also contributes to the absence of senior level female role models and mentors. As we have seen in previous sections of this report, role models and mentors are vital to women's self-image as legitimate members of the profession. Furthermore, in the workplace mentors and role models serve as a career link, helping to advance individuals through management careers. However, since women work in predominately male environments, with predominately male managers, it can be very difficult for them to find supportive mentors to help advance them through their careers.

The small number of women employed in many science, math, and technology firms also results in situations in which women find themselves the only woman in their work group. This isolating factor makes it difficult for women to form the same informal

^{87[87]} Catalyst. 1998. *Census of women corporate officers and top earners*. Catalyst:NY.

networks that are formed by men. Often times these networks not only provide support and encouragement, but also help advance women through their careers.

Forming support groups are necessary to help women feel valued in their workplaces. Such groups have a positive impact on the companies' bottom line. Elizabeth Duvivier chronicled different support groups at many U.S. engineering and IT firms. She found that improving conditions for women and increasing women's collective contributions help to increase worker productivity and profits. In addition, support groups help to increase women's representation in science, engineering, and technology jobs. For instance, one of the oldest established groups, the Aerospace Women's Committee, has succeeded in drastically increasing the percentage of women employed at the company. In 1973, the corporation had 32 women in technical positions, and 10 female administrators. By 1999, there were 302 women employed at Aerospace. In addition 104 women hold management positions and two women sit on the board of trustees.^{88[88]} Clearly the presence of informal networks and support groups benefit women.

Retooling Women

The report, *Women and Minorities in Information Technology Forum* found that IT companies are tapping into many nontraditional sources of labor to fill in the job shortage. Common sources of workers are individuals who are pursuing second careers or are reentering the workforce.^{89[89]} Often these employees are enrolled in distance education and certification courses, employer training, and self-study. Women

^{88[88]} Duvivier, E. "Women's support groups: a boost for technical women."
<http://www.diversitycareers.com>.

^{89[89]} Sandy, M. and Burger, C. 1999. *Women and Minorities in Information Technology Forum: Causes and Solutions for Increasing the Numbers in the Information Technology Pipeline (The White Pages Report)* NSF:Virginia.

make up a large portion of the workers reentering the labor force. Many times these women are displaced homemakers and possess a general skill set that can be cultivated for a career in science, math, and technology. We then have a potential pool of workers that need to be recognized.

Girls and Women in Technology: A Call to Action found that although there has been an increase in programs encouraging women to enter into the higher paying technical and trade occupations, this does not necessarily translate into women entering these jobs.^{90[90]} Researchers find that although women may show an interest in technical fields, most women are not willing to enter into the male dominated occupations. Often women will choose to work within more traditionally female occupations. These choices often are attributed to decreased levels of self-confidence that women experience as displaced homemakers reentering the workforce. As such, it is difficult for women to challenge the cultural beliefs of appropriate work based on gender. Increasing women's self-confidence will help to counter the cultural image barriers and help women enter into science, math, and technology jobs.

Much of the challenge surrounding the reentry of women into the science, math, and technology workforce involves changing women's perceptions of technology itself. For example, researchers find that since women are overrepresented in clerical jobs they do not have the opportunity to understand the real potential of computers. Instead for some displaced homemakers the computer is simply the next generation

^{90[90]} New York State Alliance for Girls and Women in Technology. 1995. *Girls and women in technology: A call to action: preparing girls and women for a technological workforce*. NYS Alliance for Girls and Women in Technology: New York.

typewriter.^{91[91]} As such we need to ensure that our training programs are framed in ways that address the needs of all women. There are some successful programs already in place that we can turn to for models. For instance, New York State's *Call to Action*, involves a contextualized learning paradigm. This approach establishes practical hands on learning in which students use skills they have previously mastered, in new and unfamiliar ways. This allows for integration of workplace literacy skills, such as communication, team building, and flexibility through collaborations with employers.

^{92[92]} Indeed we must value the skills women bring to the workplace, and foster mechanisms to cultivate and advance new skills.

CONCLUSION

America's technological revolution has helped create a U.S. economy that is among the strongest in the world. New Jersey's position as a leader in high-technology industries creates a compelling need for skilled workers who can enter science, engineering, and technology fields. As we have tried to demonstrate in this report, girls and women, as well as racial and ethnic minorities, are an untapped resource that could fill the pressing labor shortage in these fields. The New Jersey Council on Gender Parity in Labor and Education finds that it is gender inequity in science, engineering, and technology fields that inhibits the full utilization of the labor force, and that must be addressed. Like racial inequity, gender inequity is a complex, multi-faceted phenomenon that calls for creative initiatives and solutions at all levels of the educational system and workforce

^{91[91]} Corely, R. 1994. "Women, technology and the internet: How will the three get along?" Working Papers in Communication Technology and Culture. <http://www.carleton.ca/~jweston/papers.corley.94>

^{92[92]} New York State Alliance for Girls and Women in Technology. 1995. *Girls and women in technology: A call to action: preparing girls and women for a technological workforce*. NYS Alliance for Girls and Women in Technology: New York.

structure. We will not be able to compete globally if we do not self-consciously address gender inequity, and eradicate it.

Initiatives that could help to bridge the gap and achieve gender equity and parity in science, engineering, and technology have been discussed throughout this report. These include programs that encourage girls and women to explore careers in science, mathematics and technology; that address gender biases in classrooms at all levels; efforts to make computers and technology more “female friendly”; more comprehensive training of teachers in gender issues and technology; the elimination of sexual harassment and gender harassment in all educational and work settings; a sensitivity to race, which further intensifies the educational and labor force inequities faced by girls and women; and mentoring programs that encourage girls and women to persevere in science and technology fields. We need to create workplaces that allow for the integration of family and work, and we must counter cultural stereotypes that paint pictures of women’s and men's "natural" skills according to traditional gender beliefs. The Rutgers Center for Women and Work takes as its mission the importance of addressing the needs of working women by studying public policies in the field, conducting, fostering and disseminating research on areas of concern, and sponsoring educational and skills development programs for working women, policy makers, corporate leaders, students, and community organizations.

We hope that this report will contribute to a state-wide and national dialogue on gender equity in science, engineering, and technology that will lead to new public policies, research initiatives, and educational reforms. Women are expected to make up over half the workforce by 2020. If we do not address these issues now, when will

we?

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