Women In Engineering:

A Review of the 2005 Literature

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For this year's literature review, we located 374 articles, dissertation abstracts, and books, and of these, used 224 to compile this review. Consistent with past years, our primary emphasis is on articles that appeared in the peer-reviewed literature because they are more likely to be grounded in sound analytical methods. However, we also discuss small news pieces appearing in various engineering trade publications that may be a bit off the beaten path and less well known to SWE readers.

Unlike past reviews, we have not included articles that appeared in the *Journal of Women and Minorities in Science and Engineering* because we recommend that this important publication be the first one consulted when planning a program or a research project. Information about the journal is online at: http://www.begellhouse.com/journals/00551c876cc2f027.html.

We also recommend that readers looking to be brought up to speed on some of the social psychology studies that have appeared about women and engineering should consult the Camussi and Leccardi article, "Stereotypes of Working Women: The Power of Expectations." This solid resource defines and provides examples of terms such as female misogyny, stereotypes and prescriptions, self-stereotyping and self-fulfilling prophecy.

Finally, the importance of sound analysis and methodology was well illustrated at the start of 2005, when Harvard President Lawrence Summers offered uninformed remarks concerning women's suitability for careers in science and engineering.

Events Opened and Closed 2005 with an Emphasis on Women in Science and Engineering

Gender equity in science and engineering was a common theme in the media this year thanks to the comments on January 14, 2005 by Harvard President Lawrence Summers. At a National Bureau for Economic Research conference, "Diversifying the Science and Engineering Work Force," Summers suggested three reasons for women's underrepresentation in S/E. First, Summers proposed that young women did not choose these fields because of the extreme time commitments of 60-80 hours per workweek and incompatibility with family responsibilities. Second, he hypothesized that a gender difference in "availability of aptitude at the high end" was to blame. That is, because women's brains were wired differently than men's, fewer women than men had the innate ability to excel in S/E. Finally, he suggested that discrimination might play a role in limiting women's access to S/E, but, because discrimination was too costly for institutions, he felt that this explanation was unlikely to be supported by the data (Summers, Remarks at NBER, 2005).

Many respected advocates for gender equity in the S/E fields rose to challenge Summers' comments. While many media pundits chose to focus only on the innate abilities issue, there were several women who took a more balanced approach to rebut the comments. Virginia Valian, author of *Why So Slow? The Advancement of Women*, professor of psychology, and head of Hunter College's Gender Equity Project, which includes the National Science Foundation-funded ADVANCE program, wrote an op-ed piece that appeared in *The Washington Post* to rebut Summers' arguments with scholarly research evidence (Valian 2005).

Noted MIT professor Nancy Hopkins, a Harvard alumna, was so deeply offended by Summers' remarks that she walked out of his presentation. Some media pundits, most notably George Will, claimed that Hopkins was "hysterical" and over-reacting, as Summers initially denied making the comments. Eventually, a transcript was released, which buttressed Hopkins' claims about the comments. In a "Today Show" interview, Hopkins described the challenges she encounters as a woman in science and called for academia to pull together to stop perpetuating the idea that women are not fit to excel in STEM fields (Kantrowitz 2005).

The outcry was not limited to female academics. Summers' own peers, the presidents of MIT, Princeton, and Stanford, published a critical essay in *The Boston Globe* criticizing Summers' comments that biological differences could play a role in causing a gender gap in STEM fields (Boston Globe, 2005). Many other newspapers and academic publications such as *The Chronicle of Higher Education* covered the subsequent administrative changes and challenges to Summers' leadership by the Harvard faculty throughout the year. Further readings on this subject can be found in the bibliography at the end of the review.

In the wake of this controversy, Summers wrote several letters to the Harvard community apologizing for his remarks and pledged a minimum of $25 million in funds to aid in the hiring of underrepresented faculty members. He also created two task forces to develop solutions to the problem of gender equity at Harvard: The Task Force on Women Faculty and The Task Force on Women in Science and Engineering (Summers, Remarks at the National Symposium, 2005). After the task forces reported to Summers in May, he pledged that Harvard would provide $50 million to support the initiatives proposed by the groups (Summers, Statement on Reports, 2005).

More recently, Summers officially resigned his post as

president of Harvard University. On Tuesday, February 21, 2006, Summers posted a letter to the Harvard community stating he would resign as of June 20, citing rifts with faculty members in the College of Arts and Sciences as his reason for leaving. Summers resignation came almost one year after a vote of no confidence by the arts and science faculty. Derek Bok, Harvard president from 1971-1991, will sit in as interim president until the university finds a replacement. Summers is expected to take a one-year sabbatical and then return to teach at the university (Ryan, 2006).

While the Summers debacle seemed to overshadow most of the year, some less controversial events were already focusing on the problems Harvard was trying to address. To close out 2005 the National Academies hosted the Convocation on Maximizing the Potential of Women in Academic Science and Engineering in Washington D.C. The leading experts on gender and ethnic equity in academic S/E gathered to share cutting-edge research from the biological, social, and organizational sciences to understand the issues that contribute to women's success in S/E. Bill Wulf, president of the National Academy of Engineering and Donna Shalala, chair of the Committee on Maximizing the Potential of Women in Academe and a former member of President Clinton's cabinet, welcomed participants and emphasized the importance of women's contributions to and participation in S/E. Closing remarks were made by Denice Denton, who was the dean of engineering at the University of Washington until assuming her duties this past year as chancellor at the University of California at Santa Cruz.

There were four panels:

- Cognitive and Biological Contributions, with Janet Hyde, Jay Giedd, Bruce McEwen, and Diane Halpern;
- Social Contributions, with Mahzarin Rustum Banaji, Toni Schmader, Susan Fiske, and Yu Xie;
- Organizational Structures, with Joan Williams, Donna Ginther, Robert Drago, and Joanne Martin; and
- Implementing Policies, with Angelica Stacy, Joan Reede, Sue Rosser, and Kellee Noonan.

All of the panelists' talks are available at: www7.nationalacademies.org/womeninacademe/Convocation.html.

In addition to the panels, 22 posters about research and programmatic efforts underway nationwide provided more examples of successful strategies to increase women's access to academic careers. The conference agenda, also available online at the National Academies, provides biographical information about the panelists, a list of publications and poster abstracts.

The Importance of Diversity

The individuals at the Convocation on Maximizing the Potential of Women in Academic Science and Engineering were not the only ones examinimg the diversity issue. A number of reports released this year documented the value of paying attention to diversity in the labor force. Many reports highlight the need for diversity from a demographic standpoint: namely, that as the ethnic and gender composition of young workers changes, so too must professions and employers develop strategies for attracting these young workers, especially to jobs in S/E (Emerson 2005). A number of studies have pointed out the connection between embracing diversity to ensure innovation (Business Roundtable 2005), bring about a brighter economic future (National Academies 2005), or with respect to maintaining an "edge" in the global economy or national security (Council of Graduate Schools 2005). Emerson's report highlights how attention to diversity — increasing women and minorities' innovation potential — can play an important role for Canadian businesses and for national economic growth.

A *Wall Street Journal* article by Carol Hymowitz succinctly

ICWES 13 *By Cecily Jeser Cannavale*

The 13th International Conference of Women Engineers and Scientists, held in Seoul, Korea in August 2005 was an exciting event that brought together 700 participants from 53 countries. Women scientists and engineers presented their research findings in a number of areas, including gender and leadership in science and engineering. The gender and leadership oral session, consisting of 19 papers, and the gender and leadership symposium, consisting of 17 papers, are most germane to our discussion .

The gender and leadership symposium provided an opportunity for female scientists and engineers to share research on gender issues in their respective countries and to discuss solutions to the problems encountered. The symposium began with a presentation by Virginia Valian, Ph.D., who discussed why the advancement of women has been so slow and defined the barriers that continue to persist. She focused on the ways that disadvantage accumulates for women, providing many examples and valuable data.

Several presentations covered programs designed to support faculty and women working in S/E fields. The symposium examined issues that persist internationally and how research is a key for bringing about change necesary to increase women's participation in S/E. While space does not permit a discussion of all of the papers, those of particular interest are noted:

- Béraud André from Centre des Humanités discussed a large research project of teams from seven countries in Europe to determine why there are not more women majoring in engineering and working in engineering jobs, what problems women engineers face, and why it is difficult for them to get to top positions. They also looked at existing best practices in higher education institutions and companies.
- An excellent paper examining issues facing female scientists and engineers since the fall of communism in Russia was presented by Irina Dezihina . She found that 50 percent of the women surveyed do not want help from funding agencies to address gender issues, but 64 percent of men think there should be special grants to provide support for women. The men in the survey were very sensitive to women's issues and did not see gender issues as negative but rather as something that needs to be overcome.
- Naoko Tagashira presented a paper discussing how to break the glass ceiling. In Japan, only 6.4 percent of engineers are women so the gender barriers are great. Interviews with seven executive women found that courage and the ability to think through risks were important strengths, but maternity leave was a hindrance for promotion. The old boy's network continues to exist, which makes it more difficult for women to break through the glass ceiling. Tagashira suggested that women choose jobs that do not following traditional rules, but are new areas where women have a better chance of succeeding because the old boy's network is weakest in these areas.
- Catherine Didion reported on the Global Alliance www.globalalliance.org, which is trying to diversify the global S/E workforce. Global Alliance has used strategies such as developing networks, identifying and disseminating best practices, and developing common standards for data collection. The Global Alliance plans to publish outcomes of these strategies and to lobby for press coverage so that gender is not lost in the discussion on improving the S/E work force.

For information about ICWES13, please visit: http://www.icwes13.org/.

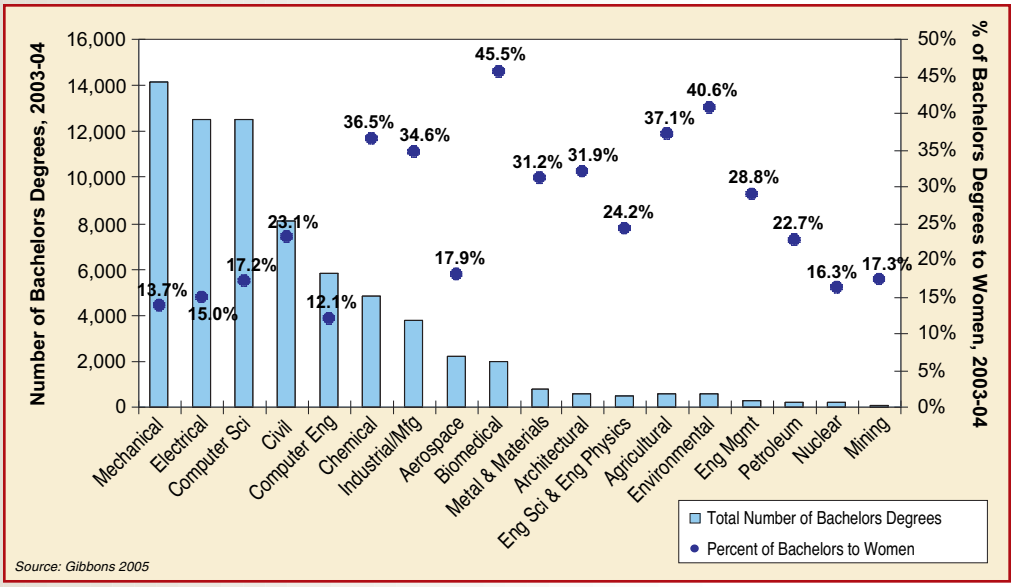
illustrates the "business case for diversity." By highlighting diversity efforts at Pepsi, IBM and Harley Davidson, Hymowitz indicates that businesses are increasingly discovering that these efforts pay off with a healthier bottom line. In many cases, diverse employees or other ways of understanding the diversity of product markets have enabled companies like these to be more responsive to broader product markets, thereby increasing sales.

Hewlett, Luce, and West discuss several ways that companies could make better use of employees' diverse backgrounds. Their recommendations were based on results of a 2005 survey fielded by Charney Research under the direction of the Center for Work-Life Policy. The survey included 1,601 professionals between 28-55 years of age with college or professional degrees working in medicine, law, education, and business/accounting. The respondents included 1,001 minority women, 200 minority men, 198 white women, and 202 white men, all from the United States. Detailed reports of findings should be available soon at www.worklifepolicy.org.

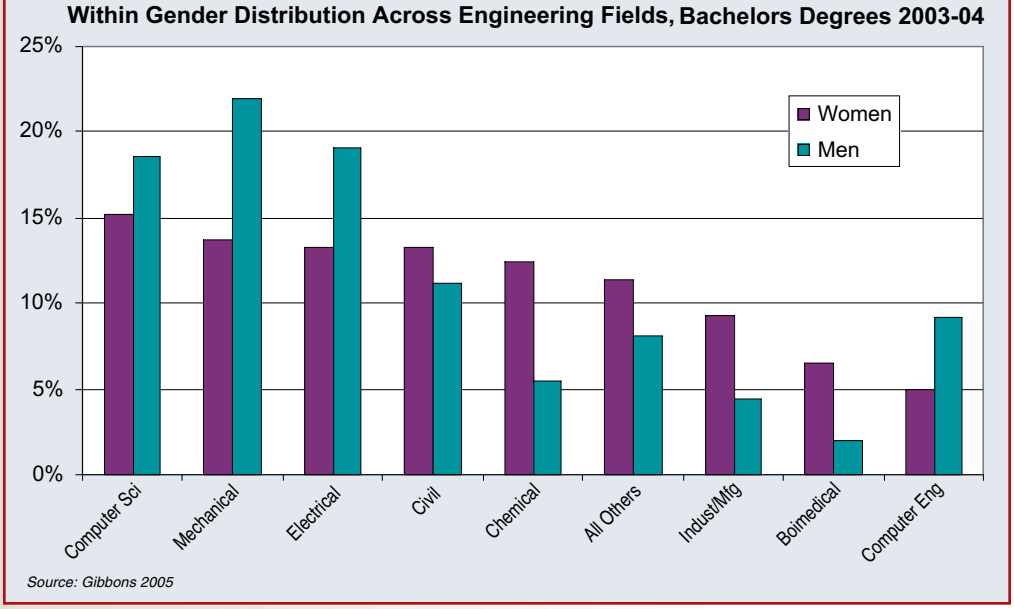
Hewlett, Luce, and West report that minority employees often hide their minority status because companies' talk about the value of diversity is often not followed through in actions. For example, one of the professionals discussed in the article volunteered with a Girl Scout troop at a local homeless shelter but felt that she could not even mention the group at her workplace. She indicated that her boss was not supportive because her involvement meant that she needed to leave work by 5:30 p.m. three days each month, and it did not seem to matter that she arrived at 7 a.m. on those days. Via this work, which she felt was significant, she learned valuable leadership skills — cultural capital — that according to Hewlett, Luce and West, represented a potential lost opportunity for her employer.

Who Becomes an Engineer?

While it is important to have a diverse work force, the question remains, how can businesses have a more diverse work force? Engineering jobs are gateways to many other positions; therefore, understanding who becomes an engineer can offer insight into the direction businesses may take in the coming years. The American Society for Engineering Education produces an annual column on "The Year in Numbers" (Gibbons 2005) that provides an excellent overview of engineering enrollments by gender, ethnicity, discipline, and level; i.e., bachelor's, master's, doctorate. The article has a number of useful graphs and tables, which would be an excellent compendium to keep handy if you ever need information for a talk about engineering. For more information about specific colleges, go to: www.asee.org/colleges.



Source: Gibbons 2005



Source: Gibbons 2005

The following graph was constructed from data in the Gibbons article to show, simultaneously, the numbers of bachelor's degrees awarded in engineering across 18 sub-disciplines along the left y-axis, and the percentage of degrees to women along the right y-axis. Women continue to account for a small percentage of graduates in the largest fields of engineering but they accounted for almost one-half, 45.5 percent, of graduates in the relatively new area of biomedical engineering. Women also accounted for just over 40 percent of environmental engineers, another relatively small sub-discipline, and over one-third of new chemical, industrial/manufacturing, and agricultural engineers were women.

A second chart also based on data in Gibbons (2005) shows the distribution of bachelor's degrees within gender across nine engineering disciplines. For example, while mechanical engineering accounted for about 22 percent of bachelor's degrees to males in 2003-04 , i.e., it was the most popular sub-discipline, the same discipline accounted for only about 14 percent of women's bachelor's degrees in

engineering. For women, the most popular field was computer science, with just over 15 percent of all the 2003-04 bachelor's degrees to women. Computer science was the third most popular choice for men, ranking behind mechanical and electrical engineering.

The role of women in academic engineering continues to be an important research issue. Marasco (2005) reports on an annual study by *Chemical and Engineering News* of women faculty at top research universities. In the 2005-2006 academic year, 213 women accounted for 13 percent of the 1,633 faculty at the 50 top research universities ranked by total research dollars, an increase of 1 percent over the previous three years. Rutgers and UCLA had the most women faculty — 10 each — representing 26 percent and 24 percent respectively of all faculty in their chemistry departments. Pennsylvania State and MIT each had six women faculty, who accounted for 21 percent and 20 percent of chemistry faculty, respectively, at those schools. Given that women have accounted for more than a third of new Ph.D.s in chemistry for a number of years, the scarcity of women faculty in top departments was seen as a problem that needed to be solved.

To understand how to solve the problem, it is helpful to look at some of the barriers that women face on the way to success in engineering. The October issue of ASEE's *Prism* magazine was dedicated to women in engineering, with a special focus on women engineering faculty members. As any woman who has completed an engineering degree or is working as an engineer already knows, women continue to be pioneers in engineering and the women who have taken up the challenge of pursuing Ph.D.s to become university professors continue to fight an uphill struggle for recognition. In an overview article, Sanoff asserts, "Engineering schools need to do more than simply say they are a good place for women — they need to prove it, and female faculty members offer compelling proof." (Sanoff 2005: 27).

Many women engineering faculty members are featured in these stories, but one vignette in particular provides a chronicle of and insight to Sheri Sheppard's struggles and success. Until 2002, Sheppard was the only woman in the mechanical engineering department at Stanford. Other stories in this issue of *Prism* provide insights into mentoring, the tenure maze, and basic data on women in academic engineering.

Continuing research by Nelson and Rogers on faculty at top research universities in selected fields of S/E documents the continued lack of women and minorities in these elite departments. Women account for less than one in five of the full professors in these departments while they are more highly represented among the most junior ranks. Nelson and Rogers conclude that with the rarity of women at these top schools, it is possible that a person could complete a doctorate without ever having worked with a female colleague.

What causes these low levels of representation to occur? Jo Handelsman et al.'s article in *Science* suggests that women's low level of representation in academic S/E is due to accumulation of anti-female bias. They point to the need for programs like the National Science Foundation's ADVANCE: Institutional Transformation Program, which are attempting to address the chilly university and departmental climate issues and conscious and unconscious biases that can have a negative impact upon women's careers in academia. The hope is that programs like this might help women to choose to stay in the S/E pipeline instead of leaving academia for careers in industry and government that provide them with a better climate.

The term pipeline has been critiqued in recent years by many analysts interested in how people move into S/E careers. The term pipeline implies a certain linearity in careers, which has been shown to be an inaccurate understanding, especially of women's careers. Instead, more researchers are attempting to understand the multiple pathways into S/E careers (e.g., Lange 2005) or to model science careers using life course methods (e.g., Xie and Shauman 2005). Blickenstaff (2005) suggests using the term gender filter instead of pipeline because many of the cultural elements of science education reflect sexist attitudes or males' interests, which tend to filter out those women who do not want to be just one of the boys.

The masculine stereotype of engineering may be part of the reason that girls forego engineering careers. Within the past several years, many advocates for women in engineering claim that media portrayals of women, combined with adolescents' peer culture have resulted in a generalized belief that it's "not cool for girls to be scientists." In order to examine this assertion, Stake and Nickens surveyed 324 gifted high school students, 161 females, 153 males, in the Midwest who participated in four to six week-long summer science programs. Brief surveys were administered on the first and last day of the program, which revealed that for both males and females, peer attitudes were important in the decision to be a scientist. The only striking gender difference was that females tended to form stronger social niches with others in the programs and were more likely to keep in contact after the programs had ended. This is important because it means that the programs effectively impacted the group females might define as peers to include others who may be destined to be scientists. Summer science programs, such as the one examined, are often promoted as a way to make S/E careers more attractive by providing promising students with information that they may be lacking in their regular school environments.

An article by Steinke (2005) explores the ways that women are portrayed as engineers and scientists in 23 popular films released between 1991-2001. Her article lists 74 films with a scientist or engineer as the primary character. Of these, 23 included a woman in the lead role. The women were often characterized as competent, in charge of projects, and were usually shown in occupationally appropriate clothes. Of course, most were very attractive, e.g., Elizabeth Shue as a theoretical physicist in "The Saint," and in some cases, there were transformations of the lead character from a homely geek to a beautiful woman, e.g., Sandra Bullock's Dr. Diane Farrow in "Love Potion No. 9." There were only a few women engineers shown. Renette Soutendijk played an out-of-control robot built in the image of its creator, robotics engineer Eve Simmons in the 1991 film "Eve of Destruction." More recently in 2000's "Space Cowboys" Marcia Gay Harden plays a NASA project engineer where most of the other female engineers pop up. Two women depicted as astronauts who might have been engineers were: Carrie-Anne Moss as Commander Kate Bowman in "Red Planet" (2000) and Jessica Lundy's mission specialist in the 1997 comedy "Rocketman."

Even though Steinke's analysis lacks depth and explanatory power — for example, her generally positive take on "Eve of Destruction" is at serious odds with analysis of the film as anti-feminist — but the article provides a useful starting point for your own analysis. Because she provides a list of 74 films that depict scientists and engineers in lead roles, it could provide the basis for an analysis of the comparison of how men and women are shown in these roles. The list itself would also be useful in putting together video nights for programs that seek to

increase girls' interest in science and engineering.

Students' unfamiliarity with engineering has long-been argued to be at the heart of the steady decline in students' selecting engineering majors (Frehill 1997). Shivy and Sullivan (2005) explored the extent to which 127 students, 28 females, and 99 males, enrolled in engineering courses at a public urban university in a mid-sized southeastern city were familiar with various engineering disciplines. Most of the students, 95.3 percent, were familiar with electrical and mechanical engineering but were less familiar with fields like petroleum engineering, as 51.9 percent indicated. The students' familiarity with a specialty was associated with the student's confidence that their interests were similar to those of actual engineers, so that there was a personal fit with the engineering track or specialty in which they enrolled.

Many programs seek to increase students' familiarity with engineering. Hazzan et al. (2005) report that in order to increase women's enrollments in an elite electrical engineering program in Israel, female high school students were provided with an exposure day. Among the 36 percent of women who completed a survey at the end of the day, ignorance of electrical engineering had given way to a multifaceted perception of the field. The 64 percent who did not complete the survey left early or were too tired by the end of the day — a finding which ought to be taken as an important piece of data, itself, for future iterations of the program. The authors plan to follow-up with participants later to see if the one exposure day had any lasting impact.

Simple one-shot exposure and interest in engineering careers is probably not enough to get more girls involved in engineering programs. If that were true, then we would expect to see young female fans of "Star Trek Voyager,"with its strong female engineering characters, flocking to the field. It is also important to ensure that young women are getting the training that they need to succeed in engineering fields. Mathematics is a critical component of engineering education, so many studies that explore gender effects on mathematics achievement provide insight into women's continued low level of representation in U.S. engineering. Erickan et al. (2005) used cross-national data for Canada, Norway, and the United States to show that home environment variables were stronger predictors of achievement for females than males in all three countries. Home support for learning and parents' highest education level were strongly associated with mathematics achievement for students of both sexes in the United States and for female students in Canada. Students' attitudes about mathematics were very strong predictors of their decisions to take advanced mathematics classes in general, but not for U.S. males. For U.S. males, the father's expectations about the son's higher education were a strong predictor of the son's decision to take advanced math classes. This seems to dispel the notion that there are innate gender differences that cause the gap in S/E fields.

While gender differences seem to receive quite a bit of coverage and are the basis for many stand-up comedy routines, one of the foremost scholars on gender similarities, Janet Hyde (2005) has assembled a meta analysis of meta analyses that documents the prevalence of gender similarities. Whereas many of the studies we mentioned earlier used large, national datasets, social psychologists rely more heavily on tightly controlled experiments often with college students as the subjects (e.g., like Correll and Benard cited earlier). Psychologists then use meta analysis to consolidate findings from many local-level experiments, usually like the ones you may have participated in during an introductory psychology class, to identify reliable findings.

Hyde's recent article (2005) shows that in more than 100 studies involving more than three million subjects, the gap between women's and men's mathematics ability is nearly non-existent. The only consistent gender difference is in the area of 3-D spatial visualization: women consistently under-perform on these tests compared to men. The good news is that 3-D spatial skills can be improved and Hyde recommends that all engineering schools should have a first year class that focuses on developing this aptitude. Indeed, Sheryl Sorbey, an associate dean of engineering from Michigan Technological Institute, won the WEPAN Betty M. Vetter Research Award for her work in developing programming and documenting the efficacy of 3-D spatial skills training for female engineering students.

Finally, an interesting study by Ingram (2005) highlights the stories of two Canadian women engineers — Melissa and Carol — as they made the transition from college to work. Both young women had been involved in an earlier project in which Ingram studied how gender played a role in three project teams at a Canadian engineering school in 1997-1999. The new article discusses how both Melissa's and Carol's self- confidence evolved starting with work experiences such as co-op assignments and summer internships while they were still undergraduates. Both women reported that their confidence grew as they became more familiar with engineering work, which helped them to "stick with" engineering in college and provided them with what they saw as an excellent foundation for work after college.

Another important theme raised in both cases was the competitive ethos of engineering as a problematic aspect of engineering education. Melissa and Carol's work involved a high degree of cooperation and required strong people skills, which they both saw as lacking in traditional engineering curricula. That is, the cockiness that they felt was conveyed by professors in engineering school was not a useful quality in the work force where it was important to collaborate to accomplish tasks.

Advancement in Engineering: Graduate School

While we have focused on some of the issues facing pre-college age women in S/E, it is also important to note the issues that are occurring at the college levels. A Council of Graduate Schools' report released in October 2005 calls attention to the decline in engineering graduate enrollments. In most other science fields, enrollments have been steady or increasing slightly but in engineering there was a 3 percent drop in enrollment in 2004-2005 as compared to the previous academic year. To some extent, the reason for this decline is itself, another important issue within graduate education in engineering. Half of all engineering graduate students are non-U.S. citizens or permanent residents, which is a far higher percentage than in any other field. When student visas were tightened following 9/11, fewer international students, which had formed a substantial core of engineering graduate programs, came to the United States for studies. Instead, they have begun to pursue graduate degrees in Europe and Australia.

What does it take to do well in graduate school and what are the issues that women engineering students encounter? A study by Litzler, Edwards and Brainard reported at the ASEE conference explored how climate issues impacted students' progress through 18 graduate programs in S/E at the University of Washington. Logistic and multinomial logit regression analysis of survey data from 574 graduate students (47 percent response rate) were performed to study the relationship among career commitment and an array of climate variables. A consistent set of findings about the role of

competition was among the most interesting findings. Competition had a negative effect on completion of stages toward the doctoral degree, suggesting that departments or programs with more collaborative environments would provide a more conducive climate for graduate student success. Women in the study continued to report more problems with gender discrimination than did men.

Lange's dissertation used the Survey of Earned Doctorates to examine institutional pathways to the doctorate in S/E disciplines and transitions from master's to doctoral programs by race and gender. The study revealed no significant gender differences in pathways; however, underrepresented minority students took significantly different pathways to the doctorate than white and Asian American students. URM students were more likely to earn the bachelor's, master's, and doctoral degrees at three different institutions, and their path was significantly more likely to include earning a master's degree en route to the doctorate, which is uncommon in some fields of science. URM students were more likely to experience transition difficulties between the master's and doctoral degrees. Lange concluded that master's degree programs have the potential to be a valuable resource for policy-makers and doctoral programs working to increase URM access to doctoral degrees in S/E.

The Digital Divide

Recent research points to socioeconomic status, gender, and ethnicity as significant factors related to the stratification of computer science and information technology professions (Freeman 2004; DeBell and Chapman 2003; Losh 2004; McGrath 2004; Van Dijk and Hacker 2003; and Wilson et al 2003). The fraction of college-educated women working as IT professionals has decreased significantly from 1990 to 2000 (Wardle 2002: 8).

Much recent research has examined how gender plays a role in selecting a CS major (Adya and Kaiser 2005, Cohoon and Baylor 2003, Losh 2004, Margolis and Fisher 2001, McGrath 2004, NSF 2004, Tillberg and Cohoon 2005). A study published by AAAS (2005) provided a rare glimpse of how ethnicity, gender, and class intersected to impact women's participation in CS and IT.

The most recent National Center for Education Statistics report on gender equity in education (Freeman 2004) indicates similar rates of computer use at home by girls and boys, but that "males leave high school with greater interest in and specialized knowledge of computers." (Freeman 2004: 8). Males accounted for 86 percent of high school students who took the advanced placement examination in CS, and males on average scored higher than females. Girls were more likely than boys to use computers for word processing, e-mail, and to complete school assignments while their male peers were more likely to use computers for playing games (DeBell and Chapman 2003).

These findings are echoed in recent work by Tillberg and Cohoon (2005) reporting results of 31 focus groups with 182 undergraduate CS majors at 16 universities. Prior to college, women reported using computers for creative play while men reported playing games on computers. In examining how women were attracted to the CS major, the importance of prior positive interaction with computers — either at home, in an introductory CS class, or work — was important as well as peer relationships that drew women into the major. Women who had switched into CS came from broader initial disciplinary areas than did men who also switched into CS. Men were likely to come from other areas of science or engineering, while women came from these fields, but also the arts, humanities and social sciences.

The Value of Mentors

With the founding of MentorNet in 1997 by Carol Mueller, there has been increased attention to the value of mentoring in many settings. In any work environment, there are always written rules, policies, and procedures, but in addition, every work environment has unwritten expectations and culture. Learning this culture can be difficult for anyone, but it can be even more so for those who differ from the average person in a field. Because a majority of engineers are white males with no visible physical disabilities and presumed to be heterosexual, people who are not white, not male, have a visible physical disability, or are not heterosexual may experience difficulties fitting in. Women in engineering, in fact, refer to this fitting in as being just one of the boys, a phrase that emphasizes this split identity.

Girves, Zepeda, and Gwathmey (2005) provide a solid overview of the literature on mentoring and describe a number of local, regional and national mentoring programs. The article is a fine resource. Another article by Boyle (2005) discusses some of the problems that firms have encountered in implementing work place mentoring programs and how these programs can be improved. In addition, Boyle's brief article indicates that business research firms have found mentoring to have positive impacts:

- 69 percent of minority women who had mentors in 1998 had at least one upward move by 2001 versus only 49 percent of those who did not have a mentor (Catalyst 2002).
- Shareholder returns increased more than 10 percent per year over a 10-year period for companies that provided mentoring to potential leaders while those who did not emphasize cultivating leaders had returns of less than 1 percent per year (Bain & Co.).

Mentoring is a way to provide everyone with someone to whom they can go to for career advice, help with dealing with new situations or political issues that arise, guidance in balancing career and family obligations, or just a simple role model who looks like oneself and provides reassurance that someone from a group with which you identify can make it in the field. Many of the articles in an issue of ASEE's *Prism* emphasized the important role of mentoring in increasing women's persistence in engineering (Daniel 2005, Loftus 2005, and Lord 2005). Mentoring can also provide critical support when you participate in an international assignment (Mezias and Scandura 2005).

MentorNet has posted evaluation reports that document the importance of mentoring on their Web site, www.mentornet.net. A recent report indicates that online mentoring has been critical in helping young women of color, in particular, persist in engineering and science because their mentors help them deal with issues like prejudice and bias from teachers, fellow students, or co-workers and provide encouragement that they can be successful (SJB Consulting 2004). According to a story by Marasco (2005), in 2004-2005 MentorNet connected:

- 4,000 students and mentors
- 1,4000 members
- 800 companies where mentors worked
- 80 colleges and universities participated.

The Gender Gap in Pay

According to the Bureau of Labor Statistics, among workers aged 16 and older in the full-time work force in 2005, men's median weekly earnings of $722 exceeded women's median weekly earning by $137, which translates to $7,127 per year. The customary way to describe the gender gap in pay is to take a ratio of women's to men's median or mean earnings and then to

interpret the ratio as the amount of money the average woman earns for each dollar the average man earns. Here, $585/$722 = 0.810. Among architecture and engineering occupations women's median earnings of $945 per week represented $0.834 for each dollar the median men earned. (Note: Bureau of Labor Statistics data were not available for engineers separately because there were too few women in those occupational groups). Economists split the pay gap into pieces that can be explained and pieces the can not be explained, which sociologists then usually chalk up to the effects of discrimination.

The gender gap in pay varies substantially across different fields, for workers of different educational levels, and for workers due to experience in the paid labor force. The following table shows median annual salaries of engineering doctorate holders employed full time, by age group and sex for 2001.

(Rounded to nearest $1,000)

	Total	Female	Male	M - F	Ratio: F/M
Engineers	**88,000**	**80,000**	**89,000**	**9,000**	**0.900**
less than 30	72,000	72,000	72,000	0	1.000
30–39	80,000	79,000	80,000	1,000	0.988
40–49	89,000	85,000	89,000	4,000	0.955
50 and up	100,000	84,000	100,000	16,000	0.840

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Doctorate Recipients, 2001.

Notice the gap is non-existent for younger workers but widens with older doctorate holders. The gender gap in engineering pay differs by engineering disciplines. Again, the most readily available data are from the National Science Foundation for employed engineers with doctoral degrees. The data in the next table report median salaries for 1997 — which are a bit dated now, but give you a feel for how engineering specializations might impact the gap in women's and men's earnings.

(Rounded to nearest $1,000)

	Total	Male	Female	M - F	Ratio: F/M
Aerospace/aeronautical engineers	79,500	80,000	76,000	4,000	0.950
Chemical engineers	74,500	75,000	68,000	7,000	0.907
Electric and related engineers	80,000	80,000	68,000	12,000	0.850
Mechanical engineers	74,000	74,000	57,000	17,000	0.770
College & university teachers	65,000	66,500	56,000	10,500	0.842

Source: National Science Foundation, Women, Minorities, and Persons with Disabilities in Science and Engineering:2002.

Morgan (1998) used data from the Survey of Natural and Social Scientists and Engineers for the years between 1982 and 1989, and a survey conducted by the Society of Women Engineers to see how the glass ceiling functions to impact women engineers' salaries. Morgan found that especially for older cohorts of women (women who have been in the field of engineering the longest), there is a fairly large wage gap, but that this gap did not increase as time went on. She found that earnings were affected by one's cohort (that is, when one entered the engineering labor force) rather than a uniform across-the-board effect. Women in younger cohorts (those who most recently graduated and entered the work force) had at most a 4 percent gap in their earnings as compared to their male peers and, in most cases, pay gap was non-existent. This led her to conclude that for younger cohorts, there is no longer a glass ceiling in the engineering field, but those women already established in engineering careers can expect to continue to face the same gap they were presented with at the beginning of their careers.

There are many online tools to check salary levels including www.engineersalary.com/ where you enter a number of key features concerning your job, skills, and background, as well as your geographic location, and then a salary estimate is e-mailed to you. Tools like this can help determine whether you are underpaid. Why does it matter if you are being underpaid? Even small disparities grow to be quite large over time — remember engineering economy class — so that your retirement earnings level and how old you will have to be in order to retire may be impacted. Furthermore, because women's life expectancies are a little longer than men's in the United States, by about four to five years, women need to plan for a longer period of retirement.

Burke et al (2005) examined the gender gap in earnings for faculty members at a unionized, public liberal arts college for the 1998-1999 academic year. They found that the average female faculty member earned 85 percent of the average male faculty member but that about 89.5 percent of the gap in salary was attributable to factors like rank and years of service, which of course means that 10.5 percent was due to something other than these factors. As is the case at many colleges and universities, salary compression was cited as problematic. Salary compression occurs when new assistant professors' salaries creep up toward or even over those of more advanced associate and full professors because of market forces.

In a larger study of faculty pay equity, Toutkoushian et al. (2005) analyzed data from the 1999 National Study of Postsecondary Faculty, which is one the most comprehensive nationally based datasets about college professors. Even after controlling for characteristics such as experience, educational attainment, field, rank, and institution type, and self-reported productivity, women on average earned 4-6 percent less than men in academe. While this may seem like a small gap, this represents several thousand dollars annually, which accumulates over the course of one's career to a large difference in pay and, subsequently impacts retirement benefits.

To illustrate the impact of the accumulation of an initial small gap, consider two hypothetical people. One person earns $50,000 per year while the other earns 5 percent more or $52,500 per year — which is a gap of $2,500 per year, the cost of a couple of house payments or a nice vacation. If we assume that each person's salary increases by just 3 percent per year, over the course of 20 years' time the first person would then have a salary of $87,675 and the second person would earn $92,059 for a gap of $4,384.

Does pay affect individuals' choices of field of work? Graham and Smith examined the 1993 National Survey of College Graduates, a large, nationally representative dataset, to shed light on how earnings affect attrition from S/E. By looking at the respondents who had science or engineering degrees, Graham and Smith showed that men were more likely to leave a science or engineering job because they were interested in increasing their earnings, while women's motivation to leave a job appeared uninfluenced by this same factor.

A study by Prokos and Padavic used data from several sources to examine how glass ceiling and cohort effects impacted the salary between men and women. They used the National Survey of College Graduates Science and Engineering Panel, the National Study of Recent College

Graduates, and the Survey of Doctoral Recipients, all of which are accepted as excellent sources of reliable nationally-representative data. Using regression models of earnings, they concluded that the glass ceiling did not have a negative impact upon women's earnings. When statistical controls for human capital, for example, education levels, occupational variables, for example, years of experience in the labor force, and demographic variables, e.g., age, were added to earnings models, the glass ceiling effects disappeared. Contrary to the popular belief that the earnings gap is a thing of the past, they found that even among younger S/E workers that there is a significant gap in pay and that explaining this gap is complex.

	1993	1999
Earnings gap (men – women)	**$11,140**	**$14,932**
Women's earnings as a percent of men's	82%	78%
Engineering	85%	87%
Physical sciences	81%	73%
Computer science & mathematics	85%	83%
Life sciences	79%	82%

Source: Prokos & Padavic 2005.

Public school teachers' pay was the focus of a study by Hoxby and Leigh, who argue that low salaries for teachers have led to a decline in teacher quality measured by the selectivity of the college where the teacher was trained. Hoxby and Leigh used five different datasets from the National Center for Education Statistics to examine data for U.S. teachers who graduated between 1961 and 1997. In 1963, 5 percent of new teachers came from highly selective colleges but by 2000, only 1 percent were from highly selective colleges. On the other hand, while only 16 percent of new teachers were educated at bottom tier colleges in 1963, by 2000 over one-third, 36 percent, were from these colleges. Hoxby and Leigh suggest that teachers' salaries are at the heart of why proportionately fewer teachers are employed who had been trained at highly selective colleges, with an influx of teachers over this time who were trained at less selective schools. Of course, the untested assumption here is that a highly selective college provides a higher quality teacher, while less selective schools produce lower quality teachers.

Likewise, prior to 1972 when Title IX forced open the doors of law, medical, business and engineering schools for women, teaching was one of only a few professional occupations open to women. Women's crowding into the profession and the active efforts to keep women out of other jobs meant that salaries could be kept low. The same mechanism operated to keep nurses' salaries low, until recent shortages have resulted in market adjustments to nursing salaries that have not yet been matched in public education.

Park and Shin quantitatively assess the impact of macroeconomic unemployment rates on the wage gap between men and women using data from the National Longitudinal Survey of Youth. Using average hourly earnings, Park and Shin found that with a one percentage point decrease in the unemployment rate, women's real wages increased by .45 percent while men's wages increased by 1.38 percent. Approximately 100 percent of this gender gap was explained by the gender gap among occupation stayers, that is, women were more likely to stay with their current employers rather than to use the reduced unemployment rate and a seller's labor market as a mechanism to change employers and get a higher salary. Also, workers in female dominated clerical job categories, sometimes referred to as the pink collar ghetto, reap fewer economic benefits of a better economy than do those in jobs that are male-dominated.

Combining Work and Parenthood: The Mommy Track Revisited

A 1989 article by economist Felice Schwartz in the Harvard Business Review ignited a firestorm of controversy. Schwartz argued that the fact that women bore children and were more likely to be primary caregivers meant that employers needed to accommodate women's needs as working parents. She reasoned that if U.S. businesses failed to do so, that a large pool of talent would be lost. The accommodations that Schwartz proposed came to be ridiculed as the mommy track, with media pundits expressing shock that all mommies would be loaded onto the slow train, chafing at the assumption that motherhood was not compatible with a successful, fast track career.

When Schwartz's article first appeared, her ideas about employers accommodating working mothers were radical. At the time, few employers had on-site daycare, flextime, the possibility of reduced hours, benefits for part-time workers, job sharing, or paid or unpaid leaves for childbearing or adoption. Women were counseled to avoid interviewing for jobs when they were pregnant or to hide pregnancies when employed in a paid position. Ironically, while Schwartz's work was roundly criticized, especially by women's groups, U.S. businesses understood the central tenet of her argument; as women accounted for nearly half of all new workers, if they were to retain the best and brightest, then accommodations of various types would need to be made and women would have more choices.

A 1995 article by Grover and Crooker suggests that family-responsive human resource policies are good for business. Using nationally-representative data for 745 respondents to the 1991 General Social Survey, Grover and Crooker show that family-responsive policies symbolize to employees that an employer has concern for their employees lives, which, in turn, leads to stronger work attachment. Those employees who had access to more progressive family-responsive policies had significantly greater organizational commitment and were less likely to report an intention to quit their jobs.

In the past few years, the impact of motherhood — and sometimes, more generally, parenthood — has become the focus of much research, speculation, and policy attention. Correll and Benard used 192 undergraduate students in a social psychology experiment at Cornell University to show that even among young adults, a motherhood penalty disadvantaged women in the labor market. In the experiment, students were given a résumé to evaluate to make a hiring recommendation. While the qualifications remained unchanged, the résumés were manipulated so that the applicant was a mother, non-mother, father, or non-father. They found that mothers were judged to be less competent and committed, were held to harsher performance standards, were seen as less promotable, were offered salaries an average of $11,000 less than non-mothers, and less likely to be hired than were female non-mothers. Fathers, on the other hand were seen as more promotable, were offered higher salaries, and were seen as being much more competent than any other group of applicants.

Ransom conducted semi-structured interviews with 37 women who were part of a larger study tracking engineering graduates in Western Canada to examine their attitudes and experiences of balancing the roles of mother and engineer. All of the women without children

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(n=17) were working in full-time engineering jobs specifically related to their training. Among those who were mothers, five had left the paid labor force to be stay-at-home moms while doing a little consulting, six reported that they abstained from advancement opportunities to juggle their two roles, and only nine, less than half, reported that they had not made any career adjustments to continue working as engineers.

Those women who did not yet have children (n=17), tended to downplay sexual harassment and expressed their desire to be just one of the guys at work even though over time, some women came to resent this identity. That is, eventually some women felt that by embracing the one of the guys identity, they minimized their status as women. Many of these women expressed a desire to have children at some time but were clear that in order to do so, their spouses would need to be willing to take on some of the care responsibilities. None were ready to give up or jeopardize their careers for the sake of having children but would be content to accept the traditional ideal of a fatherhood role if they were to have children.

The nine who reported not making career adjustments, however, indicated that husbands, family networks, or nannies provided primary care for their children. They operated in a male oriented mindset in which they privatized family responsibilities to the point where their co-workers were often unaware of their parenting status.

This notion of compartmentalizing one's family life is one of several important issues raised by a comprehensive quantitative and qualitative study by Colbeck and Drago. Faculty members were surveyed, interviewed, and even shadowed by these researchers who were interested in how faculty members managed to balance their work and family roles. Their work sheds light on the impact of caregiver bias, which had also been revealed by Correll and Benard's study of the Cornell students previously mentioned. Colbeck and Drago found that bias against caregivers was quite widespread and that women more than men suffered at work because of this bias. Drago's presentation at the National Academies Convocation is available online and provides a nice overview of his research with Carol Colbeck.

Colbeck and Drago found there were three patterns of behavior: bias acceptance, bias avoidance, and bias resistance. With bias acceptance, people accept that there is anti-caregiver bias with which they prefer not to deal, so they opt out of positions where they suspect there will be problems, e.g., tenure-track positions. The working engineering women who privatized their family lives in Ransom's study are a good example of bias avoidance. By effectively hiding their role as parents from co-workers, they are able to avoid the problems associated with caregiver bias, which includes suspicions by co-workers and bosses that mothers are incapable of being fully committed workers. Finally, a small number of faculty studied by Colbeck and Drago engaged in bias resistance, in which they diverted time to family and away from work, actively challenging the bias against

A Closer Look at Some Statistics

• The Connell Wagner company in Australia has been working hard to increase the number of female engineers in it's ranks. Currently over 15 percent of their engineers are female, which is well above Australia's national average of 6 percent (Bretherton, 2005).

• Australia has taken up a public campaign, based on the United States' WWII use of Rosie the Riveter, to encourage women to enter technical fields via commercials, posters, and billboards that highlight the manufacturing side of engineering (Hoyle, 2005).

• This past year, the Association of Professional Women Engineers of Nigeria (APWEN) sent representatives to the Nigerian government demanding that reforms be made in the job market to eliminate gender discrimination in the engineering industry. They argue that since they have the same training and must pass the same exams as their male counterparts, that it should be illegal for companies to refuse to hire women engineers (Oghifo, 2005).

• National studies done in Iceland show that boys trail behind girls in math performance, especially in small villages. Studies show that there is still a leaky pipeline, but women account for 61 percent of all university students and just over a third of all science students in Iceland (Walt, 2005).

• The United States graduates about 50,000 engineers every year. China and India each graduate about two to three times as many (Riley, 2005).

• According to the Commission on Professionals in Science and Technology, in 2003 10.3 percent of the engineering workforce in the United States was female. The lowest area of representation for female engineers was in the electrical and electronics engineering field, in which only 7.2 percent are women (Riley, 2005).

• Women earned 20.1 percent of all engineering bachelor's degrees and 15.1 percent of electrical engineering bachelor's degrees in 2003-2004 (Riley, 2005).

• Caltech's 2005 chemical engineering class of six was 100 percent female. Five of the six graduating seniors plan to continue on to get Ph.D.'s in engineering. Caltech's overall percentage of female engineering graduates is 35 percent, which is a 10 percent increase over the past decade. Caltech and the students credit good teachers, mentors, and a shift in the curricula that focuses more on seeing direct results instead of just theory as reasons for the rise in female engineering participation (Reitman, 2005).

• Women's representation in the top 50 departments (according to research expenditures) was published online by Donna Nelson and extracted in an article by Handelsman et al (2005).

Percent Women at Each Career Level

	Ph.D.	Assist. Prof.	Assoc. Prof.	Full Prof.
Chemical	25.0	21.4	19.2	4.7
Civil	17.9	22.3	11.5	3.5
Electrical	12.1	10.9	9.8	3.8
Mechanical	10.9	15.6	8.9	3.2

• There were 5,776 engineering doctorate degrees awarded in 2004, 64.6 percent of which were to non-U.S. citizens, the highest of any field reported by the National Science Foundation. Electrical engineering was the specialty posting the most doctoral degrees: 1,649, followed by mechanical engineering at 853 then chemical engineering (723) and civil engineering (675).

• The Information Technology Association of America reported that the percentage of women in the IT workforce dropped from 41 percent in 1996 to 32.4 percent in 2004. In addition:

• One in three women in IT hold administrative jobs: if these are excluded from the figures on women's participation in the field, then the IT workforce would be only 24.9 percent female.

• Hispanics are the most under represented group in the IT workforce: only 6.4 percent of the IT workforce (compared to 12.9 percent of the entire U.S. labor force) is Hispanic. This in a slight increase since 1996, when only 5.3 percent of IT workers were Hispanic.

• The IT workforce is aging: the median age is now 39.7 years, close to that of the U.S. labor force (of 40.5 years), representing an increase of 2.1 years since 2000. (*Information Week*, June 22, 2005).

caregivers. These faculty members brought their children to the office or to social events, making obvious to their colleagues that they were both committed parents and workers.

Colbeck and Drago's research draws attention to the need for academic workplaces, which are lead by department chairs, to have more inclusive practices that enable faculty members to be both a parent and a colleague. They recommended that chairs provide opportunities during candidate interview trips to involve family members; encourage faculty members to cover for each other when family responsibilities come up; and schedule meetings that do not conflict with non-work commitments.

Like Colbeck and Drago's study, a number of other researchers this year have shined a spotlight on how parenting impacts women in academia. The compilation of professors' stories in "Parenting and Professing: Balancing Family Work with an Academic Career" (Bassett, 2005) as well as Carver's (2005) autoethnographic work provide personal narratives about the day-to-day difficulties and biases that parents, especially mothers, experience in academic settings.

Is there a basis for concern about caregiver bias? According to research presented by Joan Williams, at the National Academies Convocation, she documents the rise in maternal wall or family discrimination retaliation lawsuits in which women who have taken advantage of family friendly policies have suffered various types of retaliation by employers. Williams' presentation reported that this new trend in employment law has had a 400 percent increase in the past decade with nearly 250 cases in the 2000-2004 period. These cases have a ,"higher win rate than in other civil rights suits, 27 percent v. 50 percent." Fathers also suffer adverse effects when they seek an active role in parenting. Williams indicates that in a study of more than 500 employers, "fathers who took parental leave" were "recommended for fewer rewards and viewed as less committed."

Another conference, convened by the American Council on Education in September 2005 titled "Creating Options: Models for Flexible Faculty Career Options" was funded by the Alfred P. Sloan Foundation (Marasco 2005). This conference (report available at: www.acenet.edu/bookstore/pubInfo.cfm?pubID=330 emphasized the need for academic institutions to provide alternatives to the rigid lock-step tenure process, which is one of many barriers to women's full participation in academic life. The ACE report recommends some concrete strategies in four areas:

- Enhance recruitment efforts, including creating re-entry opportunities and abolishing penalties for dependent care related gaps in the résumé/vita.
- Improve career satisfaction, retention, and advancement including providing high-quality childcare, flexibility in the tenure track, etc.
- Improve the climate for all e.g., create a professional climate where use of family-friendly policies is not penalized but encouraged.
- Develop incentives for faculty retirement.

Finally, a cross-national study by van Langen and Dekkers compares women's participation in S/E at the college level and in the labor market of four different nations: the Netherlands, Sweden, the United Kingdom and the United States. Interviews with five to six experts from each country — people who worked in educational policy or research or who were involved in promoting girls'/women's participation in S/E — were recorded, transcribed and then supplemented with other documentary evidence from the four nations. There were many similarities across the four nations:

- The quality of secondary and college S/E education was an important deterrent to encouraging young people to major in S/E.
- S/E jobs are reputed to be demanding and inflexible, especially for people who feel they might need a few years away from the labor market.
- Media representations of S/E show these jobs as "too difficult, unappealing, and unglamorous" (p. 337).
- School counselors and career advisors continue to give sexist/stereotyped advice to young people.
- In the European nations: it takes longer to earn a S/E degree while in the United States there is a perception that the S/E labor market demands more than a bachelor's degree for a decent job.
- Governments, while at different stages, are actively engaged in policy work to increase girls'/women's access to S/E careers.

There were a number of important differences across the four countries:

- Sweden had the most generous public provision of higher education but a low retention rate at 43 percent. Students can enter S/E later. Long-standing social welfare policies related to childcare and parental leave is combined with a strong expectation that both parents work in the paid labor force. Nearly two-thirds of women are in the paid labor force and 51.1 percent of families with children are dual-earner families.
- The Netherlands was the latest of the four nations in addressing the issue of women in S/E and it is still expected that married mothers with young children will not be in the paid labor force. Like Sweden, the Netherlands' funding of higher education enables students to keep a low post-graduate debt burden, especially if they maintain good grades. Sixty nine percent of students who enter college in the Netherlands complete the bachelor's degree. Students experience strict compartmentalizatio" within higher education, which makes it difficult to enter a new major once schooling for another major has been completed.
- Although expensive to students, higher education in the United Kingdom had the highest retention rate of all four countries: 83 percent due, according to van Langen and Dekkers, to the high degree of one-on-one student/faculty interaction, which is a pillar of the British system of higher education. Like in the Netherlands, students move into a narrow range of topics fairly early in secondary and into college education, which, again, makes switching into S/E difficult.
- The United States has the most expensive system of higher education, relying to a large extent on loans. Retention is on par with that in the Netherlands, 66 percent. In terms of entry to college S/E, late entry is feasible in many subjects except engineering, in which students are expected to be ready for entrance within the first two years of college. A strong expectation of women's labor force participation is not matched by overly generous benefits for new mothers or families. Like Sweden, though, the United States has long had government policies that were aimed at increasing women's participation in S/E careers.

Research Productivity

Other researchers have used large national datasets to understand how parenting impacts academics' research productivity. Women, especially mothers, are often criticized for not being productive. Suspicions about decreased productivity are at the heart of some types of discrimination that women experience in the workforce

and in graduate education. Recent research by Mary Frank Fox finds that contrary to the popular conceptualization, mothers with small children are actually more productive than women without children.

Fox's (2005) results are based on a mail survey in 1993-1994 of 1,215 full-time tenured or tenure track professors in doctoral-granting S/E departments, specifically, computer science, chemistry, electrical engineering, microbiology, and physics. Men's productivity was higher than women's but women who were married, especially those in a subsequent marriage, were more productive than those who were not married. Women were less likely than men to have children or to be unmarried. Interestingly, women with pre-school aged children were more productive than those who had no children or who had older children. To some extent, however, these were also women who had a more research-intensive focus rather than having to balance teaching and research. In short, the common beliefs that married women or mothers are less productive are false according to Frank Fox's work.

Within academia, research productivity is usually measured by the number of peer-reviewed publications and sometimes account is taken of the impact of one's publications. Publications are the principal currency by which professors seek rewards within academia, especially at elite research institutions like those studied by Nelson and Rogers (2005). Publications are essential in the promotion and tenure processes, in the allocation of merit pay, provide a foundation for successful grant applications to funding agencies, and provide the basis for honors and awards by one's peers in the academy.

Other factors that impact academics' productivity include: affiliation with a university research center in addition to an academic department (Corley and Gaughan 2005); bring in chemistry versus other fields (Corley 2005); taking a pure scientist approach to one's career (Corley 2005); and working in a supportive environment where one's colleagues value one's contributions (Corley 2005). Corley found that female scientists were less likely than their male counterparts to have a strong identification with pure science and were less likely to be in a supportive work environment.

Thursby and Thursby constructed a database that includes detailed information about the research and patent disclosure practices of more than 4,600 faculty members at 11 leading research universities over a 17-year time period. When a faculty member's research leads to an invention that could have commercial potential, the faculty member is supposed to disclose about this potential to their university. While still few faculty disclose (1 in 10 in 1996) there has been an increase since 1983 (when it was only 1 in 10). Women account for only 8.5 percent of the faculty members in Thursby and Thursby's database. According to their analysis, even though the women and men had similar productivity levels as measured by research articles, men were more likely than women to disclose. Thursby and Thursby noted that over the 17-year period, however, that the gender gap in disclosure was narrowing.

Conclusion

Is the glass half-full or half-empty for women in engineering? While some recent research shows that things are getting better for women in S/E fields, there is still a long way to go. Hewlett, Luce, and West stress the importance of diversity, but until we have reached a level where all business and institutions are working conscientiously toward gender equality, the gap will remain. The controversial speech by now former Harvard President Summers opened the door for intelligent discussions concerning gender equity in S/E and shined a spotlight that revealed the need for more education about gender equity issues.

The 374 items analyzed for this article covered many themes that concern women students, professionals, and academics in S/E. Careful research like the work by Colbeck and Drago examined the mechanisms that underlie and contribute to gender inequality in the S/E workforce. Research in gender equity must continue to be carefully crafted based on the best social science theories and methods to continue to peel back the layers to get to the root cause of the persistently low level of women's participation in fields like engineering.

This year has been an amazing year in drawing attention to the needs of women in science and engineering, and it is possible that in the years to come, we will begin to see the results of efforts like the National Science Foundation's ADVANCE program, which are trying to create a more fair and equitable workplace for everyone. Where will we head from here? Only time will tell. Perhaps next year's review will show that we are making leaps and bounds in the area of equality or perhaps it will show only small gains. One thing remains certain, there are many people out there working to understand the problem, and slowly they are making changes.

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