WOMEN IN ENGINEERING: A Review of the 2003 Literature

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Editor's Note: **For the complete list of references cited in this review please visit the SWE Web site,** www.swe.org/mag **Due to space limitations they are not included in the print version of this review.**

Women in Engineering in the News

Women in engineering actually made national news this past year. First, there was publicity on the congressional hearings surrounding Title IX and H.R. 4664, which was signed into law by President Bush in December, 2003. In addition, there were reports by the President's Council of Advisors on Science and Technology and the Pan-Organizational Summit on the U.S. Science and Engineering Workforce, which included women engineers. Women in science and engineering (S & E) made news later in the year with the publicity surrounding additional results from Donna Nelson's research concerning women's representation on the faculties of the top 50 schools in various disciplines of S & E.

Nelson's research caught national headlines in the ***New York Times*** (Lewin) and on CNN. She showed that despite women's substantial increased representation among science, technology, engineering and math (STEM) doctoral recipients over the past 20 years, most of the top 50 schools lack a faculty that "looks" like the national available "pools." That is, contrary to popular belief, in many areas of science, like biology, chemistry, math, economics and computer sciences, there is not a "pipeline problem" to explain why there are so few women-faculty members. Engineering, however, is a stand-out in that women hold tenure-track jobs in proportion to their share of Ph.D.s awarded in the field. Women of color continue to be almost completely invisible on the S & E faculties of top-50 universities.

Title IX and Engineering: H.R. 4664

Title IX states, "No person in the United States shall on the basis of sex, be excluded from participation in, be denied the benefits of, or be subject to discrimination under any educational program or activity receiving Federal financial assistance." Title IX prohibits sex discrimination in all areas of education, including admissions and recruitment, educational programs and activities, course offerings, counseling, financial aid, employment assistance, facilities and housing, health and insurance benefits and services, scholarships, athletics, and discrimination based on marital and parental status. Title IX has been successful in increasing girls' participation in athletics. Now, many observers are suggesting that application of Title IX to science, mathematics and engineering education could have similarly profound results (e.g., see articles by Rolison and Wyden).

AWIS has been an ardent supporter of application of Title IX procedures to understand and close the persistent gender gap in S & E. An article in ***AWIS Magazine*** and a fact sheet about Title IX on the organization's Web site provide thorough background information about legislation signed into law on December 19, 2003 by President Bush. H.R. 4664 instructs the director of the National Science Foundation, in conjunction with the National Academy of Sciences, to assess gender differences in the careers of scientists and engineers and to assess gender differences in the distribution of external federal research funding, (***AWIS Magazine***, V32 No. 2, Sp 2003; 20 U.S.C. 38, Section 1681).

On a related note, a report by the President's Council of Advisors on Science and Technology (PCAST) called for more spending at every point of the S & E pipeline. Accordingly, universities need to (1) increase retention rates among undergraduates who declare an interest in S & E degrees and (2) improve the climate for women. Today, the United States depends on the international labor market to fill S & E jobs; consequently, women and minorities are "underused resources."

Pan-Organizational Summit on the S & E Workforce

Another important national-level event was a summit on the S & E workforce, held in November, 2002 with a meeting summary published in 2003 by the National Academies Press (http://www.nap.edu). At the Pan-Organizational Summit on the U.S. Science and Engineering Workforce, 31 non-profit organizations discussed papers on the current issues in S & E today. The organizations engaged in dialogue to recommend solutions to these issues:

- too few native-born Americans seeking jobs in S & E
- the under-representation of women and minorities in S & E fields

The summit led to policy recommendations in the following areas: national leadership, K-12 teacher training, financial aid, undergraduate curriculum and pedagogy reforms, effort / reward ratio, agility in S & E education and workforce, minority-women participation, and a systems approach to understanding the problem. Each of the 31 organizations presented a paper, which was then included in a book published by National Academy Press after the summit. The volume includes the keynote speeches by Shirley Ann Jackson, Ph.D., president of Rensselaer Polytechnic Institute and Joseph S. Toole, associate administrator for professional development, Department of Transportation - Federal Highway Administration. The 31 non-profit organizations involved were:

- Alfred P. Sloan Foundation
- Alliance for Science and Technology Research in America
- American Association for the Advancement of Science
- American Institute of Chemical Engineers
- American Institute of Physics
- American Society for Biochemistry and Molecular Biology
- American Society of Civil Engineers
- American Society of Engineering Education
- American Society of Mechanical Engineers
- Building Engineering and Science Talent
- Business-Higher Education Forum
- Coalition of the Concerned
- Commission on Professionals in Science and Technology
- Council on Competitiveness
- Educational Testing Service
- Global Alliance
- Industrial Research Institute
- Information Technology Association of America
- Institute of Electrical and Electronics Engineers
- MentorNet
- National Action Council for Minorities in Engineering
- National Associate of Manufacturers
- National Consortium for Graduate Degrees for Minorities in Science and Engineering
- National Council of Teachers of Mathematics
- National Society of Black Physicists
- Partnership for Public Service
- Project Kaleidoscope
- RAND
- Sigma X
- Society for Advancement of Chicanos and Native Americans in Science
- Women in Engineering Programs and Advocates Network

Carol Muller's contribution to the Pan-Organizational Summit publication succinctly lays out the trajectory of women's participation in engineering and the kinds of strategies that have been used to increase women's access to engineering. Like many other authors, Muller's article indicates a need to focus our attention more upon institutional and systemic factors rather than on girls / women's "deficits." Muller's conclusions are echoed in the "WEPAN Position Statement" written by Rinehart, Metz and Woods in this same volume:

> Addressing issues of the engineering "culture" in the university environment is imperative to ensure the long-term success of women who enter the field. The difficulties women students experience in attempting to retain their intrinsic interest in science and engineering in environments that undercut their confidence, motivation, and sense of belonging in the field pose formidable obstacles to their completion of academic training and/or satisfactory performance in engineering careers. (p. 197).

National Science Foundation Publications of Interest

"New Formulas for America's Workforce: Girls in Science and Engineering" (NSF 03-208) is available on CD. The report provides details, including preliminary results and conclusions, about 211 grants awarded under the NSF's Diversity in S & E Education Program from 1993 to the present. The useful report includes helpful tips for parents, teachers (K-college), counselors, and education reformers about how to best encourage girls in pursuing S & E education and careers. The report is full of great ideas for programming and includes contact information for each of the grantees.

A new edition of NSF's invaluable publication ***Women, Minorities, and Persons with Disabilities in Science and Engineering, 2002*** was made available in 2003. This bi-annual publication has become THE source for information about the status of women in S & E with brief summaries of the current literature. The publication follows a pipeline perspective, with separate chapters about each level of education and the S & E workforce. Ample tables and graphs illustrate the trends in women's participation in S & E through 2000, the most recent year for which data are available. The publication can be ordered from the NSF or you can access it online by searching the NSF Web site at **http://www.nsf.gov.**

Conferences and Organizations

Members of SWE are already aware of and support the SWE national and regional conferences held each year, which provide networking and information exchange to women in engineering. Another important annual conference is held in June by the Women in Engineering Programs and Advocates Network (WEPAN). The WEPAN conference is an excellent forum in which program personnel compare notes on what works and what doesn't in programming to recruit girls and women into engineering. The conference brings together researchers, women in engineering program staff, members of industry and government, and foundation representatives for an intense networking and information sharing experience. We have provided a quick overview (see box on pag. 34) of the programs and research discussed at last year's conference. The 2004 conference will be June 6-8 in Albuquerque.

In addition to the annual SWE, WEPAN and regional SWE conferences, a number of other organizations sponsor conferences in an attempt to impact the diversity of the S & E pipeline. Your company or school may already send representatives to these conferences each year to recruit. If that is the case, this could be an ideal opportunity for you to become involved in recruiting underrepresented minority women to your company or school.

The Association for Women in Science (AWIS) works to accomplish equity for women in science, mathematics, engineering and technology on national and local levels. AWIS facilitates networking opportunities between women scientists through various activities and programs. In addition, AWIS publishes a variety of materials to inform girls and women about science programs and women's issues in the bimonthly ***AWIS Magazine***. AWIS membership is useful because the organization provides online job listings and information about scholarships, internships and mentoring. AWIS helps women stay aware of issues women and minorities face in science and what the organization is doing to address these issues. AWIS provides a support structure for women in science, one that already exists for men in this historically male dominated field. AWIS typically sponsors events in conjunction with the American Association for the Advancement of Science (see below). Visit AWIS on the Web at http://www.awis.org, where you can access a library of information and statistics about the status of women in S & E.

The **American Association for the Advancement of Science (AAAS)** serves over 10 million individuals and 265 affiliated societies and academies of science. The mission of AAAS is to "advance science and serve society," which the organization accomplishes through international programs, initiatives in science policy, and science education. AAAS held its annual meeting in February 2004 in Seattle, Washington. Next year's meeting will be held in Washington D.C., February 17-21, 2005. The multi-disciplinary conference conveys cutting-edge information across the spectrum of S & E in "accessible" presentations. In addition, at this past year's conference, hundreds of children and their parents were admitted free of charge to the exhibits area at the Seattle Convention Center for "Family Science Days." Visit AAAS at http://www.aaas.org.

The **National Association of Minority Engineering Program Administrators, Inc. (NAMEPA inc.)** works to provide quality services, information and tools in an effort to produce a diverse pool of engineers and scientists and consequently achieve equity in the workforce. The NAMEPA national conference was held in February 2004 at the Walt Disney World Resort in Orlando. The theme was "Beyond the Margin: Innovative Strategies for Diversity, Collaboration and Results." Next year, in late March / early April, 2005, NAMEPA and WEPAN will, once again, hold a joint convention in Las Vegas, Nevada. Visit NAMEPA at http://www.namepa.org.

The **Society for Advancement of Chicanos and Native Americans in Science (SACNAS)** works to increase Chicano / Latino and Native American students pursuing graduate education and advanced degrees in the science-teaching professions. SACNAS will hold its 2004 national conference in Austin, Tex. on October 21-24. The annual event provides an opportunity for students, faculty, and professionals in science and education to form networks and share accomplishments and challenges with one another. Visit SACNAS at http://www.sacnas.org.

The **American Indian Science & Engineering Society (AISES)** works to bridge science and technology with traditional Native values. Educational programs assist American Indians and Native Alaskans in their science, engineering and technology pursuits. The annual conference is held in late fall each year, with the 2004 conference set for November 11-14 in Anchorage, Alaska. For more information about the organization and its conference visit: http://www.aises.org.

The **American Society for Engineering Education** works to further education in engineering and engineering technology. ASEE accomplishes its goals through the promotion of excellence in instruction, research, public service and practice, worldwide leadership, and fostering the technological education of society and through providing quality products and services to ASEE members (see http://www.asee.org). The ASEE Annual Conference & Exposition will be held in Salt Lake City on June 20-23, 2004.

Dissertations

We reviewed 10 dissertation abstracts this year on topics related to engineering. Most of these dissertations rely upon local convenience samples, which makes it problematic to generalize from the results. At least half of these dissertation abstracts (Maye; Frye-Lucas; Ford; Williams; and Williams-Daugherty) explicitly mentioned that the study population involved African-American students.

Four other dissertations used various combinations of quantitative and qualitative methods to study issues of interest to women in engineering. Ito's ethnographic field study of children shows how race, class, and gender are related to the genres of edutainment and entertainment. Brunig's participatory action research with 10th grade girls documents the disconnect between what children learn about engineering and the perceived relevance of engineering to girls' lives. Ferrone studied first-year engineering students to document that professors were less likely than students to see students' team skills as effective. Finally, Suresh's use of surveys, students' transcripts, and interviews of University of Buffalo students who either persisted in or switched majors indicates that the motivation to succeed may be an important factor to understand why some students persist, even when they struggle with barrier courses.

Engineering and the Intersection of Sex and Race/Ethnicity

Every several years two organizations, WEPAN and NAMEPA, unite to have a joint conference. The conference brings together people engaged in similar work related to increasing the diversity of the U.S. engineering workforce. WEPAN, of course, focuses attention on women in engineering, while NAMEPA focuses on increasing access to engineering by underrepresented minorities. All-too-often, however, the experiences of women of color in engineering can be "missed" by members of both organizations. The joint conference is an opportunity for members of both organizations to not only learn from each other, but to ensure that minority women's experiences receive attention.

	U.S. Population Under 18	BS Degrees in Engineering, 2000
Hispanic	17.1%	7.0%
African-American	14.7%	5.4%
Asian-American	3.3%	12.9%
American Indian	0.9%	0.6%
Multi-racial	3.1%	N/A
Non-Hispanic White	60.9%	74.1%

In a 2001 presentation by the Engineering Workforce Commission, the significance of attention to ethnic diversity was highlighted by data showing the ethnic composition of the U.S. population under 18 contrasted with that of recipients of bachelors degrees in engineering in 2000 (see Table).

Locating data about the ethnic and sex composition of engineering — undergraduate students, bachelors, masters, or doctoral degrees awarded or of the engineering labor force — is difficult. In most cases, percentages of females, African-Americans and Hispanics are provided and occasionally data on Asian-Americans and American Indians, but it is rare to see tables or charts that break down these data by both sex and ethnicity simultaneously.

The NSF publication "Science and Engineering Indicators, 2002," provides only one such table based on data that is collected annually on first-year college students by the Higher Education Research Institute at UCLA. The intent to major in engineering varied by both ethnicity and sex. Asian-American males and females were the most likely to indicate an intention to major in engineering. Males within each of the six ethnic groups were much more likely than females within that same group to indicate that they intended to major in engineering, but the relative percentage of males and females varied quite a bit when looking at the ratios computed for each ethnic group. Among whites, Mexican-Americans, and Puerto Ricans, males were 6-7 times more likely to intend to major in engineering while at the other end of the spectrum, Asian-American and African-American males were just over 3 times as likely as their female peers to intend to major in engineering.

Percent of First-Year Students Who Intend to Major in Engineering, by Sex and Race/Ethnicity

	Males	Females	Ratio: Male/Female
White	15.3%	2.5%	6.1
Asian-American	22.1%	6.7%	3.3
African-American	15.2%	4.4%	3.4
Mex.-Am./Puerto Rican	16.2%	2.2%	7.4
Other Latino	15.3%	2.8%	5.5
American Indian	14.4%	3.1%	4.6

Clewell and Campbell provide a careful review of the literature to assess how far we have come in narrowing the gap between boys' and girls' achievement in the sciences and mathematics while simultaneously considering the evidence about the race / ethnicity gap in S & E. They note that while the gap in girls' and boys' preparation and retention in S & E have decreased, girls are still less likely than boys to select engineering and other physics-based-science fields in college. Clewell and Campbell suggest that increasing girls' interest in S & E and eliminating sexism are essential in increasing the number of girls who choose to pursue S & E in college. Women are also less likely to move on to graduate school and into the professoriate.

Clewell and Campbell warn that the race / ethnic gap between whites and Asian-Americans versus Hispanics, African-Americans and American Indians is quite persistent. They suggest that "improving the access of African-American, Hispanic, and American Indian girls and boys to advanced mathematics and lab-based science courses taught by knowledgeable teachers" and "having a high school curriculum of high academic intensity and quality" (p. 276) are essential steps in addressing the persistent ethnic imbalance in S & E.

In many cases, researchers examine sex differences within a particular ethnic group. For example, Eng and Layne presented a paper on Asian-American engineers based on data collected by SWE in 1992. Similar to other researchers, Eng and Layne show that early in Asian engineers' careers, men and women are at parity in terms of salary and work but over time, the gap between men's and women's rewards (pay, job satisfaction, work responsibility, etc.) widens. Also, Asian-American women engineers reported less satisfactory experiences at work than did non-Asian women engineers. In addition, Asian-American engineers of both sexes reported that the "glass ceiling" limited their career advancement into managerial positions.

Quintana-Baker analyzed the nationally-representative dataset called the "Survey of Earned Doctorates" to describe the persistent underrepresentation of Hispanics among those who received doctoral degrees in S & E between 1983-1997. Hispanics represented only 2.2 percent of doctoral recipients during that time, with Mexican-Americans — the largest Hispanic-origin subgroup — the most underrepresented Hispanic group. The life sciences were the dominant area in which Hispanics earned doctoral degrees. Hispanic women were slightly better represented in life sciences, engineering and physical sciences when compared to non-Hispanic women.

Brown reported results of qualitative interviews with 22 Hispanic students in southern New Mexico. Her study indicates a need to increase students' awareness of S & E careers, of teachers to emphasize that science and math are for all students, of schools to reduce class sizes, and for schools to encourage familial support of students' aspirations in S & E.

At the University of Maryland, College Park, Armstrong and Thompson report on the Prefreshman Academic Enrichment Program (PAEP), a 6-week summer program with math- and college-skills workshops for underrepresented minority and first generation college students in the life sciences. PAEP students were more likely than non-PAEP students to be retained in science.

Jayaratne, Thomas, and Trautman found that there were important differences in program efficacy between white versus minority participants. A careful evaluation of the University of Michigan two-week residential summer program for 8th graders, Summerscience for Girls, compared outcomes for 38 participants compared to 173 applicants who did not participate in the program. Surveys were administered pre-program, one year after the program, and again, four years after the program to determine whether the program had a positive impact upon girls' attitudes toward science and their aspirations for a career in science. While non-minority participants were found to have benefited, as expected, from the program, the opposite was the case for the minority students. Indeed, minority girls showed a decline in self-concept, indicated less interest in science, and did not hold strong science career aspirations as reported in the final surveys.

In order to evaluate the efficacy of an NSF-funded local systemic change initiative, Weinburgh randomly selected seven of the 70 participating urban, predominantly African-

The Literature Review Process

By Lisa M. Frehill, Ph.D.

Much of the literature published on women in engineering is flawed. The most important of these flaws is the use of convenience samples, which results in a lack of generalizability. Such samples often include students at colleges and universities — as when a researcher gives out surveys in class. Whether the results can be applied beyond the specific context in which the study was conducted is not taken into consideration, and this limits the value of the research. The participants in convenience samples are not selected at random nor are they selected with some specific purpose in mind. Even though such studies are flawed, we discuss some of the more interesting ones here.

Another serious flaw is low-response rate. Whenever a survey is conducted, it is important to record what percentage of the total surveys sent out were actually completed by the respondents. In general, a response rate of over 60 percent is considered acceptable, but 70 percent or higher is more desirable. The problem with a low-response rate is that there could be response bias: in other words, the people who completed the survey are somehow different than those who failed to complete the survey.

In general, research that has been subjected to some form of peer-review is considered better than research that has not been reviewed. Magazine articles, for example, vary greatly in terms of the quality of the research used by the journalist but may embody impressionistic explanations that are not supported in the social scientific research. On the other hand, peer-reviewed articles have been subjected to more scrutiny by anonymous peers who determine whether or not a piece of research has been conducted in accordance with the standards and principles considered acceptable within the discipline. These reviewers are best placed to decide the significance of an article and whether it merits publication or whether it has no major significance.

The Journal of Women and Minorities in Science and Engineering (JWMSM) continues to be the predominant location of most of the research on gender and engineering. Without this peer-reviewed journal, many of the articles that appear therein would be spread across many disciplines and, indeed, in some disciplines a specific focus on engineering may be construed as "too narrow" for the more important national journals to consider publishing. Because JWMSM articles must reach a cross-disciplinary readership, they are usually more readable than those that appear in many other academic journals. Therefore, if you are interested in the most current research on women and engineering, you might consider subscribing to this important journal. ■

American (90 percent or more of students) schools involved in a district-wide program. The program provided training (50 hours over one academic year) and science kits to 5th grade teachers. Weinburgh used a 25-item scale to measure students' attitudes toward science as a result of the program. She found that school-level factors were essential in the program's success. In those schools where the program was seen as important to the principal, where the principal supported teachers' efforts to improve the educational process, the program could be quite successful in improving students' attitudes toward science. On the other hand, in schools where the science-reform effort may have conflicted with other reform initiatives, where the principal was less supportive of teachers, where the principal was concerned with maintaining order as the primary goal, or where teachers were allowed to miss training (and, therefore, taught science without the kits), the program was far less effective.

The Sex Composition Effect

In the past several years, there has been much debate surrounding the question about single-sex education. A recent book by Salomone lays out much of the evidence in this debate to conclude that "the road to gender equity should be paved with diverse blends of same and different educational experiences" (p. 244). In other words, same-sex education may not be the best situation for all students, but there are some merits to ensuring that same-sex education is available as a choice for students at all levels (K-college). Indeed, Salomone describes the strong evidence supporting positive outcomes for women who attended women's colleges, especially among those who took women's-studies courses while at those colleges. Some evidence also suggests that minority males can benefit greatly from single-sex education within a mixed-sex environment (i.e., as a special class within a mixed-sex school). Finally, the evidence to date suggests that having separate math and science classes for girls within a mixed-sex environment may also be beneficial in encouraging girls to pursue college studies in S & E.

How does sex composition affect the work of project teams in engineering classes? Laeser, Moskal, Knecht and Lasich explored this question in an analysis of outcomes and group processes in a first-year design class (36 teams in the fall semester and 22 teams in the spring semester) at the Colorado School of Mines. They found that the gender composition of the groups — majority male, majority female, or sex balanced — had only a small effect on how the students interacted within the group and on the final grade for the group project. The most notable result was that the majority-female teams in the spring semester outperformed all other kinds of teams, including the majority-female teams in the fall semester on the final group report. Mixed-sex teams did less well during the fall semester than other teams. The lack of sex-balanced teams in the spring led the authors to speculate that perhaps first-year engineering students lacked the maturity to effectively work in mixed-sex teams without strong support and guidance from the instructor. This study did not find any notable differences in the approaches or interactions of group members on teams composed of both men and women.

Among the many programs discussed in the NSF's CD "New Formulas for America's Workforce: Girls in Science and Engineering," was a two-week summer program at Georgia Tech, called "Summerscape," that included both student and teacher components. The program provided new pedagogical skills to middle-school teachers and then involved middle-school students in workshops where the new skills could be tried out by the teachers. The program used various sex compositions in classes. The researchers found that boys tended to not read the instructions or demonstrate sufficient concern for the final product, while girls tended to be "too tied to the written rules" so that the "single-sex groups accentuated these tendencies and allowed students to stay within their behavioral comfort zone, leading to all-girl groups that were highly manageable and well-behaved and to all-boy groups that tried the patience of the teachers" (p. 39). The researchers concluded that: "Middle-school students should be given the opportunity to work in both balanced co-ed and single-sex groups." In this way, they get the "best of both worlds." In the single-sex groups, students focus more on the task, while in balanced groups they gain the skills and appreciation for working with members of the opposite sex (p. 39). Students reported that they preferred the co-ed classes.

Women's Impact on Engineering

Has feminism changed S & E? Has the movement of women into S & E had a discernible impact upon these fields? These important questions have been receiving quite a bit of attention in the past several years. Some observers have argued that diversity will be good for S & E because new perspectives will be brought to these disciplines that will help the United States maintain its competitive edge in a globalizing economy (e.g., Joseph Bordogna's address to the Engineering Societies Diversity Summit in September, 2003). Last year's literature review mentioned an important edited volume that examined answers to these questions in many fields of S & E (Creager, Lunbeck, and Schiebinger 2001). A number of 2003 articles dealt with these questions.

Gender-specific programmatic interventions, according to Darke, Clewell, and Sevo, have had an important positive impact upon girls' access to S & E. Darke et al. explain that the National Science Foundation (NSF) has supported more studies of women in science, mathematics, engineering, and technology (SMET) than any other federal agency, state or local government, or any private foundation. A study of NSF's Program for Women and Girls (PWG) conducted by the Urban Institute found that the PWG successfully effected both positive, short-term changes in human capital (e.g., skills and education) and long-term changes in knowledge and social capital (e.g., mentoring relationships, networking, etc.) to improve equity in S & E. They suggest, however, that standard measures of program outcomes are needed so that comparisons can be made across programs.

Rosser and Lane review the history and progress made by NSF in furthering programs for female scientists and engineers. The goal of such NSF programs is to "increase the participation of women and minorities and others underrepresented in science and technology." Programs over the last 25 years have been tweaked, changed, cancelled, or renamed in order to solve this complex problem. The programs were limited in their ability to accomplish this — fitting women into organizations designed with a 1950s labor force in mind was not effective — so NSF implemented the ADVANCE: Institutional Transformation Program to change institutional culture. As a relatively new program, it remains to be seen whether the program will be successful in bringing about broad-scale changes in colleges and universities to ensure gender equity, especially in the S & E fields.

The 1999 MIT report "A Study on the Status of Women Faculty in Science at MIT" had wide-ranging impact on women in academic S & E. The ADVANCE Program, discussed above, is one example of a programmatic effort that built upon the momentum of the well-publicized findings of the women faculty at one of the nation's premier S & E institutions. Lotte Bailyn, a professor at MIT's Sloan School of Management, writes this year about some of the lessons she and others have learned from the MIT study. The study, according to Bailyn, is quite significant because:

Eminent Women in Engineering

By Cecily Jeser Cannavale

In the past year there were a number of items published about eminent women in engineering. Two articles in the Bulletin of Science, Technology, and Society, *were written by well established women who explain what they have learned over time about science and engineering The first article was by Mildred Dresselhaus, Ph.D., who was a graduate student at the University of Chicago in the 1950's. When she was in the program, there were only 2-3 percent female graduate students nationwide in physics and engineering. Today 15-20 percent of graduate students in physics and engineering are women, but women are experiencing difficulty in obtaining faculty positions. Dr. Dresselhaus found personal encouragement, mentoring, networking, leading focus groups, attending conferences and speaking about the issues surrounding women in science and engineering has helped women make strides in these fields .*

Lilli S. Hornig, Ph.D., entered Harvard graduate school in chemistry in 1942. She has seen gains in science and engineering, but remains concerned that many issues have not yet been addressed She became the founding director of Higher Education Resource Services (HERS) at Brown University. HERS mission is to improve the status and opportunities of academic women through research, advocacy, and a variety of training programs. Because there are too few female-tenured faculty, funding is needed to improve and facilitate early career support for women scientists.

Another eminent woman engineer in the news this past year was Sally Ride, Ph.D., the first U. S. woman astronaut, who is now a physics professor and the chief executive of Imaginary Lines, Inc. The company was formed to sponsor science and technology activities for girls in order to keep them interested in science and engineering. The company focuses on middle-school, the time of initial separation from sciences for females. The company sponsors the Toy Challenge, where girls design a new toy or game and then develop a prototype. This event also gives girls the chance to meet female role models.

An interdisciplinary symposium is held every year at the University of California, San Diego in honor of Dr. Maria Goeppert-Mayer. When Dr. Goeppert-Mayer won the Nobel Prize in 1963 the local headlines read, "La Jolla mother wins Nobel Prize." Even with a Ph.D. in physics, published papers, and the development of nuclear structure, Johns Hopkins, Columbia, and the University of Chicago refused to award Dr. Goepper-Mayer a professorship, as they had done for her husband in the 1930's, 40's, and 50's. These institutions did grant Dr. Goeppert-Mayer access to physics laboratories, where she conducted her research without pay. Her first paid professorship was in 1959 at the University of California, San Diego.

The SWE Magazine *this year featured many inspirational stories about eminent women in S & E. They included:*

Winter 2003

- *Bonnie J. Dunbar, Ph.D.*
- *Lillian Moller Gilbreth, Ph.D.*
- *Grace Murray Hopper*
- *Margaret Law*
- *Natalie Givans*
- *Ann Rincon*
- *Rhonda Germany*
- *Peggy Whitson, Ph.D.*

Spring 2003

- *LeEarl Bryant*
- *Diane Dorland*
- *Susan Skemp*
- *Terry Helmlinger, P.E.*
- *Patricia Galloway, P.E.*

Fall 2003

- *Denice Denton, Ph.D.*
- *Ilene Busch-Vishniac, Ph.D.*
- *Linda M. Abriola, Ph.D.*
- *Christina A. Ehlig-Economides, Ph.D.*
- *Mary Jane Irwin, Ph.D.*
- *Elaine Soran, Ph.D.*

> Before all this, gender had been silenced at MIT, as at most universities. Women might occasionally talk to each other about these matters, but even that was unlikely. Each person assumed that what happened to her was entirely due to her own behaviour and thus must be deserved. . . . What is now accepted . . . is that there are subtle gender dynamics that contribute to the leaking pipeline and to the more negative experience of the women senior faculty in comparison to their male colleagues. (p. 149)

In other words, by paying attention to the status of women, and carefully collecting both quantitative and qualitative data, the women at MIT came to realize that they shared a disadvantage because of their sex. And, via the collective effort of producing the report, they were able to bring about important, positive changes in their work situations.

Ferreira reports results of a survey administered to a convenience sample of 132 students in biology and chemistry classes at a large research university to show that there is no substantial difference in how women and men students perceive science: Both sexes see science as competitive and narrowly focused with a belief in objectivity. Female students, however, did perceive that there was a conflict between having a career in science and having a family. Similar findings were reported by Sears, who analyzed survey responses of 258 students (from the 1,105 that had been notified about the survey this response rate of 23 percent is unacceptable). Responses revealed that female students were more likely than male students to feel geographically constrained by family ties and to express concerns about balancing a career and a family. These women were also more likely to downgrade their career aspirations during graduate school. Given the low response rate, it is quite likely that this survey suffers from response bias, that is, it is likely that people who were experiencing conflict with these issues were more likely than others to actually complete the survey, leading to skewed results. Sears concluded that the culture of science must be changed to accommodate the career / family aspirations of young women.

Riley's reflective article on teaching thermodynamics using liberative pedagogy at Smith College's relatively new engineering program — the first at an historically all-women's school — takes another approach to answering the question about whether women have affected S & E. In Riley's small class (less than 30 students) she was able to use strategies discussed in the pedagogy literature such as: connecting the class material to life; encouraging students to be authorities in the classroom and taking responsibility for their own learning; respecting students in the learning process; and reflective critique of science, including attention to ethics and diversity. Riley reported that limited time is the major barrier to implementing liberative pedagogies in engineering classrooms.

Cassidy and Cook-Sather wrote another interesting article about new modes of teaching in S & E classrooms. The authors teach at a women's college. Through the dialogue between the two educators and conversations with their students, they found that collaborative learning allowed students to make their own connection with the course content. This is consistent with other research that indicates that it is especially important for female students to see the real-world application of the work they do in classes.

Collaborative learning and alternate styles of teaching may be essential in convincing young women to pursue S & E at the collegiate level. Carlone reports on an in-depth ethnographic study at an upper / middle-class suburban school (84 percent white). She used extensive observation, interviews with the classroom physics teacher, and focus groups with the female students to explore girls' ideas and attitudes about physics. She found that even though the teacher actively used strategies of gender inclusivity and ample hands-on methods, the girls still did not intend to pursue physics at the collegiate level. A subtle but important feature of the teacher in this case was that he saw himself as simply conveying information rather than as someone who needed to recruit students into physics. As a result, the girls came to see him as an expert authority and to see physics as interesting, but not necessarily something that they wanted to pursue any further. The author suggested that having teachers with a stronger, integrated, career-focus in the classroom — that is, including content about the jobs, careers, and education opportunities in a particular field — may be an important way to recruit more girls to fields like engineering.

These findings are echoed in a study of physics education in Israel. Twelve years' worth of scores on matriculation exams from more than 400 schools were analyzed by Zohar and supplemented with interviews with 25 girls and 25 boys. Zohar found that boys' exam scores were on average higher than girls' scores but that the grades given by teachers were higher for girls than boys, on average. Two important factors had an impact upon girls' experiences of physics: (1) excessive competitiveness and (2) lack of teaching for understanding. Again, these findings point to the need to increase collaborative and hands-on learning in classes like physics in order to increase women's participation in physics-based fields.

Stepulevage, Henwood, and Plumeridge's qualitative study focused on 11 women's experiences in three introductory IT classes at the University of East London. The 11 students matched the institutional profile: a majority (9 or 11) were mature students (22+), nearly half were Afro-Caribbean, Black Caribbean or African; and half were middle class and the other half were working class. The authors examined whether same-sex courses provided a more positive context for women to develop skills and knowledge of IT than mixed-sex classes. All 11 students were enrolled in a specific section of a computer class that had an additional 10 female students. Formal interviews and informal chats indicated women-only hands-on IT courses are not necessarily seen as beneficial to students. Race and previous experience in IT were important factors. This research highlights the need for a more complex understanding of how setting and context assist women in acquisition of technological skills.

Engineering Pedagogy, In General

Many advocates believe that new approaches to teaching engineering are an important way to insure gender equity in the field. Research on differences in women's and men's learning styles and engineering educators' desire to respond to employers' needs have both resulted in many innovations in teaching engineering.

Can alternative instructional methods retain students "at risk" in engineering? Lim, Chua, and Wee studied the deployment of a number of interventions with 139 students in a mechatronics science class at the University of Singapore. These strategies included: incorporating subject relevance; establishing connections among topics; recalling and applying prior knowledge; introducing teacher model and peer model in solving design problems; a learning contract among students; fostering team work and support; providing feedback on progress; rewards in terms of grading; using computer modeling; simulation tools; and giving written assignments. The study concluded that instructional intervention policies did bring about significant changes in self-efficacy and intrinsic motivation among students.

Mbarika, Sankar, and Raju discuss results of a survey that evaluated the perceptions of management and engineering students at a major university in the southeastern United States. The students used a multimedia unit that provided information on a problem that engineers and managers had to solve at the Crist Power Plant in 1997-1998. Videos and a CD-ROM documented the solution process — including the use of the "Expert Choice" decision software program — that were to be used by the students in solving the same problem. Two undergraduate business and one undergraduate engineering class used the CD-ROMs in a computer lab to study and model the decision process used in the original real-world problem. The authors found that women were more responsive than men to the learning-driven factors of the program: that it enhanced their learning and increased their interest; that it challenged them; and that they were able to learn from others. Men, on the other hand, reported more so than women that they liked the content-driven features of the program: they were provided with sufficient data; the data were located in an easily-accessed location and easy to use; and that they were able to complete their task in a timely manner.

Brent and Felder describe the SUCCEED project at eight institutions in the southeastern U.S. SUCCEED stands for "Southeastern University and College Coalition for Engineering Education." This 10-year NSF-funded project (1992-2002) was responding to employers' complaints that engineering graduates lacked critical and creative thinking skills and needed to be more diverse. The teaching innovations included: an integrated first-year engineering curriculum; instructional modules and delivery tools for technology-based courses; programs to promote writing and design across the curriculum; and programs to promote the recruitment and retention of women and minorities. According to a survey of the 1,621 faculty participants conducted in 1999, high levels of satisfaction with the program were reported by the faculty who answered the e-mail survey and who had taught undergraduates in the past three years. The 41 percent response rate likely reveals some response bias: with programs like this, people who would report negative findings are unlikely to respond at all under the idea that "if you don't have something good to say, then don't say anything at all." A majority of the faculty who answered the survey also reported that they were using active learning, team-based learning, writing instructional objectives, and giving writing assignments in their classes. No data related to students' performance were presented.

Bell, Spencer, Serman, and Logal present results of a psychology experiment with 29 women- and 54 men-engineering students who had a "high grade point average" and claimed they were "good in engineering" and that it was important to be good in engineering. The students were split into three groups and given the Fundamentals of Engineering Exam with one of three kinds of instructions given. Average scores by gender and instructions are shown in the chart on the top of pg. 31. The only significant difference in average scores between males and females was when the first instruction was given. Scores for females and males were not significantly different when they were given either instructions #2 or #3.

The Academic Engineering Pipeline

The pipeline is commonly applied as a metaphor to understand how young people move through the educational system toward

INSTRUCTION	Average Score Females	Average Score Males
1. This test has been shown to be an excellent indicator of engineering aptitude and ability in a large number of settings across a wide spectrum of students. This test is especially effective at assessing people's engineering limitations in problem areas.	9%	30%
2. The problem set you will be working on today was specifically designed to present you with problems varying in their degree of difficulty so that we might be able to get an accurate picture of which problems should be included or excluded on our future version of this test. We are not interested in your overall score on the test, and, in fact, the problems are in such an early state of development that we could not say what a particular score would signify.	21%	21%
3. This test has been shown to be an excellent indicator of engineering aptitude and ability in a large number of settings and across a wide spectrum of students. The test is especially effective at assessing people's engineering limitations in problem areas. Prior use of these problems has shown them to be gender-fair — that is, men and women perform equally well on these problems.	36%	28%

careers in S & E. However, in a comprehensive book by Xie and Shauman, 11 large national data sets are used to demonstrate that the pipeline metaphor is no longer useful in understanding how women move into and out of S & E careers. Instead, Xie and Shauman take a life-course approach to document that people come into S & E from diverse points, at diverse times in their lives and that exits from S & E are similarly diverse. They conclude that just as we have witnessed a dramatic narrowing of the gap in girls' versus boys' science and mathematics preparation prior to college and the dramatic increase in women's representation in some fields of science, so too will we eventually see such changes in the physical sciences and engineering, the two fields in which women are still a minority.

Ayalon presented results from multinomial logits on data from 6,319 applications to Tel Aviv University, an elite institution in Israel. The analyses showed that women's underrepresentation among applicants to mathematics-related fields was not explained by math background in high school. Increased math and science courses taken in high school did narrow the sex gap in applicants to other selective programs — e.g., medicine and law — but not necessarily mathematics-based fields like engineering.

General attitudes toward science and engineering are becoming an important area of concern for researchers, government agencies, and advocates of women in engineering. Increasingly, observers are commenting on the negative public images of science as one possible explanation for why fewer women pursue S & E careers than do men. Osborne, Simon and Collins present a thorough review of the literature on attitudes toward science, covering research from the past 20 years. The authors emphasize the need to determine strategies to make school science engaging for students as one way to improve young people's attitudes toward science.

Girls' persistence in pursing a career in S & E was studied by Mau using data from the National Educational Longitudinal Survey of 1988. This large, nationally-representative survey was initially given to a random sample of U.S. 8th graders in 1988, with subsequent follow-ups administered every second year through 1994. Mau found that among those students who had indicated an aspiration toward a S & E career as 8th graders in 1988, by 1994, the males (26.5 percent) were more likely than females (12.1 percent) to be pursing a S & E major in college. Mau indicated that an individual's perceived ability in math and academic proficiency were the principal factors in determining persistence in the S & E pipeline.

Attention to the special issues of students in rural areas has not often been reported in the literature on S & E. Rural areas often face a range of problems in providing quality education. Ginorio, Huston, Frever, and Seibel report on the valuable lessons they learned in implementing the Rural Girls in Science project. The program was highly effective in helping the girls to:

- Gain confidence in their science skills
- Increase self esteem through public speaking and other challenging activities
- Maintain interest in scientific careers and courses of study
- Realize they are not "weird" for liking science

The program was not as positive for teachers and counselors as they tried to implement changes in their rural schools. Teachers wanted to do more in terms of changing curriculum in the classroom, but time and resources were limited. Many of the teachers had second jobs that they could not afford to give up, so their time at the school was limited. Teachers also had to focus upon state standardized tests so that their students would succeed on those tests. Counselors served two to three schools, which limited their time at each school. Most of their time went toward discipline problems or the outstanding students, so that they did not have the time to spend with the girls from the program. In order to address these problems, Ginorio suggested that there is a need to

(1) implement parental involvement activities and (2) increase teacher compensation for being involved in the program.

Networking and mentoring have long been cited as important in helping people succeed in their education and careers, especially in cases where people may feel out of place among their peers — such as women in engineering. Kleinman joined an unmoderated online group called OURNET and describes the benefits of participating in this group in an article published this past year. She found that OURNET is an inexpensive way to create a community that is accessible any time and that it allows for networking and the spread of knowledge among members.

Mary Frank Fox's chapter "Gender, Faculty, and Doctoral Education in Science and Engineering" appeared in a new book titled ***Equal Rites, Unequal Outcomes: Women in American Research Universities***. Fox reports the results of a mail survey of 1,215 faculty conducted in 1993-94. The survey had a good response rate of 69 percent, which means that these findings can be said to apply fairly well to faculty nationwide in these kinds of departments. In this survey, faculty members were in one of five kinds of doctoral-granting departments: computer science, electrical engineering, chemistry, microbiology, or physics. Her findings confirm some of the anecdotal evidence concerning the work lives of women faculty. First, women faculty serve as research advisors for a larger number of women students as compared to men faculty and among those involved in team research, women faculty have more female students on their teams. Second, women faculty are more likely than men faculty to have more structured interactions with their students — that is, they schedule regular appointments and establish mentor-mentee relationships while men are more likely to say that they have informal interactions with their students. Women faculty were also more likely than men to stress the importance of providing multiple forms of help to their advisees. Finally, women faculty recognize, more so than their male peers, that success in S & E has to do with more than simple hard work and ambition, that there are a range of factors that can influence an individual's success — one of these factors being alignment with successful faculty.

Workplace Issues

If you are concerned about the glass ceiling or just not sure whether things that happen at your workplace are "right," you might want to take a look at a book by Gregory titled, ***Women and Workplace Discrimination: Overcoming Barriers to Gender Equality***. Gregory compiles a wealth of material on still-pervasive sex-based discrimination in hiring, promotion, treatment, and termination at various kinds of U.S. workplaces. The author provides details of recent cases to illustrate the mechanisms of discrimination as well as the standards of evidence and proof for these cases. The book has extensive material on sexual harassment and material on related forms of discrimination such as age, race / ethnicity, women with children, and pregnant women. This is a readable, accessible book. Even if you don't think that you have experienced discrimination because of your sex, race, age, sexual orientation, parenting or marital status, this book will make you aware of how these factors may impact your rights to equal pay and opportunity. As the book points out, a small "trivial" gap in pay early in your career can become an enormous gulf by the time you reach your "golden years" of retirement.

Duong and Skitmore report results of a survey from the Australian Institute of Project Management to document the persistence of anti-female discrimination in engineering project teams. The buddy system, openly prejudicial beliefs, and gender stereotypes make women's work lives harder than those of their male peers. Ironically, the authors found that men were more likely to be supportive of women than were women to be supportive of each other. Response rates were low, indicating a possibility of response bias: of the 90 men, 21 responded and of the 90 women only 36 responded to the survey.

Trauth, Nielson, and von Hellens' qualitative in-depth interviews with 20 Australian women working in a variety of sectors of IT examined how women lacked formal qualifications in IT, as well as their underrepresentation in IT management, and the idea that successful women in IT prioritized work over family concerns. Three types of women emerged in the study: those unfazed by being a woman in a male-dominated field and who denied that the playing field was uneven; those who accepted the uneven playing field; and those who have experienced the uneven playing field and are willing to speak out about it. This interesting article does a nice job of describing the masculine culture, anti-female discrimination, and the various ways that women manage to succeed in IT within this environment. In addition, several respondents had worked in IT in countries other than Australia, so they offer interesting perspectives on how the government and companies can better support women's careers in IT via stronger societal support for childcare infrastructure.

Olson used the 1995 "Survey of Doctorate Recipients" data (a large, nationally-representative dataset) to document the factors that account for differences in men and women faculty members' success in academia. She ran logistic regression models on the likelihood of

WEPAN CONFERENCE REPORT

by Jammie Benton Speyer

The 2003 WEPAN Conference was held in Chicago, Ill. on June 8-11. Paper and session topics focused on a variety of issues affecting the recruitment and retention of women in S & E fields. Themes of interest included the progress of ADVANCE Programs for Institutional Change, careers in science and engineering (S & E), S & E education at the k-college level, and mentoring.

***ADVANCE Programs** for institutional change have made considerable progress in the area of gender equity for engineering faculty. The University of Washington's Transitional Support Program (TSP) has assisted faculty in meeting the demands of family and professional life during times of transition through grants that can be used to hire graduate students or pay for course release. This is particularly beneficial to women, who are more effected than men by family transitions. During the first year of its NSF grant, the University of Wisconsin-Madison ADVANCE Program created a successful multi-disciplinary research organization — the Women in Science & Engineering Leadership Institute (WISELI). WISELI evaluates current campus initiatives, conducts research projects, and evaluates the ADVANCE program and the effectiveness of its initiatives. The University of Puerto Rico at Humacao was also awarded an NSF ADVANCE grant in 2001. Since that time, the program collected baseline data, implemented programs and activities for women students and faculty, provided training for faculty and administrators, and implemented an action plan to increase the advancement of women faculty.*

A variety of programs assist women and minorities in achieving success in the S & E workforce. Research on careers in S & E was of the utmost importance at the WEPAN conference in 2003. Papers focused on:

- ▲ ***African American-women in faculty positions** at research institutions (Lucero),*
- ▲ *The first **International Conference on Women in Physics** held at the UNESCO headquarters in Paris, France (Li and Hartline),*
- ▲ *The role of **Boeing-Kansas** in attracting more women and minorities to engineering in order to diversify the workforce (Whitlock and Arnold),*
- ▲ ***Workshops** to provide advice and training on career success for women in S & E professions at Argonne National Laboratory (Laurin-Kovits, Li, Washington, Gohoure; Hartline, and Bhattacharyya), and*
- ▲ *The **Women in Technology initiative** in Maui, Hawaii aimed at increasing the "home-grown" and particularly female, high tech workforce (Mecum and Wilkins).*

These endeavors all recognized the importance of networking and mentoring, as well as the need not only for recruitment, but retention of women and minorities in S & E.

K-12 intervention and outreach programs are a popular way to introduce young people, particularly young women, to STEM education and careers. Intervention programs aimed at increasing the participation of women and girls in S & E must be informed by media images of women engineers and scientists, and how these images affect the career choices of young women (Streinke). Various initiatives work to counter the stereotypical images of science and technology young people face each day, these include:

- ▲ *The **Girls Reaching Our World (GROW)** project at Kansas State University (Arnold, Franks, Dyer, Montelone, and Spears);*
- ▲ ***The Women in Science and Engineering Saturday Academies** at Arizona State University (Irman, Anderson-Rowland, Castro, and Zerby);*
- ▲ *The **Women in Engineering Technologies Institute** at Sinclair Community College's two-week summer program for high school students (Shuler and Rittenhouse);*
- ▲ *The **Enrichment Mini Course (EMC)** at several colleges and universities around Ottawa, Canada (McDill);*
- ▲ ***Exploring Physics, Families Exploring Science and Technology (FEST)**, and **Saturday Scientist**, at the University of Missouri (Chandrasekhar and Geib);*
- ▲ *Girl Scout Saturday Workshops at Penn State (Knobloch);*
- ▲ *The **Science and Engineering for All** program at Montana State University (Gallagher and Larson).*

Institutions have been working hard to

individuals occupying different statuses within academia: full professor; senior faculty; tenured; or tenure track. Using a number of institutional (e.g., type of institution, prestige of their Ph.D. department, employing department prestige, etc.) and individual-level variables, (including marital and parenting status, years since Ph.D., productivity measures, work activities, etc.), she ran separate models for men and women. She shows that men are advantaged in academia. Women who have children are disadvantaged while men who have children are advantaged. Men in academic employment in 1995 were more likely than women to have a spouse who was not employed — 93 percent of academic women's spouses were employed while less than 70 percent of academic men said that their spouse was employed.

Ginther also used data from the Survey of Doctorate Recipients — from the 1973-1997 dataset — to show that there is a persistent gap in salaries between female and male academic scientists and engineers. The gap existed throughout the time period, 1973-1997, and at all ranks of academia.

The Digital Divide: Computing and Information Technology

Jobs that rely upon a knowledge of computers and use of information technology (IT) are becoming more common the world-over. These issues are also critical to engineers. The digital divide is a term used to refer to the gap between those who have greater and those with lesser access to computers and information technology: men versus women; upper and middle class versus working and lower class students; rich versus poor nations; whites versus underrepresented minorities; urban versus rural students; etc. If the jobs of the future require IT and computer skills, then it is imperative that all young people can acquire these skills.

Van Dijk and Hacker use Dutch and U.S. Census Bureau data to construct an analytic framework for understanding the digital divide. The study determined that significant gaps exist in both nations based on gender, income, ethnicity and education level, but that the relationships among these variables and access to the information superhighway are complex.

Looker and Thiessen document the presence *create an inviting climate for women and minorities in S & E education at the college level. A variety of programs attempt to ensure women undergraduate and graduate students are supported in their education, such as:*

▲ *The* ***WiSE Living and Learning Community*** *at Iowa State University (Chrystal),*

▲ *The* ***Summer Research Experience for Women Undergraduates (REWU)*** *at the University of Cincinnati (Purdy, German, and Ghia),*

▲ *and the* ***Women in Science and Engineering Residence Program*** *at the University of Michigan (Hathaway, Loesch, Sharp, and Davis).*

These programs facilitate academic confidence and self-efficacy, and provide students with a variety of mentors. Overall, they appear to be successful in that students who participate have increased GPAs and retention rates compared to those who do not participate.

Gender-equity goals cannot be met if faculty are not aware of the problem. Therefore, a number of initiatives have been instituted to increase awareness of gender equity and its underlying causes, such as the NSF-funded project at Texas A & M titled "Changing Faculty Through Learning Communities" (Covington and Froyd). Additionally, faculty forums have been developed to enable networking and discussion of issues of gender equity in order to attract and retain women in S & E. One example of such a forum is the Leveraging Experience to Accelerate Progress (LEAP) conference organized by the Intel Corporation and Tufts University (Layne, Knight, Cunningham and Barton). Another example of an effort to recruit and retain women faculty is a proactive policy, instituted by the faculty of applied sciences and engineering at the University of Toronto (Holmes and Escedi).

Mentors and networking *provide invaluable systems of support. Many programs have integrated aspects of each of these to improve the climate for women students and faculty. Perhaps the most popular mentoring initiative is MentorNet. MentorNet is a structured, online mentoring program which pairs female undergraduate and graduate students in STEM fields with professionals working in industry and government (Alapati, Fox, Dockter and Muller). Qualitative analysis indicates the program is beneficial for both mentors and protégés (Chin, Dellagianrino, Midelford, Vinarcik, Ziaba, and Miller). Mentors indicate it is a learning experience and an opportunity to share what they have learned with a younger generation. Protégés benefit from MentorNet's encouragement and networking opportunities and from having a role model, particularly a woman, which is especially important for those participants who may not be exposed to many women in their S & E field (Heaton). Although self-selection bias makes evaluation problematic, MentorNet has proven beneficial in various universities' programs of recruitment and retention of women as follows:*

▲ *Penn State and MIT (Acar, Rung and Staton)*

▲ *IT Scholars Program at the University of Michigan (Koch; Forsythe and Davis)*

Other mentoring initiatives may also be successful, including those that pair graduate and upper level undergraduate students with first year women in STEM fields such as the RISE program. Rise is a two-tiered initiative that provides mentoring and networking opportunities to first year students and students in the middle of their undergraduate program to increase retention (Schmidt, Smith, Schmidt and Vogt). Other programs mentor women transferring from community colleges to four-year universities. The University of Arizona has implemented a program that has been successful in assisting transfer students with "transfer shock" (Reyes, Powell, Aronsen; and Goldberg). All of these initiatives indicate that mentoring is an ideal tool that may retain women in S & E fields. Mentoring connects participants to the wider community, provides role models, assists with networking and provides guidance and encouragement.

All of the papers presented at the WEPAN 2003 conference are available by going to the WEPAN Web site: ***http://www.wepan.org.*** ■

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of a digital divide between urban and rural students and between those whose parents have higher or lower levels of education. They use data from three pan-Canadian surveys, including the Youth in Transition Survey (YTS), the General Social Survey (GSS), and the Second International Technology in Education Survey (SITES). A subset of 1,001 individuals was examined from the GSS, approximately 350 from the YTS, and 589 schools were included in the SITES data subset. Students with parents who did not have a high level of education were less likely to utilize information computer technology (ICT). Students in rural locations had less access to ICT at home, but just as much exposure, if not more, to ICT at school as compared to urban students. Very few gender differences exist with regard to use of ICT. Males are more likely to engage in computer programming, to use spreadsheets and desk top publishing based on interest, while girls are more likely to use ICT for study needs.

Adams, Bauer, and Baichoa examined enrollment information for the University of Mauritius to determine the numbers of women in computer-related programs. Mauritius women enter such programs in proportion with the general population, in the absence of programs aimed at recruitment and retention. The authors suggest a number of fundamental cultural differences that may explain the high numbers of women in Mauritius studying computing. For example, women in developed countries have other choices besides computing. The authors also speculate that the single-sex secondary schools that students in Mauritius attend — which is where they begin to learn computing — provide a context in which women simply fail to see computing as a masculine endeavor.

Johnson interviewed 50 students and office workers in Singapore and 36 in Kuala Lumpur, Malaysia to study how technology could be used in these nations to mitigate poverty and in the modernization process. Johnson asked about various types of technology: cell phones, computers, e-mail and Internet functions. The study concluded that the women and men respondents in Singapore used technology in similar ways and have similar access to technology. Women in Malaysia, however, were less comfortable using technology, in part due to the emphasis their culture places on modesty. For example, they were less likely to explore the Internet than their male counterparts for fear of stumbling upon inappropriate Web sites.

Moody, Beise, Woszczynski, and Meyers examined how the academic community has responded to requirements for a diverse IT workforce. Current academic research on gender, age, ethnicity, disability and diversity of perspectives in IT was thoroughly reviewed. The authors concluded that little, if any, research has addressed IT recruitment and management for diversity despite the fact the effects of diversity on team processes and performance can and does impact organizational outcomes. Additionally, little research focuses on gender, ethnicity, age or disability within the IT workforce.

Wilson, Wallin, and Reiser examined whether socio-economic factors explained racial, geographic and gender divides in computer technology usage. Questionnaires were administered to a random sample of 522 people in North Carolina by phone (52 percent response rate). The study concluded that African-Americans, rural, and female respondents were less likely to have home computers, and less likely to have Internet access. The majority of these respondents, particularly African-Americans, knew of public Internet access. Differences were mainly due to income and education. The racial / digital divide, however, was the strongest and could not be fully explained by social and economic variables.

Colley examined gender differences in perceptions of computing at school among boys and girls in the early and late stages of secondary education in the United Kingdom. Questionnaire data were collected for convenience samples from three schools of two age groups: the younger age group, 11-12 years of age with 95 females and 118 males; and an older age group, 15-16 years of age, with 116 females and 127 males. Skill levels and tasks performed with the computer varied by age, which affected perception of computing. For example, older students were more likely to use e-mail than were the younger students. Gender differences also varied by age. Younger boys focused more on play than younger girls, while younger girls focused more on the utility of computing to complete specific tasks. Older girls were not too keen on the database and spreadsheet applications but liked to use the computer for e-mail. Older boys were more likely to use the Internet.

Duffy and Walstrom examine changes in three aspects of student's attitudes toward computers over 13 years via a questionnaire administered during the first week of classes to students enrolled in a business information systems class at Illinois State University (i.e., convenience samples). Data were collected at three times: in 1988 there were 212 participants; in 1995 there were 271; and in 2001 there were 400 participants. Duffy and Walstrom concluded that over time students have become more pessimistic about the impact of computers upon students' quality of life. The perceived benefits of using computer technology are decreasing while the perceived costs to freedom and privacy of using computer technology is increasing. With regard to gender, each year slightly more than half of the respondents were male but the authors did not discuss any substantial gender differences.

Editor's Note: ***For the complete list of references cited in this review please visit the SWE Web site,*** *www.swe.org/mag* ***Due to space limitations they are not included in the print version of this review.***

Lee examined data from surveys administered to three cohorts of students (1998, 1999, and 2000) at the beginning and the end of the academic year to determine how participation in a program affected self-reported IT skills and attitudes at Hong Kong University. There were low response rates and the year-end surveys were not matched to the beginning-of-year surveys. Although female students rated themselves as less competent and knew fewer software packages than their male peers claimed, over time, the gap between females and males on these metrics declined markedly. Results of an optional IT proficiency test were also examined. Women were less likely than men to take this exam and those who did take the exam made lower average scores than did men who took the exam.

Brown et al. examined the academic and technology related self-efficacy skills of 234 high school students participating in a six-week GlobalEd Project — an Internet based simulation of negotiations on a variety of international policy issues. Pre- and post-test surveys (58 percent response rate) were administered to students participating in the project. There was an equal distribution of males and females in grades 9-12 in Connecticut and Massachusetts who completed the surveys. Girls had higher academic self-efficacy than boys. Boys had higher knowledge scores than girls, but both girls' and boys' knowledge scores increased significantly between the pre- and post-tests. Boys also reported higher computer self-efficacy at both the pre- and post-tests but this level did not change as a result of the project.

How does the digital divide play out among school teachers and administrators? In a study of teachers, technical support staff and administrators in 30 schools in five Canadian provinces, Jensen and Rose found that males were seen as technical experts in using computer technology in the classroom while women were not seen in the same way, even when they possessed computer skills. Women who possessed technical skills were seen as liaisons between the technology and the classroom. As a result, men filled the IT positions in the schools and a climate that saw women not as technology users was produced. ■

References

(2003). "AWIS Media Alert: Women in Science Leadership Skills Workshop and Annual Networking Luncheon." AWIS.

(2003). "Engineering World." SWE 49(1), 70-71.

(2003). "Engineering World." SWE 49(2), 60-62.

(2003). "New Formulas for America's Workforce: girls in science and engineering." NSF 03-207.

(2003). Unequal Rites, Unequal Outcomes, Women in American Research Universities, Kluwer Academic Publishers.

(July, 2003). "Women, Minorities, and Persons with Disabilities." National Science Foundation, Arlington VA.

Acar, N., Rung, C., and Staton, B. E. "Campus Success Stories." WEPAN 2003 Conference, Chicago, Illinois.

Adams, J., Bauer, V., and Baichoo, S. "An expanding pipeline: Gender in Mauritius." Proceedings of the 34th SIGCSE Technical Symposium on Computer Science Education, Reno, NV, 59-63.

Alapati, M. R., Fox, S. J., Dockter, J. L., and Muller, C. B. "Mentornet in Depth; Structured Mentoring Practices." WEPAN 2003 Conference, Chicago, Illinois.

Arnold, S., Franks, S. E., Dyer, R. A., Montelone, B. A., and Spears, J. D. "The Grow Project: 'Show Me the Money!'" WEPAN 2003 Conference, Chicago, Illinois.

Ayalon, H. (2003). "Women And Men Go To University: Mathematical Background And Gender Differences In Choice Of Field In Higher Education." Sex Roles, 48(5-6), 277-290.

Bell, A. E., Spencer, S. J., Iserman, E., and Logel, C. E. R. (2003). "Stereotype Threat and Women's Performance in Engineering." Journal of Engineering Education.

Brent, R., and Felder, R. (2003). "A model for engineering faculty development." International Journal of Engineering Education, 19(2), 234-240.

Brown, S., Boyer, M., Mayall, H., Johnson, P., Meng, L., Butler, M., Weir, K., Florea, N., Hernandez, M., and Reis, S. (2003). "The GlobalEd Project: Gender Differences In A Problem-Based Learning Environment Of International Negotiations." Instructional Science, 31(4-5), 255-276.

Brown, W. S. (2002). "Hispanic Students Majoring in Science or Engineering: What Happened to their Educational Journey?" Journal of Women and Minorities in Science and Engineering, 8(1), 123-148.

Brunig, M. (2003). "How Young Women Come To Know Engineering." DAI, 64(5A), 175.

Carlone, H. (2003). "(Re)Producing Good Science Students: Girls' Participation in High School Physics." Journal of Women and Minorities in Science and Engineering, 9(1), 17-34.

Cassidy, K. W., and Cook-Sather, A. (2003). "Putting the 'Social' Back in 'Socially Constructed': Revising the Teaching of Psychology as and in Collaboration." Journal of Women and Minorities in Science and Engineering, 9(1), 35-52.

Chandrasekhar, M., and Geib, J. "Hands-On Programs for Middle Level Students." WEPAN 2003 Conference, Chicago, Illinois.

Chin, B., Dellagirino, G., Midelfort, K., Vinarcik, M., Zieba, M., and Muller, C. "Mentornet Mentors and Proteges: The Real Story From Participants, in Their Own Words." WEPAN 2003 Conference, Chicago, Illinois.

Chrystal, L. L. "Growing Wiser with Time: The Women in Science and Engineering Living and Learning Community at Iowa State University." WEPAN 2003 Conference, Chicago, Illinois.

Clewell, B. C., and Campbell, P. (2002). "Taking Stock: Where We've Been, Where We Are, Where We're Going." Journal of Women and Minorities in Science and Engineering, 8(3&4), 255-284.

Colley, A. (2003). "Gender Differences In Adolescents' Perceptions Of The Best And Worst." Computers in Human Behavior, 19(6), 673-682.

Covington, K., and Froyd, J. "Changing Learning Environments Through Changing Faculty." WEPAN 2003 Conference, Chicago, Illinois.

Darke, K., Clewell, B., and Sevo, R. (2002). "Meeting the Challenge: The Impact of the National Science Foundation's Program for Women and Girls." Journal of Women and Minorities in Science and Engineering, 8(2), 285-304.

Dresselhaus, M. (2003). "Personal Views on Careers of Women in Science and Engineering." Bulletin of Science, Technology, and Society, 23(1), 44-45.

Duffy, T., and Walstrom, K. (2003). "Changes in student computer technology attitudes over time." Journal of Computer Information Systems, 43(3), 27-33.

Ferreira, M. (2003). "Gender Differences in Graduate Students' Perspectives on the Culture of Science." Journal of Women and Minorities in Science and Engineering, 9(2), 119-136.

Ferrone, J. K. (2003). "Enabling Performance Skills: Assessment In Engineering Education." DAI, 64(4A), 1188.

Ford, B. K. (2003). "Social Cognitive Career Theory And Racial Composition Of College Campus: Predicting Graduate School Consideration For Undergraduate Black Males." DAI, 64(5A), 1538.

Fox, M. A. (2003). Pan-Organizational Summit on the Science and Engineering Workforce, The National Academies Press, Washington D.C.

Frye-Lucas, S. (2003). "Factors Associated With African American Engineering Student Success In First-Year College Calculus." DAI, 64(3A), 822.

Galagher, S., and Larsson, A. "Exciting Children About Engineering Through Interactive Exploration of Bridges and Dams." WEPAN 2003 Conference, Chicago, Illinois.

Ginorio, A. B., Huston, M., Frevert, K., and

Seibel Bierman, J. **(2002). *"The Rural Girls in Science Project: From Pipelines to Affirming Science Education." Journal of Women and Minorities in Science and Engineering, 8(3&4), 305-326.***

Ginther, D. **(2003). *"Is MIT an exception? Gender pay differences in academic science." Bulletin of Science, Technology, and Society, 23(1), 21-26.***

Gregory, R. **(2003). *Women and workplace discrimination: overcoming barriers to gender equity. New Bruswick, N.J., Rutgers University Press.***

Hathaway, R., Loesch, E., Sharp, S., and Davis, C.-S. ***"Factors Influencing First Year Undergraduate Science and Engineering Academic Confidence." WEPAN 2003 Conference, Chicago, Illinois.***

Heaton, M. ***"The Mentornet Experience-From the Mentor's Side." WEPAN 2003 Conference, Chicago, Illinois.***

Holmes, A., and Ecsedi, M. ***"Ways to Attract and Retain Women Faculty and Graduate Students in Engineering." WEPAN 2003 Conference, Chicago, Illinois.***

Hornig, L. **(2003). *"Taking The Long View." Bulletin of Science, Technology, and Society, 23(1), 50-52.***

Inman, A. H., Anderson-Rowland, M. R., Castro, M., and Zerby, D. ***"Assessing the Evolution of Engineering Saturday Academies for Middle School and High School Women." WEPAN 2003 Conference, Chicago, Illinois.***

Ito, M. **(2003). *"Engineering Play: Children's Software And The Productions Of Everyday Life." DAI, 64(3A), 968.***

Jayaratne, T. E., Thomas, N. G., and Trautmann, M. **(2003). *"Intervention Program to Keep Girls in the Science Pipeline: Outcome Differences by Ethnic Status." Journal of Research in Science Teaching, 40(4), 393-414.***

Jenson, J., and Rose, C. B. **(2003). *"Women@work: Listening To Gendered Relations Of Power In Teachers Talk About New Technologies." Journal of Risk Research, 6(1), 45-60.***

Johnson, H. **(2003). *"Gender, Technology And The Potential For Social Marginalization: Kuala Lampur and Singapore." Asian Journal of Women's Studies, 9(1), 60-79.***

Kleinman, S. **(2003). *"Women in Science and Engineering Building Community Online." Journal of Women and Minorities in Science and Engineering, 9(1), 73-88.***

Knobloch, C. ***"The Pennsylvania State University WEP 'Girl Scout Saturdays' (GS2) Project: Collaborative Outreach Teaming Women Engineering Students With Pathway Prospects." WEPAN 2003 Conference, Chicago, Illinois.***

Koch, D., Forsythe, M., and Davis, C.-S. ***"IT Scholars - A Collaborative WIE/MEP/UROP Initiative at the University of Michigan." WEPAN 2003 Conference, Chicago, Illinois.***

Kushner, D. **(2003). *"The Social Life of Engineers." IEEE Spectrum, 40(10), 52.***

Laeser, B., Moskal, B. M., Knecht, R., and Lasich, D. **(2003). *"Engineering Design: Examining the Impact of Gender and the Team's Gender Composition." Journal of Engineering Education, 49-56.***

Laurin-Kovitz, K., Li, D., Washington, L. P., Gohoure, E., Hartline, B. K., and Bhattacharyya, M. ***"Survival Skills for Successful Women Scientists and Engineers-A Series of Career Development Workshops." WEPAN 2003 Conference, Chicago, Illinois.***

Layne, P. **(2003). *"Women Leaders in Engineering Societies." SWE, 49(2), 20-24.***

Layne, P. **(2003). *"Women in the National Academy of Engineering." SWE 49(1), 12-14.***

Layne, P., Knight, M., Cunningham, C., and Barton, C. ***"Leveraging Experience to Accelerate Progress: Moving Towards Gender Equity in Engineering Education." WEPAN 2003 Conference, Chicago, Illinois.***

Lee, A. **(2003). *"Undergraduate Students' Gender Differences In IT Skills And Attitudes." Journal of Computer Assisted Learning, 19(4), 488-500.***

Li, D., and Hartline, B. K. ***"A Report on the IUPAP International Conference on Women in Physics." WEPAN 2003 Conference, Chicago, Illinois.***

Lim, G., Chua, K. S., and Wee, K. U. **(2003). *"Effects of Instructional Intervention on Students At-risk in Engineering Education." International Journal of Engineering Education, 19(4), 525-531.***

Looker, E., and Thiessen, V. **(2003). *"Beyond the digital divide in Canadian schools-From access to competency in the use of information technology." Social Science Computer Review, 21(4), 475-490.***

Lucero, C. ***"Understanding the Tenure-Track Experiences of Black Women in Science and Engineering." WEPAN 2003 Conference, Chicago, Illinois.***

Mau, W.-C. **(2003). *"Factors the Influence Persistence in Science and Engineering Career Aspirations." The Career Development Quarterly, 51(3), 234-243.***

Maye, M. C. **(2003). *"Study-Group Collaboration Among High-Achieving Students Of African Descent Studying Mathematics At Selective United States Colleges." DAI, 64(5A), 1572.***

Mbarika, V. and Raju, P.K. **(2003). *"Identification Of Factors That Lead To Perceived Learning Improvements For Female Students." IEEE Transactions on Education, 46(1), 26-36.***

McDill, J. M. J. ***"Participation Trends in and Lessons Learned from Outreach." WEPAN 2003 Conference, Chicago, Illinois.***

Mecum, S., and Wilkins, L. ***"Women in Technology (WIT): A Paradigm for Working Toward Systemic Change in Science, Technology, Engineering and Math (STEM) Education and Employment." WEPAN 2003 Conference, Chicago, Illinois.***

Meili, M., Franks, S. E., Whitlock, J., and Arnold, S. ***"Promoting Diversity in Kansas'***

Future Technological Workforce Through Outreach Programs: The Boeing Experience." WEPAN 2003 Conference, Chicago, Illinois.

Moody, J. ***(2003). "Diversity and the Information Technology Workforce." Journal of Computer Information Systems, 43(4`), 63-71.***

Nelson, D. ***(2003). "Special Supplement - THE STANDING OF WOMEN IN ACADEMIA - Surveys Shed Light On How Well Universities Are Utilizing The Women Engineers And Scientists In The Technical Talent Pool." Chemical Engineering Progress, 99(8).***

Olson, K. ***(2002). "Who Gets Promoted? Gender Differences in Science and Engineering Academia." Journal of Women and Minorities in Science and Engineering, 8(3&4), 347-362.***

Osborne, J. ***(2003). "Attitudes Towards Science: A Review of the Literature and Its Implications." International Journal of Science Education, 25(9), 1040-1079.***

Purdy, C., German, R., and Ghia, U. ***"Sustaining a Multidisciplinary Summer Research Program for Women Undergraduates." WEPAN 2003 Conference, Chicago, Illinois.***

Quintana-Baker, M. ***(2002). "A Profile of Mexican-American, Puerto Rican, and Other Hispanic STEM Doctorates: 1993-1997." Journal of Women and Minorities in Science and Engineering, 8(1), 99-122.***

Reyes, M.-E., Powell, K., Aronson, M., and Goldberg, J. ***"Mentoring and Community Service for Recruitment and Retention of Women in Science and Engineering at the University of Arizona." WEPAN 2003 Conference, Chicago, Illinois.***

Riley, D. ***(2003). "Employing Liberative Pedagogies in Engineering Education." Journal of Women and Minorities in Science and Engineering, 9(2), 137-158.***

Riley, D. ***(2003). "Employing Liberative Pedagogies in Engineering Education." Journal of Women and Minorities in Science and Engineering, 9(2), 137-158.***

Roliston, D. ***(2003). "Can Title IX Do For Women In Science And Engineering What It Has Done For Women In Sports?" APS NEWS, 12(5).***

Rosser, S., and O'Neil Lane, E. ***(2002). "A History of Funding for Women's Programs at the National Science Foundation: From Individual POWRE Approaches to the Advance of Institutional Approaches." Journal of Women and Minorities in Science and Engineering, 8(3&4), 327-346.***

Salomone, R. ***(2003). Same, different, equal: rethinking single-sex schooling. Yale University Press, New Haven, CT.***

Schmidt, J., Smith, P., Schmidt, L., and Vogt, K. ***"Research Internships in Science and Engineering (RISE): Lessons From the First Year." WEPAN 2003 Conference, Chicago, Illinois.***

Sears, A. ***(2003). "Image Problems Deplete the Number of Women in Academic Applicant Pools." Journal of Women and Minorities in Science and Engineering, 9(2), 169-182.***

Sheppard, L. ***(2003). "Fire Protection Engineers Help Save Lives." SWE 49(1), 52-60.***

Shuler, D., and Rittenhouse, G. P. ***"Creating a Successful Summer Institute for High School Girls." WEPAN 2003 Conference, Chicago, Illinois.***

Steinke, J. ***"Media Images of Women Engineers and Scientists and Adolescent Girls' Conceptions of Future Roles." WEPAN 2003 Conference, Chicago, Illinois.***

Stepulevage, L., Henwood, F., and Plumeridge, S. ***"Women-Only Computing In Higher Education." Proceedings of the IFIP TC9/WG9.1 Fifth International Conference, Manchester, UK.***

Suresh, R. (2003). "Persistence And Attrition In Engineering: Understanding The Nature Of Students' Experience With Barrier Courses." DAI, 64(1A), 85.

Thi Duong, T., and Skitmore, M. ***(2003). "Female Project Managers' Workplace Problems: A Survey." Journal of Women and Minorities in Science and Engineering, 9(2), 183-196.***

Thomas, C. (2003). "The Next Frontier - Women in Academic Leadership." SWE 49(4), 12-18.

Trauth, E., Nielson, S., Hellens, V., and Liisa, A. ***(2003). "Explaining the IT Gender Gap: Australian Stories For The New Millennium." Journal of Research and Practice in Information Technology, 35(1), 7-20.***

Van Dijk, J., and Hacker, K. ***(2003). "The Digital Divide As A Complex And Dynamic Phenomenon." Information Society, 19(4), 315-326.***

Weinburgh, M. ***(2003). "The Effects of Systematic Reform on Urban, African American Fifth Grade Students' Attitudes Toward Science." Journal of Women and Minorities in Science and Engineering, 9(1), 53-72.***

Williams, B. A. ***(2003). "Charting the pipeline: Identifying the critical elements in the development of successful African American Scientists, engineers and mathematicians." DAI, 64(2A), 376.***

WIlliams-Daugherty, Y. ***(2003). "Classroom racial composition and perceived self-efficacy or African American students." DAI, 64(5A), 1504.***

Wilson, E. K. ***(2003). "Maria Goeppert-Mayer's Legacy." Chemical and Engineering News, 81(13), March 31, 2003.***

Wilson, K. R., Wallin, J. S., and Reiser, C. ***(2003). "Social Stratification and the Digital Divide." Social Science Computer Review, 21(2), 133-143.***

Wyden, R. ***(2003). "Title IX and Women in Academics." Computing Research News, 15(4), 1-8.***

Xie, y., and Shauman, K. ***(2003). Women in Science: Career Processes and Outcomes, Harvard University Press, Cambridge, Massachusetts and London, England.***

Zohar, A. ***(2003). "Her Physics, His Physics: Gender Issues in Israeli Advanced Placement Physics Classes." International Journal of Science Education, 25(2), 245-268.***