

SWE

A C O M P E N D I U M

OF THE

SWE ANNUAL
LITERATURE
R E V I E W S

ON WOMEN IN ENGINEERING

15 YEARS OF ANALYSIS AND INSIGHT
FROM SWE MAGAZINE: 2001-2016



Contents

Please click
a chapter
to be taken
directly to that
year's review.

Foreword	1
Introduction	2
Chapter 1: Review of the 2001 Literature	3
Chapter 2: Review of the 2002 Literature.....	12
Chapter 3: Review of the 2003 Literature.....	27
Chapter 4: Review of the 2004 Literature	44
Chapter 5: Review of the 2005 Literature.....	60
Chapter 6: Review of the 2006 Literature.....	81
Chapter 7: Getting the Most from the 2007 Review	107
Chapter 8: Review of the 2007 Literature.....	109
Chapter 9: Getting the Most from the 2008 Review	136
Chapter 10: Review of the 2008 Literature.....	138
Chapter 11: Review of the 2009 Literature	159
Chapter 12: Review of the 2010 Literature	182
Chapter 13: Review of the 2011 Literature.....	200
Chapter 14: Review of the 2012 Literature	224
Chapter 15: Review of the 2013 Literature	242
Chapter 16: Review of the 2014 Literature	262
Chapter 17: Review of the 2015 Literature	282
Chapter 18: Review of the 2016 Literature	304



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The Society of Women Engineers (SWE), founded in 1950, is a not-for-profit educational and service organization. SWE is the driving force that establishes engineering as a highly desirable career aspiration for women. SWE empowers women to succeed and advance in those aspirations and be recognized for their life-changing contributions and achievements as women engineers and leaders.

In the Spirit of Our Mission



The Society of Women Engineers is the world's largest organization supporting women in engineering and technology. As such, we are pleased to provide this compilation of *SWE Magazine* Literature Reviews, which represent many years of research and expert analysis concerning the social science literature on women in engineering and other STEM professions.

Women have increased their numbers in many professions previously dominated by men, including law, business, medicine, and other STEM fields. In engineering, however, currently less than 15 percent of engineers in the United States are women, a number that has been stagnant since the early 2000s. Such an underrepresentation is problematic for many reasons. Engineers are needed for leadership in a competitive global marketplace. Further, research has shown that diverse teams lead to greater innovations.



Various themes have emerged from the social science literature to explain both the low numbers of women studying engineering and the low number remaining in the profession. As a significant step toward solving this lack of gender diversity in the profession, our reviews of this important literature make a broad swath of information available in an understandable and easily accessible manner.

Individually and taken as a whole, these literature reviews shed light not only on the various issues, but also on possible solutions.

SWE is actively engaged in working with our university partners and employer partners to increase gender diversity in the engineering profession. Using a data-driven approach coupled with the sharing of diversity and inclusion best practices, we hope to make engineering a more welcoming profession for all.

In the spirit of our mission, we are pleased to provide this compilation of literature reviews as a valuable resource, and look forward to working together to achieve a diverse engineering workforce.

A handwritten signature in black ink, appearing to read "Jessica Rannow".

Jessica Rannow
SWE FY17 President

A handwritten signature in black ink, appearing to read "Karen Horting".

Karen Horting, CAE,
Executive Director and CEO

A Resource in One Volume



The research discussed in the literature reviews addresses common issues facing women in the STEM professions, as well as on the educational pathways leading to a successful career in engineering. When we began this undertaking in 2002, we believed that easy access to this research, combined with expert analysis and discussion, would benefit SWE members and the larger community.

A great deal of research on women in engineering has been conducted over the past decade in particular. This has resulted in a greater understanding of the reasons for women's underrepresentation as well as a rethinking of recommended solutions. As the conclusion of our 2015 review states: "While increasing the quantity of research and targeting unanswered questions will not, by themselves, bring about gender equity in engineering, filling in the research gap and resolving ongoing debates will certainly help to create the knowledge base on which effective policies can be built."

Over the years, many women engineers, and men and women working to support diversity in the profession, have commented on the value of the annual literature review. We are pleased to provide this compilation of all our literature reviews, plus some additional commentary, as a resource in one "volume," as another step toward solving the underrepresentation of women in engineering, and creating a truly diverse engineering workforce.

Anne M. Perusek

Anne Perusek
Director of Editorial and Publications

Women in Engineering:

A Review of the 2001 Literature

Recognizing the long-standing need to compile research on women in engineering, the SWE Magazine Editorial Board has committed to producing this essential information.

BY CLAIRE THIELEN, SWE

The focus of this summary is research on engineering as it relates to women. Publications are from the year 2001, and most were indexed and abstracted in the major literature databases. Doctoral dissertations cited were published in 2000.

Demographics

The National Science Foundation (2001) presented statistical data on U.S. science and engineering degrees by race and ethnicity of recipients between 1990 and 1998. The Institute of Education (2001) conducted a longitudinal study of the career and personal life experiences of women in science, engineering and technology in the U.K. Layne (2001) summarizes statistics describing diversity in engineering from several agencies, including: the US Census Bureau, the U.S. Bureau of Labor Statistics, the U.S. Department of Education, the Engineering Workforce Commission, and the National Science Foundation.

Career choice

Self Assessment. Correll (2001) considers how gendered beliefs about mathematics impact an individual's own assessments of mathematical competence, and lead to gender differences in decisions to persist on a path toward a career in science, math, or engineering. Lent

et al. (2001) tested cognitive theory related to the career choice process and found that self-efficacy and outcome expectations were jointly predictive of interests and choice intentions. Schoon (2001) investigates how job aspirations expressed in adolescence, which differ between the sexes, relate to adult occupational attainment. Factors influencing job aspirations are also discussed. Fox and Stephan (2001) analyze how the preferences and subjective prospects of engineering doctoral students relate to their objective employment experiences. Blaisdell (2000) studied predictors for students entering engineering and whether female under-representation is due to girls' expectations that they will not be successful in that occupation. Chan (2000) discusses how bright girls underestimate their math ability and are therefore reluctant to consider careers in engineering, especially if they do not have access to role models and information about these careers. Cross (2001) examined the issue of women's low rates of participation in science and engineering graduate school, finding women evaluated their abilities related to intelligence lower than did men. Lackland and DeLisi (2001) analyzed the predictors of choice for traditional and nontraditional college majors, finding engineering majors among those with low con-

fidence, satisfaction, and expectations for future success. Gwilliam and Betz (2001) examined three measures of self-efficacy in science and mathematics, found both race and gender differences, and questions about appropriate application of the measures.

Social Factors. Jepsen (2001) suggests that increasing the number of women in IT careers addresses two goals: achieving social equity; and fulfilling the critical need in the IT sector. Parzinger and Lemons (2001) discuss possible sociological factors influencing the number of women entering a career in information technology. The relationship of these variables with perceptions of organizational justice in women's advancement to management careers is considered. In a National Council for Research on Women report (2001), Thom presents strategies for ensuring full participation and achievement in the sciences by women and girls, calling upon adults to support the interest and persistence of females in engineering. Davey (2001) investigated the reasons high school students had for their career choices and found that male students chose their careers based on interest, while female students chose theirs based on altruistic values. Siann and Callaghan (2001) suggest that less consideration should be given to the barriers to women choosing an engineering career,

and more to why women make positive choices of alternate occupations. McClelland (2001) discusses how to close the gender gap in IT careers by increasing positive role models, access to technology, perceptions, and self-confidence. Roser (2001) discusses the challenges and opportunities for attracting women into, and retaining women in careers in engineering, to meet the projected shortage of technically trained workers. Myers and Beise (2001) investigate how media images, role models, gender, and age are factors that attract and discourage students who initially display an interest in IT careers. Ramirez and Wotlpka (2001) raise questions about the persistence of an inequality perspective regarding women's access to engineering education, reporting that women's and men's enrollment in other fields has a positive spillover effect. Gadalla (2001) found differing patterns of enrollment among university women in mathematics, engineering, and computer science suggesting that the factors which influence women to pursue these fields are discipline-specific. Baryeh (2001) found that 11.1 per-

cent of the engineering students in Botswana were female, and that women chose engineering based on interest and job opportunities.

Generating interest in engineering

Methods. Isaacs (2001) discusses why engineering recruiting efforts directed toward encouraging girls to study math and science are focused on the wrong problem. The study proposes that we should instead educate schoolchildren and the public about the problem solving aspects of engineering. Isaacs and Tempel (2001) discuss how college class projects focused on making the general public enthusiastic about engineering will have the long-range benefit of attracting more women to engineering. Hasoun and Bana (2001) summarize current practices by engineering departments aimed at recruiting and retaining women graduate students and outline the need for research to study the effectiveness of these practices. Estes et al. (2001) describe a statewide achievement program designed to increase women in engineering, its connections to university programs, and

its impact on retaining women in the profession.

Program Evaluations. Wolcott (2001) describes programs that encourage women to become engineers, and stay in their programs. McLester (2001) discusses an information technology program for high school students held on a university campus that encourages students to envision themselves in a university environment and invites women, and minorities, as motivational speakers. Cano et al. (2001) discuss a four-week summer program, at a university, where fourth grade through high school girls receive science, math, engineering and technology enrichment and motivation. Secola et al. (2001) assess the effectiveness of a NSF-funded eight day engineering academy for 6th through 12th grade girls, where students learn how engineering solves human problems. Phillips (2000) investigated how participation in a NSF funded engineering intervention program for high school girls, and subsequent high school science coursework, affected students' interest in engineering careers one year later. Teshome et al. (2001) de-

A New Gender Equity: Learning How to Learn

How do women learn? How does it differ from the way men learn? What barriers create road-blocks in the female cognitive process? What are the implications for these differences? And how can those given the task to teach alter what many women see as a chilly and often hostile learning environment? The following featured articles examine the role environment plays in math and science education, and how traditional methods, which tend to favor a more "masculine" approach to learning, often leave many women feeling that such subjects hold nothing for them.

Breaking the Cycle: Only 1,920 More Years to Equity

BY RICK SEAMAN, KATHY NOLAN AND CORBIN DWYER, UNIVERSITY OF REGINA

There is a cycle of learning that has worked to keep women out of the loop in approaching such fields as math and science — where information is believed to be set in stone rather than fluid, according to Seaman, Nolan and Dwyer. Breaking that cycle would mean revisiting how such information is taught, they contend.

Women make up the fastest

growing section of the student population in higher education, yet there is little research on how women learn. What little is available shows that women, more so than men, see their universities as inhospitable places, with many reporting that they are not satisfied with the quality of their educational experiences.

Academic success in college not only depends upon

the intellectual characteristics of entering students, but also on such variables as the students' capacity to adapt to their new environment, researchers said. Some women enter university not only questioning their abilities in specific areas (such as math and science) but also their overall abilities. They wonder if they have what it takes to be successful, the authors write.

"I always thought I wasn't smart enough to go to university," says Dawn, an undergraduate student featured in the article. "It wasn't a spoken thing but it was kind of like nobody ever said 'you will be going to university.' It was more like 'graduate and then get a job, get married or something.'"

There are a limited number of current research studies available on the school experience of women university students. But these few have shown that using adaptive academic strategies (such as study, note-taking, and test-taking skills) increase the chances of success of traditional, as well as academically at-risk, students.

Math can affect a female student in her quest to secure

veloped instruments and collected data to assess the impact of a grade school program on students' attitudes toward hands-on science, math- and gender-related issues.

Education

Teaching. Hughes (2001) explores reconfiguring the science curriculums and the importance of both gender and ethnicity in the production of, or rejection of, scientist-identities. Gilbert (2001) deconstructs assumptions regarding gender and science, and discusses school science programs designed such that girls participate as women, rather than as "substitute" men. Stepulevage (2001) discusses research in computing and technology in primary and secondary school classrooms addressing assumptions made about girls' constructed incompetence. Clegg (2001) discusses the role of education in presenting computing as a masculine domain. Stake and Mares (2001) studied the benefits of science enrichment programs on gifted high school students, finding benefits significant for girls. Mawasha et al. (2001) describe factors required for the development

of a successful science, math, engineering, and technology training program for high school women. Jackson (2001) describes the role that higher education of today's students has on the advances of the future economy. Colbeck et al. (2001) investigated relationships among college teaching practices, classroom climate, and other factors related to motivation to pursue engineering careers. Hoole and Hoole (2001) discuss engineering education practices at universities in Sri Lanka, and systematic difficulties for increasing women's participation and promotion.

Learning. Smith (2001) studied the learning preferences of technology students and their implications in training program design. Sneller (2001) addresses how professors can improve gender equality in engineering education by recognizing the gender problem, reevaluating teaching methods, and subsequently reconstructing classrooms. Sorby (2001) describes a college course in 3-D spatial visualization skills and discusses its relationship to the success and retention of female engineering students. Seaman et al. (2001) discuss barriers to suc-

cess, how women experience learning, and how educators can support the development of females to ensure that they reach their potential, focusing on math and science students.

Performance. Macdonell-Laeser et al. (2001) examine the influence of gender on the engineering design team process in a college classroom. McAnear and Seat (2001) examine self and peer perceptions of the relative performance of men and women on student project teams, and discuss the implications for female students on predominately male teams. Waldrop (2000) studied gender, race and the effectiveness of peer tutoring on the academic performance of engineering students and those who changed their majors. Ong (2001) discusses how women of color who major in physics can use invisibility to gain presence, power and legitimacy. Fleck (2000) studied whether student expectations improved the prediction of academic performance over other predictors such as test scores. Brown (2000) discusses how factors such as college preparation, mentoring, special school

both a post-secondary degree and a professional one. In this light, the authors chose to learn more about the past experiences of women enrolled in Math 101 courses and to examine the impact that thinking strategies might have on those who did not see math as a strength. Fourteen female students from a section of the course of 21 students volunteered for the study. Eleven (79 percent) said math was not their strongest subject.

"I was never very good in math, although some sections of the course I loved and understood well," says one student surveyed. "If I don't understand the concept, and why this is this and that is that, I'm totally lost."

Says another: "In elementary school I did all right. [In high

school] I did poorly. There's always one little thing in each section that frustrates me."

At the beginning of the course, the women said they liked math about half the time. After 13 weeks, the women generally perceived their math skills as improving from average to almost good. They described how well they solved word problems, ranging from about average at the beginning to almost good at the end of the course. But there was no significant change in the women's attitudes toward math, though many indicated having more control over their thinking and improved perception of their math problem-solving performances, and an improved attitude toward problem solving.

Many studies have shown

that students enter teacher education programs with an obvious dislike for math and science. The traditional view is that math is a well-defined and well-described body of knowledge, rooted in the belief that it has been discovered, not invented.

If women have to teach in areas that are incompatible with their ways of knowing, and that come in a masculine packaging, then it is no small surprise that they will tend to avoid these subjects in their learning as well as in teaching, said the researchers.

This all points to the need for faculty equity, the authors conclude. They argue that having female role models in traditionally male academic fields could produce more positive results.

The women in many studies relied on advisors, for example, for emotional support, and several studies showed women Ph.D. candidates were twice as likely to change advisors as were men.

Breaking the cycle that excludes women from participation in math and science means a reconstructing and a re-visioning of women's roles in teaching and learning. Is the "product" more important than the "process?" The women in many studies did not see themselves as participants in the process of knowledge construction, rather they saw the teacher as an agent who delivers the product as facts and truths in the form of rules, procedures and definitions.

— Summary by James Michael Brodie, SWE Contributing Editor

and summer programs, and gender role conflicts affect the success of minority and women engineering students. Sax et al. (2001) studied

the technological preparedness of college freshmen finding variances by race, class, gender, and academic background. Ting (2001) evaluated

the ability of standardized tests to predict academic success of engineering students. Different predictor variables were found based on gender. Tai and Sadler (2001) discuss how the design of high school physics courses affects the success of female college physics students, and an apparent gender bias in college physics courses. Thom (2001) discusses progress in increasing girls' performance and participation in science and technology studies in secondary schools in recent years.

Mentoring. Coppola (2001) presents examples of mentoring as a mode of professional development for the next generation of science scholars, and discusses how mentoring will broaden the definition of education. Marra and Pangborn (2001) provide examples of mentoring in engineering as models for how to relate to students beyond the traditional classroom format and provide rewards for both students and the faculty mentors. Braselmann (2001) discusses support groups formed by women scientists and academic women, and the roles these groups play in promoting equality. Moreno (2001) discusses how participating in, and having friends in, a college calculus mentoring program contributed to women's excelling in calculus.

Persistence and Retention. Cross and Vick (2001) examined social support as related to undergraduate student self-esteem and predicted continued enrollment in engineering. Sax (2001) examines the personal and environmental factors, and gender differences that predict persistence in engineering graduate education. Wyer (2001) measured persistence to determine not why students leave engineering, but why they stay. Gender was not a factor in why students stay in engineering, as it is in why they leave. Fletcher et al. (2001) describe a university's summer program for entering female freshman and its impact on retention. Hathaway et al. (2001) presented study findings on how participation in a student residential learning program for

The New 3Rs: Gender and the Science and Engineering Classroom

South Dakota School of Mines and Technology

BY JUDY E. SNELLER

Even as the 21st century begins, remnants of the old "boys-are-smart/girls-are-nice" reward system routinely pop up. A June 1994 article in the *Wall Street Journal* cited an elementary school that granted boys such awards as "best thinker," "most eager learner" and "most scientific," while bestowing such honors as "all-around sweetheart," "cutest personality" and "biggest heart," to girls.

"Unfortunately, this wasn't a joke, and it wasn't a joke in our grandmothers' time," Sneller writes. "How sobering it is to see boys still being rewarded for being smart and girls for being likable."

Two American Association of University Women reports spell out the disparities that remain in the unequal educating of girls during their K-12 years. Their 1992 study, *How Schools Shortchange Girls*, concluded, "girls are systematically, if unintentionally, discouraged from a wide range of academic pursuits." Their follow-up report in 1998, *Gender Gaps: Where Schools Still Fail Our Children*, noted, "for many girls, an equitable education is in many respects still an elusive goal, in sight yet out of reach."

Over the past decade, the numbers of women in the sciences and engineering have increased by 4 percent, according to a 2000 National Science Foundation study. But women still account for only 19 percent of all undergraduate engineering students and earn fewer than 40 percent of all graduate engineering degrees.

Sneller argues that one way to improve these numbers is to adopt a new "3Rs Gender Equity," which stresses Recognizing the problem, Reevaluating teaching methods, and Reconstructing classrooms.

"Our classrooms are not the neutral sites for learning we might desire, but are microcosms of our society and its inequities," she writes. "As professors and students, we enter the classroom with gender identities assumed or given by the discourse of our society, and we do not simply 'shed our identities at the door with our coats.'"

Before teachers and students can change methods, they both must reject perceived notions of appropriate behavior for men and women, Sneller argues. For example, the notion that engineering is men's work, and that women who take up the subject are choosing it as an act of courage, stigmatizes a women as being somehow "different" rather than accepting her naturally as another member of the academy.

It is crucial that all teaching materials display a positive attitude toward both sexes to avoid the image of the profession as male only. These images, Sneller says, only add to the stereotypic notions of women as dependent, passive, emotional, and put women who break from the image as "incredible Super Women who somehow do it all." She adds that teachers must ensure that their treatment of male and female students demonstrates fairness. Suggestions include not falling into a pattern of directing more questions to men and not allowing men to dominate discussions.

"It's past time for us to get serious about gender issues in our society and how they affect our classroom," Sneller writes. "Our students deserve equal treatment and opportunity, and the science and engineering professions deserve to have the best people they can get, and that means men and women."

— Summary by James Michael Brodie, SWE Contributing Editor

A Course in Spatial Visualization and Its Impact on the Retention of Female Engineering Students

Michigan Technological University

BY SHERYL A. SORBY

“As a first-year engineering student, I found that calculus, chemistry and English were ‘breezes,’ whereas a course called ‘Engineering Design Communication’ caused me so much trouble that I nearly switched majors,” Sorby writes. “This one-year course was essentially a course in engineering graphics, and I simply could not visualize what all of those lines on the paper were meant to represent. My frustration was further aggravated by the fact that most of my male colleagues found the class exceptionally easy. They would try to explain the sketches to me, often leaving me more confused than before I asked for help.”

As a teacher, who ironically ended up teaching the very graphics course that caused her frustration, Sorby noted that her female students also struggled with the visual side of the lesson. Many expressed to her a desire

to switch majors.

According to the Piagetian theory — the learning theories developed by Swiss psychologist Jean Piaget — children learn in three ways: topologically, spatially and through visualization of concepts. There is a great deal of evidence to suggest that the spatial visualization skills of women lag far behind those of men, with many researchers asserting that this ability is transmitted as a recessive characteristic on the X chromosome — that spatial ability is related to the

male sex hormone.

A number of activities may also contribute to these differences, she writes: 1) playing with construction toys as a young child; 2) taking shop, drafting or mechanics classes in middle school; 3) playing 3-D computer games; 4) playing certain sports and 5) having well-developed math skills.

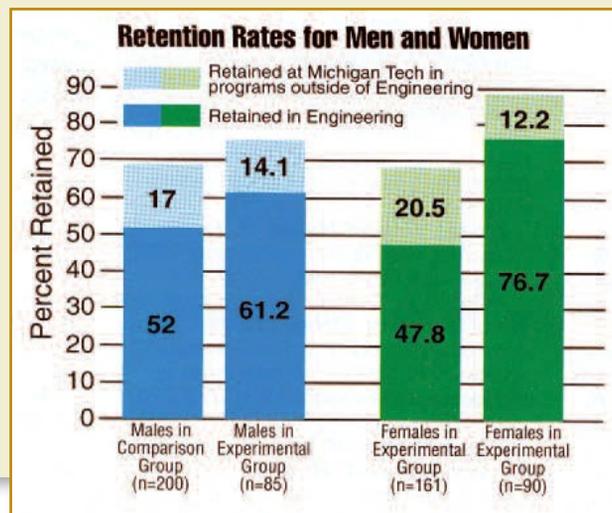
In 1993, researchers at Michigan Technological University launched a study to improve the spatial skills of its students. Between 1993 and 1998, 285 men and 251 women at Michigan Tech failed the Purdue Spatial Visual-

ization Test: Rotations, a standardized test. Those students were divided into two groups: those who were enrolled in the experimental course and those who were not. The students who participated in the experimental group earned better grades than their counterparts, the research showed. Women in the experimental group also outperformed their female counterparts.

According to the study, the improvement in spatial skills resulted in students performing much better in graphics-related courses. Performance standards at Michigan Tech were based upon the students’ final grades.

Typically, calculus, chemistry and physics have been regarded as the “gateway” subjects in engineering. But this study may show that for both sexes, engineering graphics courses may play a more significant role in determining who goes forward in the field.

— Summary by James Michael Brodie, SWE
Contributing Editor



women in science and engineering was significantly connected with retaining science students but not engineering students. Conefrey (2001) discusses how sexual discrimination in science education leads to attrition as it causes women to question their ability to succeed and stay in science and engineering programs.

Workplace

Management. The National Foundation for Women Business Owners (2001) reports that women are more likely to own fast-grow-

ing high tech firms. Women are also more likely to own biotech firms, while men are more likely to own information technology firms. McGregor and Tweed (2001) study the similarity and differences in managerial competence between male and female manufacturing managers in small and medium manufacturing enterprises. Liu and Wilson (2001) discuss factors, such as stereotypes and family responsibilities, that have restricted the career development of women managers in information technol-

ogy. Lemons and Parzinger (2001) discuss how family characteristics, corporate cultures and social values contribute to women encountering obstacles to managerial positions within the IT profession, and suggest ways to increase promotion opportunities. Lee and Sweeney (2001) studied the behaviors project managers use to influence their team members and found women are less likely to use threats and more likely to explain reasons for their requests. Fielden et al. (2001) studied women in construction and found that in order to

be considered for senior management they needed to be in mainstream roles such as design and engineering, versus human resources or administration.

Representation. Vick (2001) reports from the findings of Pollution Engineering's annual career survey that only one out of every 11 professionals in the pollution control industry is a woman.

Schmidt (2001) examines why women are disproportionately represented in part-time employment, on-call work, temporary-agency employment, independent contracting, and other forms of self-employment within the fields of science and engineering. Yates (2001) investigates problems and issues encountered by nontraditional engineering professionals.

Gender Differences. Adam (2001) discusses engineering ethics and how ethical theories may differ in how they serve men and women in the workplace. Beasley et al. (2001) present a study that investigates the similarities and differences between men and women in the IT industry, including desire for flexible working arrangements. From a National Research Council (2001b) study, Long compares the career outcomes of women and men Ph.D. scientists and engineers. Barker (2001) examined the careers of engineers and noted differences by gender in commitment, tenure, salaries, and workplace experience, including promotion. Mahlck (2001) presents study results on how seemingly gender-neutral processes in research organizations impact researchers. Martinsons and Cheung (2001) studied staff member concerns about emerging IT practices such as outsourcing and re-engineering, and found perceptions differed by gender and work experience.

Engineering Faculty. The National Research Council (2001a) has compiled data on the experiences of women faculty, including demographic data, employment satisfaction, mentoring experiences, and career decision factors. Byrum (2001) presents the results of a sur-

vey which found a slight increase in the number of women chemistry faculty funded by their departments. Davis (2001) discusses how a support group for women scientists at an academic research institution facilitated legitimate participation in the science community.

Claire Thielen has been a member of the Society of Women Engineers for 23 years, and is currently national chair of SWE's program development grants committee. She is employed as a clinical and cost data analyst at Silver Cross Hospital in Joliet, Ill. She received a bachelor's degree in industrial engineering from Bradley University, and a master's degree in human resources and organization development from the University of San Francisco.

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Women in Engineering:

A Review of the 2002 Literature

BY LISA M. FREHILL, PH.D., JAMMIE BENTON-SPEYER, AND PAMELA HUNT

In the past year, there has been much interest in understanding the movement of women and girls into and through the engineering pipeline and their experiences in that pipeline. At least 22 dissertations explored a range of issues about gender and engineering and more than 40 articles appeared in peer-reviewed publications. Large conferences — like the 12th International Conference of Women Engineers and Scientists (ICWES12: see box on p. 18) and large-scale reports — such as the Helsinki Report on National Policies on Women and Science in Europe — made women's experiences in science and engineering more visible to a larger audience. Such conferences and reports received wide coverage in engineering society magazines and the mainstream press, calling more attention to the international engineering pipeline and the experiences of women in engineering.

Institutional Transformation

The NSF's ADVANCE awards program, specifically the Institutional Transformation Program, was well underway at the nine institutions awarded grants under this new NSF initiative. The ADVANCE program replaces the earlier POWRE grants, which went to individual women in STEM fields. Rosser and Lane's analysis of the impact of POWRE indicated that even though the program was one of the most competitive grants programs at the National Science Foundation, colleagues of women who received the grants devalued the program because they were under the mistaken impression that the program was less competitive. Rosser and Lane also point to the need to change policies and procedures of institutions to be

more family-friendly and that stereotypes and harassment need to be curtailed if academia is to recruit and retain a diverse labor force. Sevo provides a good overview of NSF funding related to gender equity in science and engineering.

The Institutional Transformation program is a bold new initiative aimed at changing the institutions in which gender bias is often subtle and built into work structures rather than overt and personal. Nine institutions were awarded grants in the first year. Each has set up its own Web site:

University of California -

<http://advance.uci.edu/home.html>

University of Colorado, Boulder -

<http://advance.colorado.edu>

University of Michigan, Ann Arbor -

<http://www.umich.edu/~advproj>

New Mexico State University -

<http://www.nmsu.edu/~advproj>

Hunter College, City Univ. of New York -

<http://www.hunter.cuny.edu/genderequity>

University of Puerto Rico, Humacao -

<http://cuhwww.upr.clu.edu/~advance>

University of Washington -

<http://www.engr.washington.edu/advance>

University of Wisconsin, Madison -

<http://wiseli.engr.wisc.edu>

Georgia Institute of Technology -

<http://www.advance.gatech.edu>

These programs are not only aiming to change their own institutions, they are also working together to provide models for all academic institutions on how institutional change can happen. Consult the individual web pages or contact the principal investigators for more information about these programs. See also Rosser's (2002b) and Rosser's and Lane's (2002)

for more details about these programs.

Over the past couple of years there have been a few books and articles that address questions about the impact of feminism on science and technology. An excellent edited volume by Creager, Lunbeck, and Schiebinger (2001) as well as a 1999 book by Schiebinger address this very issue and both conclude that feminism has had an interesting impact upon science, technology and medicine — but in different ways in different fields. An article by Uden found that among Swedish master's degree candidates, females' thesis topics did not differ from those of their male counterparts in engineering.

Mack's chapter in Creager et al. (2001) on engineering compares how two kinds of feminism impacted how women could affect engineering. In the earlier part of the twentieth century "difference feminism" — the notion that women and men occupied different spheres and had different concerns — provided feminist engineers in the early 1900s with the ability to do engineering in a more humanistic way, consistent with the "difference" standpoint. On the other hand, the "equal-rights feminism" of the late twentieth century emphasized the similarities between men and women, so women found themselves more defined by their male environment and defied any notion that they were different from their male counterparts.

Consistent with the notion of what impact feminism has had on science, Rosser (2002a) examines the ways in which women's issues and feminism did or did not occupy a central place at large interdisciplinary science meetings such as the American Association for the Advancement of Science (AAAS). On the other hand, she simultaneously looks at how well represented are is-

sues about health, science, and technology at the National Women's Studies Association (NWSA) conference. Rosser is a prominent scientist who has long had a foot in both the worlds of science and women's studies. Her article discusses the importance of building a two-way street between women's studies and science and technology as a way of accomplishing the broader goal of institutional transformation, which is part of NSF's newly funded ADVANCE program.

Another new NSF-funded program of interest is the Information Technology Workforce (ITWF) program that attempts to rectify the underrepresentation of women and minorities in the IT workforce (reported on by Wardle and Burton). This program initiative has three themes: (1) environment and culture, (2) educational continuum, and (3) IT workplace. The grants awarded under this program will explore a range of issues related to women's and minorities' participation in computer science.

Reports Concerning the Status of Women in Science and Engineering

Ever since the MIT study garnered major publicity in 1999, causing the president of the university to state publicly that women had experienced discrimination within the walls of one of the nation's premier institutions, there have been a number of significant developments. A number of institutions replicated the MIT study; the NSF made nine awards in its ADVANCE Institutional Transformation Program, and several large-scale reports of national or international scope were completed and disseminated to a wide audience via the world wide web. These reports — from various sources — all cite the leaky pipeline and the persistence of sexist practices in science and engineering as problems that must be overcome in an increasingly competitive global economy.

The report of the Helsinki Group on Women and Science of the European Commission confirms a pattern of discrimination against women in science (Rees 2002a and 2002b). The report, which covers 30 European countries, synthesizing data collected over a two-year period, cites a leaky pipeline

whereby women drop out of science careers at every level and represent a tiny minority in top scientific jobs. However, many countries have instituted positive measures to support women in science, including role model and mentoring schemes, and targets and quotas. Significantly, the report affirms the importance of the field of gender studies as a research area and is supported by many countries. The report stresses the desirability of mainstreaming gender issues into EC's 6th Framework Programme, spanning 2002-2006.

The European Commission published a study by a group of 48 experts in top European research and development companies, universities, research institutes, and professional organizations in Europe and North America that reports on the status of women across the EU's member nations in industrial science and engineering (Rubasamen-Waigmann et al.). The report, "Women in Industrial Research," follows up on earlier efforts by the EC, which included the 1999 "Women and Science: Mobilising Women to Enrich European Research." The "expert panel" approach was essential for this particular study because while good data are often maintained by many nations on educational institutions, private industry data are harder to locate. The study found broad variations across the EU nations in terms of the utilization of women. According to the report's executive summary:

"At present, women constitute approximately 15 percent of industrial researchers in the EU. As significantly more women are graduating in science and engineering, they are an obvious source of new recruits. In addition, the disproportionate loss of women from scientific careers needs to be overcome. Old-fashioned ideas and practices still impede women's careers in industrial research. Their input into innovation, and creativity of science does not reflect their buying power or their growing role as decision-makers. (p. viii)"

You can access the full report online at http://europa.eu.int/comm/research/science-society/women/wir/report_en.html. Black, Holden, and Schultz all report on this study in separate articles in various science and engineering magazines.

A Committee on the Status of Women in the School of Engineering repeated the 1999 study of the MIT Schools of Science (Boyce et al., with a report by Lawler in Science).

Engineering is the largest of MIT's schools, but only 10 percent of its professors are women. Although they receive similar pay and space as their male peers, these women reported that they were consistently marginalized in a number of ways within their departments and the university. Subtle biases result in fewer women on Ph.D. committees and in senior administrative posts. To create a more welcoming environment, MIT is modifying its family leave and child care policies, and has agreed to use consultants to search for qualified women and to examine why women reject MIT offers at twice the rate that men do.

NSF published an update of its study of trends in research spending, "Science and Engineering Indicators." This report finds that programs to make science more appealing to women and minorities are having an effect. Women earned 9,396 Ph.D.s in the sciences in 2000, up from 6,932 in 1991, while the number of white males earning doctoral degrees in science or engineering fell from 8,585 to 7,909. The report includes numerous tables and graphs documenting the participation of women and minorities in science and engineering at all stages of the pipeline and within the many subfields of science and engineering. If you need information for a talk about your field, this report is an excellent place to start.

Other government documents related to the issue of education and engineering can be found at the Web site for the National Center for Education Statistics (<http://nces.ed.gov//programs/coe/>), where you can access their annual report "Condition of Education." The "Condition of Education" reports on education at all levels, compiling information from numerous data collection programs at the U.S. Department of Education.

Another large-scale report, titled "Professional Women and Minorities: A Total Resources Data Compendium" was published by the Commission on Professionals in Science and Technol-

ogy. The compendium reported modest gains in the number of women earning baccalaureates in science and engineering fields. Women increased their share of baccalaureates in these fields by 16 percent over the last 35 years, to 39 percent. But their share of science and engineering doctorates was only 36.2 percent — inclusive of social and behavioral sciences. The compendium’s more than 300 tables are available on the web at <http://www.cpst.org>.

The status of women in the Canadian science and engineering academe was the focus of an ICWES paper presented by Williams et al. and an article in *Science* by Kondro. Williams et al. report on the efforts by the Natural Science and Engineering Research Council of Canada (NSERC), which established a network of prominent academic women as chairs for women in science and engineering in cooperation with industry at five Canadian universities. These Chairs spent 50 percent of their time on issues related to women in science and engineering. The ICWES paper dis-

cusses the background of the Chairs and the challenges that they have faced.

What is the status of women at your alma mater and your field of engineering?

There are two ways you might be able to find information. Nelson (2002a and 2002b) has been working on a series of “Diversity Surveys” that have been published by AWIS and are available at their Web site. In these surveys, Nelson presents data about the top fifty programs in a number of science and engineering disciplines comparing the number of faculty (by rank, sex, and race/ethnicity). Not surprisingly, a large majority of departments in ChemE, ME, EE, CivE, and CS are all white and male.

Also, numerous small-scale reports on the status of women can be found via the Web. With the exception of the various MIT studies — which had principal investigators like Hopkins (2002), who presented findings in many print and conference contexts — most college and university-level re-

ports are only available from the homepage of the college or university. If you are curious about whether your alma mater has paid any attention to the status of women, visit its homepage and do a search. It should be pointed out, however, that as more attention is being paid to the academic workplace in general, more universities are doing more general studies about the quality of worklife or “climate” without using the key phrase “status of women.”

Research Findings

More than 50 research studies were examined for this article. We have placed greater emphasis on findings that are reported in peer-reviewed publications, especially those that are scrutinized by social scientists, like those from the *Journal for Women and Minorities in Science and Engineering* (JWMSE). We have chosen to omit some articles that reported on research that was either poorly designed or that were tangential to the issues in which women engineers would be interested. The research in these articles reports

Program Evaluation Basics

BY LISA M. FREHILL, PH.D.

A number of articles appear each year that examine programs designed to increase the number of women and girls involved in science, technology, engineering and mathematics (STEM). Program evaluation has become an important tool for determining how limited public and private funds are spent to increase women’s access to STEM. There are many different kinds of program evaluations. Here I will discuss several different types and the kinds of conclusions one may draw from these methods.

First, many times when a program is new, the people involved with the program are interested in making continuous quality-improvements. Formative evaluation refers to this process. Articles that focus on a particular program and how it is run and what they would like to do to improve the program are exemplified by a piece by Nicoletti. In this piece, the author examines data over time, for the program to decide whether or not they need to change the way they admit students. In the course of the evaluation, the author found that changing the admission process could have an adverse affect on the program, therefore, she decided to keep the same process.

Second, people want to know whether or not a program works. Is single sex education a good thing? Did a summer program for 8th grade girls really make more of these girls decide to pursue STEM fields? Summative evaluation is used to answer these questions. The standards by which the findings of these evaluations are judged are fairly strict in the social sciences, although we do recognize that some elements of an

ideal and strong research design may be missing.

The real name of the game when it comes to strong research design is reducing the various threats to validity. Social scientists use the term validity to refer to whether or not a particular study’s findings hold up under intense scrutiny. The social world is a complex place: people are not machines! That means that social researchers are always faced with the challenge of naysayers who say “Yeah, but did you consider . . .”

So, social scientists use research design to deal with the potential threats to validity. The “gold standard” for summative evaluation is the Solomon four-group design, but the design is difficult to apply in the real world. The second best thing to the Solomon 4-group design is the pre-test-post-test control group design. This is similar to the kind of research-design used for clinical trials of new drugs, therefore, much of the social science literature uses the language of experimental design.

	TIME 1		TIME 2	
	Program Group	O ₁	‡ Program ‡	O ₂
Control Group	O ₃	‡	O ₄	

To determine if the program had an effect, the evaluator compares the observations (O₁, etc. as shown in the diagram) at the two points in time for each group. For example, suppose these O’s represented students’ scores on a test of interest in math and science and that the program in question was supposed to increase students’ scores. For the researcher to document a con-

about: (1) programmatic efforts to encourage women and girls to pursue engineering; (2) the factors associated with why women and girls choose (or, more often) don't choose engineering; (3) the experiences of women and girls in science, technology, engineering and mathematics (STEM). To better help you understand the literature about program evaluation, we have included a box about this particular area of social research.

The quality of research varied substantially from those that employed "convenience samples" — such as surveys administered to classes at colleges and universities, which are generally considered unacceptable in social science — to those that had carefully selected samples and controlled research. Just because a researcher did not use a strong design, this does not mean that the research should be dismissed. Instead, each piece needs to be understood within the broader framework of research in a particular area, and research findings based on convenience samples need to be viewed with much

caution. But because the quality varies, that means that there is the potential for inconsistent findings.

Evaluations of Programmatic Efforts

Goodman Research Associates was funded by the National Science Foundation to do a large-scale study on the experiences of women in college engineering. Data were collected from students, WIE program directors, engineering deans and faculty, institutional databases, and site visits by Goodman Research Associates. This carefully collected and analyzed qualitative and quantitative data led to the following conclusions:

- Pre-college exposure encourages students to pursue an engineering major.
- Women are most likely to leave engineering majors in their freshman or sophomore years.
- Women are not leaving engineering because they can't make the grade.
- Women's self-confidence must be recognized as a major factor in persistence.
- The climate in college engineering

affects whether women persist.

- Women undergraduates in engineering need community.
- WIE programs are beneficial, and they are challenging to administer.
- Schools can benefit from close institutional data-keeping and analysis.

This report will be important to advocates of women in engineering and educators in designing new programmatic initiatives to address the low level of women's participation in engineering. Cunningham and Goodman presented their results at WEPAN.

Pre-College Programs

DeGuzman's 2001 dissertation evaluated the effectiveness of teacher-intervention programs in cultivating the participation and achievement of girls in 7th grade mathematics classrooms. Using a design that included a comparison group, DeGuzman's carefully designed study concluded that a gender equity intervention program did not affect the classroom environment or the participation of girls within the classroom but that the increased atten-

clusion of programmatic impact, $O_2 - O_1 > O_4 - O_3$.

The possible participants are located and randomly assigned to either the program or the control group. When random assignment is impossible — which is the case many times — then the control group is called a comparison group. Researchers will work hard to identify a group that is at least as similar as possible on fundamental demographic characteristics like age, sex, race/ethnicity, socioeconomic status, etc. so that they can document that the program actually had an effect. The comparison group is essential to avoid threats to validity like:

- ▼ **MATURITY:** program participants grew and the program simply happened at the same time as other developments.
- ▼ **HISTORY:** the effects were likely to be observed because of other factors in the environment that were also changing.
- ▼ **TESTING:** the mere process of testing people alters their behavior.

Two groups are examined prior to the program. One group is given the treatment (in the case of a program, this is the program or participant group) and the other group is either not given any program at all or is given some other program (this is the control group). At the end of the program, these people are all given some sort of post-test or some other characteristic of interest is measured (e.g., grades, selection of an engineering major, persistence in school, etc.).

One threat to validity is that somehow the people who participated in the program are different from people in general. In the best-case scenario, people are assigned — just like in clinical drug trials — by random to either the program or the control group. Of course, the best-case scenario rarely exists

in the real world of programs. Programming aimed at increasing the number of women and girls most often involves self-selected participants, who already may be more motivated to participate in STEM than their counterparts. In addition, the selection process programs may be biased in favor of girls from more affluent families or families in which there are fewer cultural restrictions for female faculty members. So it is often the case that the program participants are very different from their peers even at the start.

Sometimes programming occurs within a school. For example, in the article by Baker, the author was interested in whether single-sex math and science classes would have a positive impact upon girls' science and math achievement. Obviously, within a particular school, it would be difficult to have a control group that is insulated from the program group. However, forming a comparison group within the school that is similar to the group receiving the programming, especially if this other group can be given some other programming besides the one you mean to test, is better than having no comparison group at all.

In summary, program evaluation is an important social research approach because evaluation helps us to improve programs, allows us to determine whether programming had the effects that were intended, and can reveal unintended effects of programs. But, just as in the natural and physical sciences, there are proper standards of research. Unlike the natural and physical sciences, however, social scientists must operate in the more "fuzzy" social world, where upholding idealistic standards may not always be practical or even ethical.

tion — for both the program and comparison groups and for both girls and boys — led to higher math averages.

There has been quite a bit of debate about the merits of single-sex education over the past several years. Some advocates of single-sex education, especially for math and science education in middle and high schools, claim that single-sex settings enable girls to thrive and approach mathematics and science without various forms of teasing (including sexual harassment) by their male counterparts. On the other side of the debate are people who question single-sex education for one of two reasons: (1) that boys actually “lose” because co-educational settings are better for their achievement and (2) that philosophically single-sex settings mean that existing gender relations, including the interactions of boys and girls, go unchallenged and that whatever positive impact there may be on girls will eventually be lost after the student leaves the single-sex environment.

Parker and Rennie compared gender-inclusive strategies in coeducational and single-sex high school classrooms. Ten rural and urban Australian high schools are taking part in the Single-Sex Education Pilot Project to determine if female participation and outcomes in mathematics and the physical sciences and teacher awareness of gender issues in the classroom are increased in single-sex settings. Without evaluating the single-sex setting’s impact on girls’ chances of participating in math and science, the study found both girls and boys benefited from single-sex classroom initiatives because it allowed teachers to focus on the gendered educational deficiencies of the students and allowed teachers to not have to deal with confronting boys’ sexual harassment of girls. Boys’ shortcomings were in the areas of language and communication, while girls’ shortcomings were in hands-on work. Finally, the success of single-sex education was dependent upon teachers’ commitment and the support of parents, students and the community.

Craig used qualitative methods to examine how a two-week summer in-

stitute influenced teachers’ ability to apply information about gender differences in the classroom and 5th-8th grade female students’ attitudes towards science, mathematics and computers. Not surprisingly, female students’ perceptions of science as a male field changed during the two-week program and the girls expressed a preference for the single-sex environment immediately after participating in the single-sex summer program. Further, girls’ interactions with each other while using computers were more like those of boys described by other researchers. Craig also found that most teachers did not use the information they learned during the gender-differences awareness workshops in the classroom.

Other studies also attempted to understand the impact of single-sex education on girls and boys. Baker’s study of an experiment in single-sex middle school mathematics and science classrooms in a southwestern urban area used multiple qualitative methods — classroom observations, interviews with teachers and students, review of students’ work, and students’ grades — to document that the single-sex context did increase girls’ achievement, feelings of empowerment, peer support, and self-concept. While boys’ grades were also higher in the single-sex environment, the overall impact was less positive for boys than girls. Boys’ single-sex classrooms environments, for example, were less supportive. Because the study lacked a comparison group, the findings do not unequivocally mean that girls will benefit from single-sex middle school math and science classrooms.

A 2001 dissertation by Edwards at Georgia State University compared one single-sex to one co-educational algebra classroom taught by the same male instructor to determine how this environment affected levels of mathematics anxiety, achievement and classroom performance. Apparently, female students in the single-sex classroom exhibited higher levels of success in the classroom than did girls in the coed class. Girls’ participation levels were higher in the single-sex class, but, confirming prior research on sexism in educational settings, the teacher was

responsible for girls’ marginalization in the co-ed classroom.

One question concerning programming to recruit girls into engineering is whether or not the programming has a lasting impact.

That is, pre-tests at the start of programming, then post-tests immediately after the program, invariably have very positive results. Phillips, Barrow and Chandrasekhar, while not using a comparison group, were able to document that one program did have a lasting impact upon high school girls’ interest in science and mathematics. Although the girls were self-selected participants in the program and likely to have a high level of initial interest, Phillips et al. demonstrate the need for programs to remain in contact with participants in order to insure that the program’s desired long-term goals can be met. The researchers’ use of standard and widely-available instrumentation to measure students’ occupational and science interests enables some comparison to larger samples and should be used by others interested in evaluating the program’s impact on participants.

Nicoletti’s article reports on a formative evaluation of the admissions procedure for a summer outreach program for girls in Worcester County, Mass. Nicoletti looked over the course of several years’ applications, which included an essay that had to pass a basic quality threshold. Admissions were competitive: only 30 participants of 70 who applied could participate. Nicoletti wondered whether making the evaluation guideline stricter would be appropriate. She found that doing so would mean that the program might not be able to reach some very deserving girls from lower class backgrounds who do not write stellar essays but who excel in the program — precisely the girls whom the program hoped to reach.

Davis’ formative evaluation of an urban after-school Explorer’s program for 6-12 year-old girls highlights the importance of stable funding for these kinds of programming efforts. Davis studied the case of a program that was part of a “Girls’ Club” that was merged with a “Boys’ Club.” The merger of the two programs was necessitated by the change in funds provided by the city in

which the two programs were located. The girls' and boys' programs were originally very different, but after the merger there was pressure on the newly consolidated organization to provide the same structure science programming for boys that had been offered to girls. As a result of insufficient resources (not enough staff and staff salaries that were too low), the Explorer's Program suffered. Programming was not consistently available and many girls who had previously been very interested in the program were unable to keep track of the ever-changing Explorer's program schedule. Davis points to the need for programs to recognize the differences between girls and boys and to make sure that the community has a voice and supports a program in order for the program to be most effective in achieving its goals.

Edwards' (2002) dissertation at the University of Colorado is a formative evaluation of a program that targeted low-income African American middle school girls. Edwards designed technology-rich activities and experiences for an after-school program so that the girls could learn to use science in diverse ways, while at the same time presenting them with strong African American female role models (area businesswomen who were able to show the girls that science and technology were avenues to higher income and status).

Huge, Houdek, and Saines briefly evaluate the addition of a team library project to a two-week intensive summer program for minority and women high school sophomores at The Ohio University. The article describes the program with hints for success based on the authors' experiences. The authors have found that students learn best when they are in teams of 4-6, are provided with a list of topics that will ensure searching success, and are held accountable for their searches by doing a short presentation with challenging questions posed by the librarians.

A formative evaluation was performed by Jones et al. for the Texas Academy of Mathematics and Science to determine why bright and gifted students who had applied to the two-year program failed to complete the application process. The residential

program allows students to earn dual credit in high school and college courses. In surveys of students who had decided not to pursue the program, Jones et al. found that most students indicated that they were not willing to abandon their current school and its extracurricular activities. Hispanic students were also more likely than white students to report that financial concerns played a role in their decision not to apply to the program while female students more often than male students indicated that their parents would not allow them to move away from home.

Boudria evaluated Bristol Community College's Women in Technology Program in which high school women from academic and technical-vocational high schools worked in teams of eight on specific engineering projects at Texas Instruments Incorporated and Leach and Garner. After eight months they presented their projects to advocates, mentors, community members and educators. Sixty-five percent of WIT students who enrolled in the program from 1997-1998 are seeking engineering or computer technology degrees. This study had no comparison group and involved self-selected participants.

College Programs

Atkin, Green and McLaughlin's article in the *Journal of College Science Teaching* offers no new insights into the problem of retaining women in science during college and, in fact contains a number of errors due to an outdated review of the literature.

Rinehart and Watson evaluated the new curricula-model in place at Texas A&M designed to increase the number of women graduating in the field of engineering. The new model is based on the Learning Community Theory and involves an increased linking of courses, active learning strategies, and team-taught courses. The program has proven successful, with data indicating students have a better conceptual understanding of material in comparison to traditional teaching methods. Students completed the curriculum in less time, with higher grades and were retained at a higher ratio in this new curriculum.

Roberts, Kassianidou and Irani re-

port on how interventions at Stanford University are being used to ensure women's success in moving through the computer science academic pipeline. Like many other programs, the authors of this article found that: "By designing an introductory course that is widely seen as relevant and supportive of its students, we have increased the number of women in both the introductory course and the program as a whole." (p. 88). There was no comparison group but other computer science and engineering departments may find the suggestions for changing the curriculum helpful.

Muller, Dokter, Ryan-Alapati, and Mueller evaluated Mentor-Net, an E-Mentoring network for women in engineering and science, particularly in a cross-cultural context. Mentor-Net has been in operation for five years. A survey conducted one year after implementation of the program concluded that 95 percent of the women who used MentorNet persisted in engineering and science. There was no comparison group and, obviously, participants were self-selected.

Why do women and girls choose engineering? What factors affect decisions at key transition points in the STEM pipeline?

Farrell's (2002) article titled "Engineering a Warmer Welcome for Female Engineering Students" will be of general interest to *SWE Magazine's* readers. The article reports on changes in ABET's standards, known as "Engineering Criteria 2000," which opens the way for colleges to change their curricula and pedagogy as they see fit. Many engineering educators and students interviewed by the author said that they saw the changes as enabling the transformation of engineering education into a more hands-on, socially relevant field, which they felt would attract more women students.

What do science shows teach children about science and engineering? Long, Boiarsky, and Thayer studied four children's science programs: "Bill Nye: The Science Guy," "Beakman's World," "Magic School Bus," and "Newton's Apple." Long et al. found that the stereotype of scientists as male and Caucasian were not reinforced

even though female and minority characters were underrepresented overall. Female characters were typically younger than male characters, and males were represented on screen for longer periods of time.

Children have already adopted sex-stereotypical behaviors by the time they attend pre-school, according to an ethnographic study by Desouza and Czerniak, who observed a university-based early childhood learning center in the Southeast during two weeks in the spring for two consecutive years. Based on the observations of 49 total students observed, the authors concluded that pre-school children exhibited stereotypical-gendered behavior during science activities as well as during free play. Boys tended to be more curious and domineering, while the girls displayed an aversion to arthropods and a compassion for other animals. The authors offer suggestions for a gender-inclusive curriculum that encourages girls to get involved.

A 2001 dissertation by Howell examined gender differences in 284 students' mathematical performance in the 3rd, 5th, 7th and 8th grade classrooms. Howell found no gender differences with regard to grades in mathematics, California Achievement Test Scores (CAT), high school mathematics placement, or self-perceptions as math-learners.

Paolucci's 2001 dissertation examined 566 students in three New England high school chemistry classes to explore the connection between students' views about the nature of science (NOS) and gender identity. There were no gender differences in students' scores on NOS. Masculinity, science, and math achievement were positively and significantly related to interest in science for both girls and boys.

Francis studied 14-16 year olds at three separate state schools in the United Kingdom (one inner city, one semi-suburban and one suburban). One hundred students from the top and middle math and English classes in the 10th and 11th grades were interviewed, about 20 minutes each, about their occupational aspirations. Both boys and girls had high occupational aspirations and both sexes upheld gender-stereotypic views of occupations. Only 10 percent of girls but 34 percent of boys reported that they were interested in technical/scientific jobs.

In Nova Scotia, the Hypatia Project strives to increase participation of women and girls in science and technology, promotes the participation of women in policy development, and promotes economic equity for women. Armour et al. conducted a survey coupled with focus groups to elicit high school students' attitudes and perceptions of science and scientists. Armour

et al. concluded that high school students have little knowledge about what a scientist is; they are unaware of the range of occupations a scientist may fill; and that gender stereotypes permeate high school students' perceptions of scientists.

Lee conducted surveys among 320 high school juniors and seniors who participated in summer programs at nine geographically diverse universities and one private school in 1995-1996. The program was designed to encourage already-interested students to pursue careers in STEM. Lee found that formation of a STEM identity was less salient for girls, whose persistence and achievement in STEM was more influenced by STEM programs and relationships — girls benefited from a friendlier academic environment. Like girls, boys' persistence and achievement in STEM depended on emotionally satisfying relationships centered on STEM activities, but program experiences had less effect on boys' than on girls' persistence in STEM.

Hughes reports on a survey of a convenience sample of 297 undergraduate students in upper-division undergraduate STEM classes at Georgia Southern University. The convenience sample means that these results cannot be generalized to any population, but the author would probably provide another researcher with the instruments to be

Conferences of Interest to Women in Engineering

JAMMIE BENTON-SPEYER

There were two major conferences — beyond SWE, of course — that focused attention on issues about women in engineering. Perusek and Layne and Sheppard reported on the International Conference for Women in Engineering and Science (ICWES) in earlier issues of *SWE Magazine*. Second, the Women in Engineering Programs and Advocates' Network (WEPAN) conference was held in Puerto Rico in June, 2002. Both conferences were attended by a range of people from industry, government, academia, and funding agencies and foundations and permitted a focused exchange of information about how to bring more women and girls into engineering and technology fields.

ICWES. The ICWES 12 webpage is available at: www.Carleton.ca/cwse-on/icwes12/junk/icwes12.htm

Engineers, scientists, social scientists and students were invited to participate in the 12th International Conference of Women Engineers and Scientists (ICWES12) in July of 2002.

The international conference is held every three years in different locations across the globe.

ICWES 12 was held in Ottawa, Canada on July 27-31. The theme was Women in a Knowledge-based Society. Panels focused on topics including women in research and development, women in computing and engineering, gender equity, balancing career and personal life, and affirmative action. Additionally, symposiums on global climate change and ethics were conducted (Sheppard). Twenty-five presenters left ICWES12 with awards for their research endeavors.

Plenary speakers included Professor Emeritus Monique Begin and Dr. Miriam Stewart. Professor Begin challenged the health industry to increase biomedical research on "daily life" concerns, ranging from osteoporosis and autoimmune diseases to mental health issues. Dr. Stewart also addressed gender and health, outlining issues pertaining to women and girls. In addition, she highlighted five research priorities, including access to healthcare and equality of healthcare for at-risk populations, chronic conditions, gender and health across the lifespan, the promotion of positive health behaviors, and gender and the environment.

used in a better-designed study. Hughes found that females did not differ from males in terms of class participation, commitment to major, or subjective and objective achievement, but females were more likely to say that they planned to enroll in graduate school. Female and male respondents indicated that science was sex-typed masculine but this attribution did not affect their own sense of gender identity. That is, females said that science was masculine, but did not necessarily see themselves as masculine.

Blättel-Mink presents results of a survey of 224 students and possibly 20 interviews with male and female students majoring in constructional engineering, chemistry, business management, and German studies at a German university in Baden-Württemberg. Although many methodological details are missing, and Blättel-Mink does not present a detailed analysis, she indicates that a student's family has an impact on the choice of major, but it is unclear whether this impact is due to the family's socioeconomic status, finances, or some other effect.

An important cross-national study of 12 industrialized nations by Charles and Bradley appeared in a top sociology journal using data about women's representation in various STEM fields, women's

labor force participation data, and attitudinal data from the International Social Survey Program.

Charles and Bradley indicate that women are more likely to major in engineering in those countries where people expressed stronger gender-egalitarian cultural attitudes. Wotipka (2001) is another cross-national study that shows that as women's participation in higher education increased in general, so too did their participation in science and engineering. Wotipka concludes that larger, global processes account for women's increased participation in science and engineering by linking these trends to trends in how United Nations' publications portray the transformative potential of science and technology.

Lasiewski's dissertation (2001) analyzed 1994 data from the first follow-up of the 1993 Baccalaureate and Beyond Longitudinal Study by the National Center for Educational Statistics to understand the factors that affected students' decisions to go to graduate school. Females compared to males, and non-white students compared to white students, were equally likely to enroll in graduate school. However, childbearing and marriage affected women's rather than men's, and minority rather than white students' pathways into graduate school.

What are women's experiences in engineering?

There are two kinds of studies that answer this question. The first kind of study relies upon quantitative data to discuss women's status, often broken down by race/ethnicity in addition to gender, relative to that of men (usually specifically white men). Nelson's work as well as the other large-scale studies reported by the NSF and the Commission on Professionals in Science and Technology exemplify this work. There are also smaller-scale studies that seek to quantify women's experiences in engineering and the relationship between various psychological attributes (like self-esteem and self-efficacy) and persistence in engineering.

The second kind of study involves more qualitative research methodologies to describe how various women have experienced engineering. Studies on the "chilly climate" like Ferreira's case study exemplify this research. In this study Ferreira found that research labs were "chilly" for women graduate students in science by using in-depth interviews, field notes from a support group for women in science, and departmental records. In evaluating qualitative research, there are a few factors to consider. First, it is important that the researcher uses more than one research method — this is known as triangulation — because there are so

The larger article includes references to 11 papers that were presented at ICWES, which are accessible via the Web page. In addition, Andrews and Wilkins and Huyer and Westholm's papers are likely to be of general interest to women in engineering. Also, Brainard et al. report about the Global Alliance, an important program coordinated by WEPAN, AAAS, and AWIS that attempts to increase the international participation of women in science and engineering. The Global Alliance focuses on partnerships and collaborations in multinational settings to build networks of scientists and engineers.

WEPAN. The WEPAN website is: <http://www.wepan.org>

WEPAN was recently recognized with a Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring. The organization held its thirteenth annual national conference "Engineering for all Women: Exploring Perspectives," on June 8-11, 2002 in San Juan, Puerto Rico. Conference sessions broached issues such as the development of girls and women from all ethnicities in engineering, race, gender and institutional transformation. A session by Brady emphasized how to apply the concept of "equity filters" to evaluate programming and materials

to insure that diverse people are represented.

The conference consisted of presentations, poster sessions and workshops, all revolving around the theme of increasing women in the engineering workforce and restructuring environments so they are conducive to this goal. Keynote speakers Mabel Esteves Velasquez, Diane Murray and Ruto Sevo brought their individual experiences to share with conference attendees. Also, two multi-cultural panels were conducted, titled, "Tying it all Together: Reflections across Cultures and Challenges for the Future" and "Reflections across Cultures on Engineering, Education and Practice."

Finally, WEPAN recognized one organization and two individuals for "outstanding contributions to enhancing the success of women in the engineering profession." The Electrical Engineering and Computer Sciences (EECS) Center for "Undergraduate Matters" at the University of California, Berkeley, was recognized as an exceptional program and model for other institutions for improving the educational environment and offering professional guidance to students. Dr. Mary Frank Fox and Linda Scherr were awarded the WEPAN Betty Vetter Award for research and the WEPAN Founders Award, respectively.

many possible sources of bias. Second, each of the methods needs to be examined for these possible sources of bias, such as the size of the sample and the extent of “self selection” by respondents. For example, in Ferreira’s study, it is likely that women who participate in a support group for women (i.e., they are already self-selected) are more likely than women who do not participate in such a group to be more aware of possible gender issues.

Pre-College Experiences

Science fairs are, perhaps, the first introduction that students have to the practice of science. Chaudhuri and Chaudhuri examined gendered participation patterns in a five-year study of Canada’s largest regional science fair, the Calgary Youth Science Fair. Over 4,000 student-profiles were examined in this study to find that slightly more female students participated in the science fair than male students. Higher participation rates for both sexes were found at the elementary level, while participation dropped for both sexes in higher divisions. Female students were more likely to take biology, while males were more likely to take physics. Medal-recognition was higher for males than females.

Wood used both qualitative and quantitative methods to explore the perceptions of science by 12 gifted Canadian girls in grades 4-6. Wood concluded that peers, teaching methods, feedback, ability to voice opinion, and equity were influenced by the school environment. Fun in the classroom emerged as imperative to overall success. Parents assisted their gifted daughters by filling in the information gaps not supplied by the school.

Strand and Mayfield asked retrospective questions of 355 young (21 years of age and under) female college students concerning high school math experiences. They found that teachers who had used alternative “female-friendly” teaching styles such as emphasizing the success of the many rather than few and establishing a strong real-world connection to mathematics fostered in female students a higher propensity in math and an increased desire to continue to study math in college.

Chinn’s in-depth interviews of four

Asian-Americans from different backgrounds explored how culture affected the women’s experiences in science. Two of the women had been born in Honolulu, one was raised in the continental United States, and the fourth was born and raised in Japan. Chinn found that Confucian beliefs in educating women to be wives, mothers and daughters can pose significant barriers with regard to women’s educational attainment. While gender-equity science practices within the K-12 classroom have heightened girls’ interests and capabilities in science, this has not changed parents’ traditional beliefs, which often culminate in male siblings being sent to private schools or college, while girls are afforded fewer educational opportunities.

College Experiences

Shain’s dissertation research involved qualitative one-hour interviews to study persistence and success patterns of 12 undergraduate, female, African-American engineering students at two northeastern engineering schools. The study found these factors affected persistence: the ability to develop short and long term goals through each woman’s belief in herself; participation in inter-cultural family gatherings; and balance between academic and social life and having a supportive confidant.

Heyman, Martyna, and Bhatia used convenience sampling to survey 142 computer science and engineering majors (38 female, 104 male) and 96 non-engineering majors (57 female, 39 male) to show that female engineering students were more likely than male engineering students to view engineering ability as “fixed.” That is, when women do not do well in an engineering course, they view their performance as indicative that they (women) do not have what it takes to be an engineer. Consistent with earlier findings by Frehill (1997) women engineering majors versus non-engineering majors placed more emphasis on factors such as high pay as the reason for their choice of a college major and female engineering majors were more likely to say that they received differential treatment based on gender than their male counterparts.

Tharp’s dissertation was a cross-cul-

tural study using both qualitative and quantitative research methods. Questionnaires and individual interviews were conducted to examine the influential factors in the career development of 26 women engineers. There were eleven European Americans, eight Native Americans, five Hispanics and two African Americans. Tharp concluded that respondents’ self-efficacy increased through educational, professional and personal support. While barriers such as isolation and sexual harassment were encountered, when these barriers were overcome, self-efficacy often increased as a result of surmounting these barriers. Lack of career opportunities and limited support led to lessened self-efficacy for some respondents, which resulted in leaving engineering or modifying career goals in a downward direction.

Joyce’s 2001 dissertation attempted to determine if there was a relationship between the institutional engineering culture at the department level and the “production” of male and female doctorates in the engineering field by aggregating data from four national database sources. A higher percentage of women doctoral students enrolled at more prestigious schools but women were more likely to complete doctorates at less prestigious schools.

Industry has been asking academia to better prepare students to work in teams for the past 10-15 years.

In addition, women-in-engineering advocates have been instrumental in educating engineering educators about the important collaborative skills that women often bring to engineering — skills that need to be further developed via more collaborative learning and teaching strategies in engineering. Research interest in understanding the dynamics — especially the gender dynamics — of teamwork in engineering education has also increased. Several pieces used a range of qualitative methods such as participant-observation and in-depth interviews with students and teachers to explore women’s experiences of teamwork in engineering school.

In a rich ethnographic study of two teams in a Canadian engineering classroom, Ingram and Parker reveal “successful collaboration was influenced

less by gender and more by such factors as a strong work ethic, team commitment, and effective leadership.” (p. 33).

Effective leadership was lacking in Ferreira’s analysis of two female graduate students’ experiences in their research labs. Ferreira used an in-depth case-study approach to describe how two highly talented women graduate students in chemistry experienced a “chilly climate” working in two different labs. In the one case, the student was able to successfully complete her doctoral degree because even though she experienced a chilly climate due to her male labmates, the faculty advisor was able to more effectively manage the situation to enable her success. On the other hand, the second woman’s advisor was largely responsible for creating the chilly climate she experienced: He singled her out for public humiliation on numerous occasions and was instrumental in her leaving the program without a doctoral degree. The findings point out the need for graduate advisors to be mindful of differences in males’ and females’ attrition rates and the need to exert leadership to insure equitable treatment of students in group settings.

Burris (2001) examined teamwork using surveys of 38 team members at a Fortune 500 aerospace company. This research underscores the problems of “tokenism,” originally detailed in the rich research of Kanter’s study of women’s early experiences as managers in the 1970s. The addition of one or two females to a team produced an adverse effect on overall effectiveness, but the addition of three or more females produced a beneficial impact compared to all-male teams.

Workforce Experiences

Adamuti-Trache and Andres used longitudinal data on 622 females who graduated from high school in 1988 in British Columbia with an interest and talent in science. By 1998, 332 of these women had earned college degrees in both science and non-science majors. Among those who earned degrees in science, 75 percent were in life sciences majors. About one-in-four women with an interest in physical sciences actually earned a college degree in a STEM field.

Ahuja’s ICWES paper provides a comprehensive review of research on women in information technology (IT), including the influence of gender on technological innovativeness, and the promotion of women in IT. Long discusses the small numbers of women in academia.

Prokos’ (2001) dissertation looked at the sex gap in pay in science and engineering using data gleaned from a collection of three national surveys of degree holders from the NSF SESTAT. The sex gap in wages was higher for older cohorts and lower for younger cohorts, a finding partially consistent with earlier research reported by Morgan (1998). Glass ceiling effects on earnings varied according to the level of sex segregation within the field. For example, Prokos found that occupations with 30-50 percent female employees had greater glass ceiling effects than those dominated by men (i.e., 70 percent male or higher — engineering is a male-dominated occupation). An IEEE report (2002c) documents a fairly narrow sex gap in pay. Among the organizations’ membership, a survey was completed by 9,500 members, of which 7 percent were female. Women earned an average of \$0.93 for every dollar earned by their male counterparts. See also Appiah for earnings models — this dissertation also examines the impact of race/ethnicity on earnings in addition to sex effects.

A common explanation for women’s lower average earnings than men and for non-whites’ lower earnings compared to whites is that white males have higher productivity than any other demographic group. Jackson’s (2001) dissertation indicates blacks, Hispanics, and white women faculty all performed at or above the levels of productivity of white males in all three important areas of academics’ jobs: teaching, research, and service. Asian faculty performed at higher levels than white males.

Pripic studied scientific productivity of young scientists (under age 35) in Croatia. Pripic found that while men did publish more than did women, inequalities at the very outset of women’s careers disadvantaged them in Croatian science. Women who attended international conferences were more productive than those who did

not. Pripic concludes that the increased differential productivity of men and women was a result of the introduction of an increasingly selective and competitive scientific system that stresses publication in international journals: i.e., “male scientists have set the standard for productivity.” (p. 49)

There has been a common perception that women’s retention in the engineering workforce is problematic.

Several studies in the past couple of years have addressed this issue. Reeder, Fitzpatrick and Brown provide information about several companies’ “remedies” to the general problem of job satisfaction among women, was a way to retain women within the organizational ranks. Procter and Gamble, Deloitte and Touche, and IBM were among the companies employing innovative methods to improve the representation of women. Changes employed by these companies included increased recruitment efforts and internship opportunities, increased top management and commitment, flexible work arrangements, and approval of “women-style” networking expenses (i.e., spa visits). The early impressions at these companies are that these efforts have been somewhat successful in improving women’s retention at those companies.

Ever since Schwartz’s controversial but now-classic “mommy track” article appeared in the *Harvard Business Review* in 1989, strategies to provide women with meaningful work that enabled them to balance a career and family have been undertaken by some U.S. companies. The question remains, however, whether being on this “mommy track” unduly hurts women’s careers. In an interesting case study of a Swedish computer company, Salminen-Karlsson (2002) documents that women in one department were treated differently because of the potential for women to hold part-time positions. It was assumed that women were not able to work on projects that required travel and overtime, so, with limited projects, these women’s careers were shaped by the needs of the department. In another department women were assumed to be the same as men, since all workers worked full

time. However, even in this department, women were considered stable whereas men were considered mobile, meaning men's advancement was enhanced greatly by the informal contacts they met through travel.

Layne et al. (2002) report on the role of technical organizations in the advancement of women in science and technology. The article cites representatives from four of the largest U.S. professional engineering societies: ASME, IEEE, AIChE, and ASCE. The article outlines a multitude of programs, grants and awards, initiated by each organization with the goal of the recruitment and retention of women scientists. IEEE's Women in Engineering Committee offers an extensive suite of programs to support women IEEE members.

MacLachlan used questionnaires and two - four hour telephone interviews to examine the career paths of 31 women who obtained Ph.D.s in various SET fields at the University of California, Berkeley between 1980-1990. At the time of the study, 16 of the participants taught in colleges or universities, three women were employed in academic research positions at universities, four worked in government agencies and laboratories, four conducted research in private industry, one was a science librarian, one led an alternative educational organization, one was a lawyer, and one left the workforce to have children. The career paths and choices of the women greatly varied, but there were many similarities with regard to their experiences in the workforce. Many of the women were able to balance career and family demands through part-time work at various times during their careers. Despite the presence of (sometimes intense) sexism and racism, most of the women chose not to focus on these barriers. Often, organizational dynamics that conflicted with personal priorities made it difficult for these women to receive the same treatment as men within their work organizations. Overall, the experiences of these women were characterized by difficulties in finding a career that suited them and their priorities. Underemployment, such as part-time or non-scientific work, and academic positions characterized by negative experiences

sometimes led the women to choose career paths away from STEM. Additionally, many of these women made professional concessions for their husbands and children.

Kulis, Sicotte, and Collins analyzed data on 1976-1989 doctoral cohorts gathered through the 1989 "Survey of Doctoral Recipients" conducted by the National Research Council. There were several important findings. (1) At the end of the 1980s women were poorly represented in the physical sciences, but were nearly equal to men in the social and behavioral sciences. (2) The increase of women in the physical sciences occurred after 1976, therefore, these women had little time to advance into tenured positions by 1989. (3) Women's representation in computer sciences declined after 1976. (4) Women's representation in tenured faculty positions was less than their representation in the doctoral labor pool, indicating that the commonly-cited "pipeline" problem was not the reason for women's underrepresentation in faculty positions in STEM.

Bartolomei-Suárez et al. present a pilot study with an unacceptably small sample size (either 12 or 16 people — it is impossible to discern sample size in the article, which itself is problematic) on how faculty self-assessment might help to promote institutional change. The small sample size and failure to administer the survey to any male faculty members at the University of Puerto Rico, Mayagüez (the UPR's main campus) indicate that caution should be exercised in interpreting the descriptive results. The strategy of asking women but not men to assess their jobs is problematic from a programmatic standpoint as program planners run the risk of alienating men rather than of enlisting their support for initiatives that are likely to positively rather than negatively impact men's working lives.

Rosell's qualitative case study at an international engineering company in Sweden found that gender is created in this social context through images, interactions and self-definition. Procedures at the company and their apparent gender neutrality preserved traditional thinking about male hierarchy and brotherhood. The content and context of conversations affirmed the

notion that women and men occupy different spheres, thereby affirming segregation of men and women in the workplace. Sonyer's and Phipp's articles in the difficult-to-obtain *International Journal of Engineering Education* appear to examine how engineering professional identities are constructed and gendered. Novek's interesting article about why an automated drug distribution system was returned to the manufacturer is also an interesting item in this vein.

Jorgenson's careful and interesting study involved interviews with 15 women in a variety of engineering specialties to understand how women negotiated gender and their identity via technical work. Jorgenson's rich data enabled her to show how even though the women were reluctant to acknowledge the importance of gender in their worklives, nonetheless, gender figured prominently in how they approached their work and their own identities.

Settle (2001) surveyed a convenience sample of 259 undergraduate and graduate women majoring in science and engineering. Results indicated women who experienced less identity interference considered their woman and scientist identities compatible, whereas women who experienced more identity interference as a result of lower-psychological well being, physical health, identity satisfaction and performance, considered these identities less compatible.

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Women in Engineering:

A Review of the 2003 Literature

BY LISA M. FREHILL, PH.D., JAMMIE BENTON-SPEYERS AND CECILY JESER-CANNAVALE ADVANCE PROGRAM, NEW MEXICO STATE UNIVERSITY.

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 underrepresentation 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 Association 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 avail-

able 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 page 38) 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 accom-

plish 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 bi-monthly *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, Texas, 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 under-

	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%

	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

represented 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.

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 bachelor’s degrees in engineering in 2000 (see Table).

Locating data about the ethnic and sex composition of engineering — undergraduate students, bachelor’s, master’s, 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 are 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

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 sci-

ences 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-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

The Literature Review Process

BY LISA M. FREHILL, PH.D.

Much of the literature published on women in engineering is flawed due to poor methodology. 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.

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:

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

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 1950s. 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 1930s, 40s, and 50s. 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.

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 a 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 page 36. 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 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 pursuing 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 pursuing 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 chal-

lenging 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

INSTRUCTION	Average Score	
	Females	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%

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 prejudi-

cial 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 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.

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 affected 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 "homegrown" and particularly female, high tech workforce (Mecum and Wilkins).

These endeavors recognized the importance of networking and mentoring, and the need for recruitment and 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

Looker and Thiessen document the presence 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 ac-

cess 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 re-

tention. 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

program at Montana State University (Gallagher and Larson).

Institutions have been working hard to 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, Dellagiannino, 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>.

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, Woszczyński, 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. Also, 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 second-

ary 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.

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. ■

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Women in Engineering:

A Review of the 2004 Literature

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Overview

For this year's literature review, the ADVANCE team at New Mexico State University collected 299 sources published in 2004 and early 2005. Of those, 123 were journal articles that appeared across a wide array of disciplines. There were 14 dissertations, 37 conference proceedings papers (or entire conference proceedings), seven reports, and 118 items from newspapers, magazines, electronic sources, and other media. A total of 130 resources were finally included for examination in this year's review.

The process of assembling the literature review requires an enormous effort. The ADVANCE Program staff search online databases several times throughout the year, ordering many references via inter-library loan. In this literature review, as in the past, we focus our attention on the findings presented in peer-reviewed journals or large-scale reports by reputable organizations. While there are quite a few articles about women in engineering that appear in various trade magazines, most of these do not report original research findings. We tend to prioritize research that has been subjected to peer-review, such as journal articles and books from academic presses rather than magazine articles, which have not usually been subjected to similar review.

We have also found that even peer-reviewed articles suffer from substantial methodological flaws that call into question the reliability, validity, and generalizability of the authors' findings. For example, some articles report findings based on convenience samples, have unacceptably

low response rates, or fail to report response rates at all. In some instances we chose not to discuss the most severely flawed articles even though we do describe key methodological features so readers will be aware of each study's strengths and weaknesses.

Many dissertations about women and diversity in science and engineering were produced in 2004. More than a dozen were collected for this review. Both qualitative and quantitative (about an even split), these dissertations covered subjects including girls' science education; college science experiences and persistence; recruitment and retention in academia; mentoring; and gender, race, and ethnicity issues. Many of the best dissertations discussed the interconnections of various oppressions in student and faculty success and representation in science and engineering.

The *Journal of Women and Minorities in Science and Engineering* (JWME) 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 disciplines and, indeed, a specific focus on engineering may be construed as "too narrow" for the more important national journals in some fields. Therefore, if you are interested in the most current research on women and engineering, you should subscribe to this important journal. Likewise, the proceedings for conferences like those for the Women in Engineering Programs and Advocates Network (WEPAN) provide another regular resource for information about programming and research on women and minorities in engineering. The WEPAN homepage,

<http://www.wepan.org>, features a link to conference proceedings and reports. Because both of these resources are fairly common and well-known, we make reference in this review to only a few items from each, and, instead, dedicate space to sources that are possibly less well-known or more difficult to casually locate.

In addition, in the past year there was a special issue of the journal of the National Women's Studies Association, the *NWSA Journal*, dedicated to women's participation in science and engineering. Our review includes a couple of these articles, but we recommend that you carefully consider the others, all of which have been included in the references section. Pieces by Beoku-Betts, Bix, Bystydzienski, Hanson, Harris et al., Jackson, Kohlstedt, Niemeier and Gonzalez, Rosser and Valian were included in this important volume.

Of course, *SWE Magazine* is also an important source of reporting about the status of women in engineering. The organization has long been concerned with diversity, indicated by the many articles published this year that recognized the intersection of ethnic, racial, and gender issues for individuals pursuing careers in engineering. In a winter 2004 article, the National Action Council for Minorities in Engineering's (NACME) 30th anniversary was covered. *SWE* also covered such events as National Hispanic Heritage Month, highlighting the necessity and benefits of diversifying the engineering profession (Reydman 2004).

There are many good sources of quantitative data about women's education in general (e.g., see the National Center for Education

Statistics report *Trends in Educational Equity of Girls and Women: 2004*) and women's and minorities' participation in science and engineering (e.g., see the National Science Foundation's publication *Women, Minorities, and Persons with Disabilities in Science and Engineering, 2003*). The American Society for Engineering Education (ASEE) as well as many of the other engineering societies routinely include articles that highlight even more timely data than the National Science Foundation report on engineering and engineering technology enrollment and degrees awarded, often with the data disaggregated separately by gender and race/ethnicity (Gibbons 2004 and 2005).

"Big Stories" about Women in Engineering

This past year, several topics of interest to women in engineering have caught the media's attention or are of particular note. Perhaps one of the most important stories concerned the release of a new report by the American Association for the Advancement of Science (AAAS) and NACME titled *Standing Our Ground: A Guidebook for STEM Educators in the Post-Michigan Era*. This is essential reading for administrators of targeted programs such as those for minorities in engineering (MIE) or women in engineering (WIE). In light of recent Supreme Court decisions, the report attempts to clarify the appropriate procedures and tactics that are legal for those administering programs aimed at recruiting and retaining these targeted populations.

In addition to a "Legal Primer," the report offers advice to program administrators. First, the report stresses that administrators need to work at their institutions to create a campus mission statement that embraces a commitment to diversity. Second, programs should be built around a specific, identified problem supported by data and related directly to the campus mission statement. Third, "race-neutral alternatives" and the possible deleterious effects that could occur to omitted populations as a result of criteria for providing benefits should be considered and appropri-

ately documented. Fourth, the need for comprehensive data collection, internal and external networking, and continuous research, evaluation and analysis are emphasized as key components of any successful and compliant program. Lastly, the report underscores the need for adequate faculty recruitment and retention and emphasizes the importance of an allied relationship with leadership within the institution at every level. A free downloadable PDF version of the report is available at the AAAS Web site (<http://www.aaas.org>).

Many articles appeared in newspapers, magazines, and in the electronic media in 2004 concerning science- and engineering-based programs and summer camps designed to reach out to girls. One traveling camp called Exploring Interests in Technology and Engineering (EX-CITE) sponsored by IBM provided more than 1,000 girls around the world last summer an opportunity to meet female scientists and participate in hands-on engineering projects. Another summer conference with a focus on increasing diversity within engineering for teachers, scientists, parents and students was the 28th Annual Summer Institute of the Southeastern Consortium for Minorities in Engineering (SECME) at the University of Houston with workshops, presentations, and hands-on activities. Other outreach efforts covered this year included ExxonMobil's Introduce a Girl to Engineering Day; the University of Washington's, Rural Girls in Science program; and the University of California's, Mathematics Engineering Science Achievement (MESA) program.

Several articles reported about Smith College's Picker Engineering Program. Started in 1999, this is the first engineering program established at an all-women's college and its first all-female class of engineers graduated in May 2004. The engineering program at Smith College is noted for its basis in the humanities and its rigorous, comprehensive requirements. According to Grasso (2004), the founding director of the Picker Engineering Program, engineering is defined as "the application of mathe-

matics and science to serve humanity," and Grasso, Callahan and Doucett (2004) describe Smith's engineering program as "redefining engineering education" (p. 414). They point to at least three unique aspects of the Picker Engineering Program. The first is an emphasis on "unity of knowledge," which redefines engineering more inclusively and emphasizes its relationship to other sciences, the humanities, and social issues. The second is a focus on quantitative literacy, which they feel is often overlooked throughout a student's science education, but is a vital building block to broad-based knowledge. Third, they nurture entrepreneurship, corporate-student partnerships and industry problem-solving, while at the same time supporting engineering projects that lack corporate appeal. The Picker Engineering Program represents an exemplary new approach to engineering education. If past trends for graduates of women's colleges hold true, this program is likely to produce new leaders in the engineering profession.

Accomplishments of current women engineering leaders were also popular magazine topics. In Fall 2004, *SWE Magazine* spotlighted two female engineering deans, Dr. Belle Wei of San Jose State University and Dr. Janie Fouke of Michigan State University, as part of a yearly series exploring the influence female leaders have on the engineering profession (Layne). *U.S. Black Engineer and Information Technology* featured a number of biographies of women leaders in engineering associations and their impact on the profession. These leaders included Susan Skemp (past president of the American Society of Mechanical Engineers), LeEarl Bryant (the first female president of the Institute of Electrical and Electronics Engineering - USA), Teresa Helmlinger (the first woman president of the National Society of Professional Engineers), Dianne Dorland (president of the American Institute of Chemical Engineers), and Patricia Galloway (president of the American Society of Civil Engineers) (Phillips 2004). Finally, the November 2004 issue of *Prism* (ASEE's maga-

zine) featured a story about Sherra E. Kerns, the society's president (Halford). Dr. Kerns is now the vice president for innovation and research at the new Franklin W. Olin College of Engineering. Her platform for the presidency of ASEE includes increasing opportunities for women and minorities to pursue engineering.

The annual WEPAN Conference was held in Albuquerque, New Mexico, this year and featured speakers Patti Lopez of Hewlett Packard and Sandra Begay-Campbell of Sandia National Laboratories. Both of these leaders are natives of New Mexico: their inclusion as keynote speakers at the conference provided an opportunity for WEPAN to highlight the accomplishments of two important women-of-color in engineering (Lopez is a Latina, while Begay-Campbell is Navajo).

There was much reporting related to two other "big stories" about women engineers as academic leaders: Susan Hockfield's selection as president of MIT and Denise Denton's advancement to chancellor of the University of California-Santa Cruz. At least a dozen stories appeared in the national electronic media, newspapers, and magazines about Hockfield, former Yale University provost, between October 2004 and January 2005. (See Symond's piece in *Business Week Online* for a particularly good summary of the story.) Additionally, at least 19 different articles appeared reporting on Denise Denton's appointment as chancellor to the University of California-Santa Cruz. An electrical engineer, Denton had been the University of Washington's engineering dean (and, she is openly gay) (Bartindale 2004).

Many articles in 2004 reported on Donna Nelson's research about the representation of women and minorities among the faculty in 14 science and engineering fields at the country's 50 most elite departments. Nelson explained the scarcity of women and minorities as a result of considerable barriers to diversity including few mentoring opportunities, problematic hiring patterns, obstacles in the tenure process, and a clustering of women and minority

faculty at the lowest ranks in their departments at these elite institutions. Nelson's data and reports are available at her homepage:

<http://cheminfo.chem.ou.edu/faculty/djn/djn.html>.

Diversity in the Professoriate

Donna Nelson's research was one of many studies that examined diversity in the engineering professoriate. The first-round NSF-funded ADVANCE schools were closing out their third year of programming in 2004 while a new cohort of 10 schools finished their first year. ADVANCE programs seek to increase recruitment, retention, and advancement of women in the professoriate. Each funded institution (funding levels are \$3.5 million or more for five years) works as part of the ADVANCE community to better understand the social forces that affect women's participation in academia. ADVANCE program personnel attended conferences in many disciplines to disseminate the results of their programs in order to encourage other institutions to adopt similar strategies.

With a new National Science Foundation report (Rapoport, Bentley and Wise 2004), a new book on faculty diversity (Moody 2004a), journal articles (Jackson 2004; Mantani 2004; Valian 2004) and various magazine articles (Gordon and Keyfitz 2004; Layne 2004; Moody 2004b) questions, answers and solutions to the underrepresentation of women and minorities at the pinnacle of the U.S. science and engineering enterprise was the focus of much attention beyond the ADVANCE efforts. In many cases, as in the past, this literature featured pieces that did an excellent job on one dimension of diversity while treating other dimensions of diversity only superficially. Unlike in previous years, however, the number of counter-examples (i.e., literature that dealt with ethnicity and gender simultaneously) seems to be increasing. Frehill (2004) reviews the engineering pipeline by race/ethnicity and gender. Riskin et al. (2004) provide an important document (available online) for those interested in increasing diversity in the engineering professoriate, which was

compiled as a result of a conference on the topic.

The question remains: Why are there so few people of color among the professoriate? According to a 2003 book by Cole and Barber, the principal issue in diversifying the professoriate in science (and, by extension, engineering) depends upon academia's ability to deal with what economists call "supply side" issues rather than "demand side" issues. "Supply side" refers to the notion that characteristics of underrepresented minority groups account for their low participation rates, while those who advocate "demand side" forces as responsible for low participation cite institutional racism and other actions by employers as the cause of disparity. Cole and Barber argue that low average educational attainment among African Americans and Latinos/as is the principal reason that these groups are not highly represented among the professoriate. Their study examines the fields chosen by high-achieving African-American and Latino/a college students. They indicate that without early mentoring, including research experiences as undergraduates, high-achieving underrepresented minority students will continue to choose economically lucrative areas like medicine and law rather than the comparatively lower economic rewards of academia.

Maton and Hrabowski (2004) report on a "strengths-based" approach to increasing the number of African-American Ph.D.s in science and engineering that has been quite successful at the University of Maryland, Baltimore County (also a "second round" recipient of an ADVANCE: Institutional Transformation grant). Their approach has incorporated many elements cited as essential by the supply-siders Cole and Barber, such as early identification of students with an interest in academia and interventions to improve the human capital of the African-American student participants with important bridges between secondary and post-secondary school.

Smyth and McArdle (2004) used data from 23 colleges included in the 1989 dataset "College and Beyond"

Trends in Educational Equity of Girls and Women

The National Center for Education Statistics (NCES) recently released a new report *Trends in Educational Equity of Girls and Women: 2004*. Key findings from that report are:

- “In terms of many learning opportunities, males and females start school on a similar footing. In certain areas, females appear to start school ahead.” (p. 2)
- “Females are less likely than males to repeat a grade and to drop out.” (p. 2)
- “On a variety of measures, males seem to be more likely than females to experience serious problems at school and to engage in risky behaviors.” (p. 3)
- “High school seniors’ attitudes towards school have become increasingly negative, particularly among females.” (p. 3)
- “Females have consistently outperformed males in reading and writing.” (p. 4)
- “There are some gender differences favoring male students in mathematics and science.” (p. 6)
- “Females are just as likely as males to use computers at home and at school.” (p. 7)
- “Females are more likely than males to participate in various afterschool activities, except athletics.” (p. 8)
- “Female high school seniors tend to have higher educational aspirations than their male peers.” (P. 9)
- “Females are more likely than males to enroll in college the fall immediately following graduation from high school.” (p. 9)
- “A majority of undergraduates are female.” (p. 10)
- “Females make up the majority of graduate, but not first professional students.” (p. 10)
- “Females are more likely than males to persist and attain degrees.” (p. 12)
- “Degrees in certain fields of study continued to be disproportionately awarded to males or females, although changes have occurred in recent years.” (p. 12)
- “Females have made substantial progress at the graduate level overall, but still earn fewer than half of the degrees in many fields.” (p. 12)
- “Gender differences in participation rates in collegiate sports have narrowed.” (p. 12)
- “Employment rates for females have increased across all levels of educational attainment since the 1970s.” (p. 14)
- “Females with bachelor’s degrees tend to earn less than males with the same level of educational attainment, but the gap is narrowing.” (p. 14)
- “Females ages 25-64 have lower labor force participation rates than males, regardless of education, but participation increases with education.” (p. 14)
- “Females are more likely than males to participate in adult education.” (p. 14)

to examine persistence in science for the 5,074 students who had declared an intention to major in science. The authors found support for the notion that at selective institutions, prior academic preparation explained the high persistence rates of Asians (highest) and whites and the comparatively lower persistence rates among American Indians, Hispanics, and African-Americans. Prior academic preparation also explained the gap between men’s and women’s persistence rates. The authors’ analysis did not support the notion that more selective colleges had higher persistence rates than less selective colleges.

The actions and structure of colleges and universities (demand-side) were the focus of much attention from scholars interested in campus diversity and campus climate. Smith’s (2004) report on a campus diversity project, also available

online, focuses on the role that institutions can play in attracting a diverse professoriate. Likewise, the General Accounting Office released in July, 2004 a report titled, *Gender Issues: Women’s Participation in the Sciences Has Increased, but Agencies Need to Do More to Ensure Compliance with Title IX*, which emphasizes the key role that institutions must play in ensuring equal opportunity in science and engineering. Crowley et al. (2004) discuss the importance of minority campus-climate perceptions and suggest ways in which climate might be improved in the laboratory and at the institution more broadly. The authors note the various moral and utilitarian benefits associated with STEM field diversity in academia and provide indicator questions that should be considered when analyzing campus climate, including: “Is it easy for me to find people at my workplace of the same race?”, “Have I ever been expected to speak for all

members of my race?”, “Are my differences in race accepted?”, “Do I feel isolated due to race differences?”, and “Do I feel excluded because of race differences?” (Note: we have edited some questions because the original form was imprecise). Additionally, the authors provide ideas for enhancing climate including: developing tasks that can be done in teams, ensuring that leaders consider all perspectives when making decisions; bringing in external consultants to do tolerance training; getting together informally outside of work; mentoring; and implementing tough policy to ensure respectful workplace conduct.

Brown’s dissertation (2004) used a national sample of African-American undergraduate engineering students to determine their attitudes toward campus climate. Contrary to prior literature on climate, Brown found African-American students’ perceptions of climate to be positive. Like

other researchers, Brown found that more selective colleges and Historically Black Colleges and Universities had higher rates of retention than less selective colleges.

Demand-side forces were also the focus of two articles that appeared in a special issue of the *American Economic Review*. Following up on their 2000 book, Myers and Turner (2004) argue that persistent discrimination (e.g., tokenism, chilly climate, etc.) on the part of academic institutions plays a major role in the continued marginalization of minorities within the academy. Their economic models indicate that merely addressing the supply-side factors argued to be significant by Cole and Barber will actually do little to alter the relative numbers of minority faculty compared to non-minority faculty.

In the same volume of the *American Economic Review*, three panelists, Slaughter, Ehrenberg, and Hanushek (2004), do a nice job of framing and synthesizing the demand-side and supply-side perspectives. This article emphasizes the need to look at both sets of factors to understand how to increase minority participation in the sciences and engineering. An important shortcoming of many sources mentioned in this section so far is the classic problem of overlooking gender when dealing with racial/ethnic issues. That is, none of these authors devotes significant attention to how gender affects the participation of underrepresented minorities in science and engineering, nor the unique problems that are encountered by women of color in the academy. While Moody (2004a and 2004b) tackles this persistent problem head-on, many authors still pose ethnic and gender equity as players in a zero-sum game.

Herzig's (2004) article, like the *American Economic Review* panelists, does an excellent job of examining both supply-side and demand-side issues. Synthesizing a wealth of literature on mathematics and doctoral student attrition, Herzig argues that persistence of students in doctoral programs is dependent on their level of integration into their institutions and departments (i.e., a "persistence

framework"). Disproportionate attrition of women and minorities in mathematics may be attributed to their relative difficulty in participating meaningfully, or integrating, with faculty, other students, and in the classroom. Herzig identifies many common obstacles doctoral mathematics students face in achieving adequate participation and interaction in their studies. Several personal factors appeared as themes in Herzig's literature review, such as: women's relative lack of socialization in independence and autonomy, characteristics useful in degree completion; women's lack of confidence in their abilities; and the disproportionate burden of family responsibilities on women students. Interactive inhibitory factors Herzig identified included: the need for moral support; the inadequacy of current mentoring and advising schemes; feelings of loneliness; and women's distaste for competitive work environments. Lastly, Herzig identified community-based factors that partially explain attrition from doctoral mathematics, including: weak program structure and lack of supervision; lack of student financial support; institutions that fail to offer appropriate responses to a student's family's needs; and the state of the mathematics job market.

We again see the interplay of supply-side and demand-side factors in a study of Stanford Ph.D. recipients. Aware of doctoral attrition and decreasing rates of timeliness of degree completion, Maher, Ford, and Thompson (2004) conducted a study aimed at (1) identifying factors that facilitate or inhibit women's success in achieving a doctoral degree and (2) ascertaining the relative consistency of these constraints or aids in women who achieved their Ph.D.s over a short versus a long time span. A questionnaire was distributed to 295 doctoral alumni of Stanford University who had received their degrees between 1978 and 1989. A total of 160 respondents returned their surveys for a 54 percent response rate (which is considered unacceptably low). The authors identified six themes that either in-

hibited or facilitated timely graduation: commitment to degree completion, faculty networking, access to funding, family responsibilities, research experience and competence, and the capability of working within the academy's existing framework.

Patitu and Hinton (2004) also take on the subject of underrepresentation of minorities in academia analyzing what, if anything, has changed for African-American faculty and administrators in the academy. Based on five interviews with African-American women administrators and five interviews with African-American faculty members, the authors conclude that little has changed for the women they interviewed. Finally, they offer some tentative recommendations, such as encouraging professional networks, hiring multiple persons of color within a department to reduce isolation, diversity training, and policies of taking strict action against problem individuals as possible solutions to some of the problems identified by their interviewees. However, this like many other articles in the field, utilized what could be characterized as sketchy methodology. The sample size was small, the process by which the women were selected, other characteristics about the women, and other crucial components were not addressed at all, leaving the reader wondering about selection bias. However, the quotes and micro-analysis provided were interesting to consider.

Finally, two dissertations this year made use of the Women's Experiences in College Engineering dataset (WECE). Curry at the Colorado School of Mines found that black women were more likely than other women to persist in engineering in college. Choudhuri's dissertation at the University of Iowa worked with a set of 18 personal and contextual variables to examine how self-efficacy affected commitment to the engineering major. Many other dissertations relied on local convenience samples, which may be interesting but provide limited insight into the larger social forces that shape recruitment and retention into academia.

Motherhood and Academia. An important area of research related to women's participation in academia saw an explosion of attention in the past year. Many articles addressed the subject of balancing family with academic success. In *Academe's* November/December 2004 special edition (Vol. 90, No. 6) titled, "Balancing Faculty Careers and Family Work," various issues related to women, families, and the academy are discussed. Quinn, Lange and Olswang (2004) and Sullivan, Hollenshead and Smith (2004) analyze the role of family-friendly policies at universities. Lobel (2004) and Ward and Wolf-Wendel (2004) write about the challenges to career growth related to taking time off for children and family. Mason and Goulden (2004a and 2004b), Williams (2004), and Curtis (2004) also have articles in this edition relating to postponing children in the pursuit of an academic career, balancing work and family, and motherhood-based stereotypes in the workplace. The edition is available online at the AAUP Web site.

More specifically, Kelly and Wolf-Wendel (2004) determined how junior women faculty with small children manage their parental and professional roles at research universities. Twenty-nine women from nine different universities were formally interviewed. Thirteen of the women were from AAU top tier research universities and the other 16 were from other research-extensive universities. The interviewees were assistant professors currently on the tenure track or associate professors promoted within the past year who had children between the ages of birth and five years old. Four themes were found in the interviews with the women: joy in professional and personal roles, the idea of having both an academic and family life as "greedy," watching the clock to determine when to have children, and the way that having children puts work into greater perspective. The respondents found autonomy and flexibility allowed for them to be mothers, but also that this choice coincides with a never-ending workload, never having enough time in the day, the ambiguities of tenure ex-

pectations, and expectations for working a "second shift" at home. Policies will have to be reviewed by university administrators as they understand the experiences of junior faculty mothers.

Jacobs and Winslow (2004) analyzed data from the 1999 National Survey of Post-Secondary Faculty, which were supplemented with 2000 Census data. Their research documents the generally high workload of faculty members. On average, faculty members spent between 51 and 56 hours per week at work. Single women without children and married men (with and without children at home) spent the most time at their jobs (about 56 hours), with married women (with and without children at home) and single men spending less time (about 53 hours per week). Single parents spent the least amount of time at work, but still worked beyond the "normal" forty-hour work week: males averaged 52 hours while females averaged 51 hours. Among those who were married, female academics were also more likely than male academics to report that their spouse held a job, that their spouse worked full-time, and that their spouse was also an academic. Indeed, 29 percent of married male faculty but only 9 percent of married female faculty reported that their spouses did not work in the paid labor force.

The Science and Engineering Workforce

Academia represents a small segment of the science and engineering workforce. This past year there were many articles that explored issues about the larger science and engineering workforce. These articles highlighted issues such as: the unfilled demand for skilled workers; workforce attrition; and the need to diversify and improve the climate of science and engineering to fill positions in this important portion of the job market.

The Commission on Professionals in Science and Technology issued a report of a conference titled, *The Changing Nature of Work and Workers in Science and Engineering*, in October, 2004. This comprehensive report pro-

vides details about the demographic characteristics of the current science and engineering labor force, with a focus on several specific science disciplines (i.e., chemistry, physics, psychology) and the rise of biotechnology. On a related note, in a one page spread, Wraige (2004) discusses research conducted by the Equal Opportunity Commission, which has identified the need to recruit and retain women in the engineering profession. Ideas include apprenticeships for women and girls and other strategies designed at introducing women to engineering and improving the profession's image.

Preston (2004) examines the problems associated with occupational exit from the science and engineering workforce. She acknowledges that regardless of gender and race, occupational exit rates from the natural and physical sciences far exceed the rates in the comparable social sciences. Preston offers a number of recommendations for simultaneously reducing attrition and making careers in the sciences more desirable, which would benefit both men and women pursuing careers in these fields. These suggestions include: ensuring that students of science are better informed about what they will encounter in scientific careers so they know if their expectations are likely to match their intended careers; increasing pay and non-monetary benefits of science and engineering positions; establishing family-friendly policies such as dual career options, on-site day care, and flexibility in working hours; continuing formal mentoring opportunities for women encouraged by those at the top of the organization or institution; and providing skills-updates and training programs so men and women can stay on top of their ever-changing disciplines.

Reviewing literature on the recruitment and retention of women and minorities, Tapia and Kvasny (2004) review the components of the IT workforce crisis, discuss various theoretical perspectives, and offer suggestions to managers in the IT industry aimed at recruiting and retaining talented women and minorities in the field. According to the

authors, currently women and minority IT employees lack access to mentors, have feelings of unmet expectations, experience stress, and are exposed to a male-dominated, sometimes hostile, workplace culture, all of which contribute to their low numbers in the industry. Among the authors' many recommendations to remedy this situation are: the development of role models and mentors, community-based workplaces with an emphasis on the importance of family, diversity and tolerance training, a focused effort on hiring more underrepresented groups into positions of power, counseling programs, and appropriately enforced employee conduct rules.

Research on K-12 Preparation for Engineering

Of course, when it comes to understanding the social forces that affect differential participation in engineering, the "pipeline" is a significant issue. The underrepresentation of women and minorities in the engineering professoriate in particular, and the engineering workforce in general, is likely to persist until K-12 educational differences for girls and especially minorities are addressed. The National Center for Education Statistics (NCES) recently released a new report titled, *Trends in Educational Equity of Girls and Women: 2004* (see box on page 47 for key findings). In a nutshell, at the K-12 level, the math and computer usage gender gaps have disappeared; a small science proficiency gap remains; and girls outperform boys in reading and writing and are less prone to behavioral problems.

The NCES indicated that male students were favored in mathematics and science — but in far fewer ways than ten or fifteen years ago. Males were more likely to take AP exams in science and calculus but, in terms of performance, there were no significant differences between girls' and boys' proficiency in mathematics. There does remain a slight gap in girls' scores on AP science exams relative to boys' scores, and younger girls' proficiency scores lag behind those of younger boys' (fourth and eighth graders).

The availability of advanced placement (AP) courses has long been an issue for schools located in poor and minority communities. Klopfenstein (2004) documents the persistent gap

between whites and minorities in participation in AP courses using data from the Texas Schools Microdata Panel for the 1998-99 academic year. These data included in-

Engineering Conferences 2004

At this year's American Society for Engineering Education (ASEE) Annual Conference and Exposition, "Engineering Education Reaches New Heights," a number of papers salient to the topic of women and engineering were presented. The conference held in Salt Lake City last summer had many interesting sessions including: "K-12 Engineering: The Future is in our Hands," "The Changing Face of Engineering," and "What Will it Mean to be Educated in the 21st Century." The conference generated dozens of articles, all of which could not be discussed here, but they are all available for free PDF downloading at the ASEE Web site.

Many authors tackled the subject of mentoring female engineering students (for example, Dockter 2004 and Demir 2004). In addition, at least two articles discussed community-based approaches to mentoring. Eschenbach & Cashman (2004) describe a community-based service-learning project which blends youth outreach, peer mentoring, and community service undertaken by the Humboldt State University section of the Society of Women Engineers. A similar project initiated by Utah State University's SWE section worked collaboratively with local girl scouts to increase interest in engineering and build peer mentoring networks (Haupt & Gregory 2004).

Eight articles discussed the role of race and ethnicity in engineering outreach programs, recruitment, and persistence. Four of these discussed specific outreach projects. Llewellyn, Uselman, & Gaughan (2004) report on an NSF-funded Alternative Pathways to Success in Information Technology (APSIT) program; Kuyath & Yoder (2004) discuss the Diversity in Engineering Technology Project, the Junior Engineering Technical Society (JETS) and the Tests of Engineering Aptitude, Mathematics and Science (TEAM+S); Lawrey, Heyman & Rockland (2004) discuss the Pre-Engineering Instructional

and Outreach Program (PrE-IOP); and Crawford & Schmidt (2004) discuss the University of Texas at Austin's Achievement in Mathematics for Engineering (AIM for Engineering) program. Taking into account a global, ethnically-conscious consideration of engineering, Sukumaran, Hartman & Johnson (2004) highlight a successful and inclusive engineering program in Kerala, India. Rochefort, Levien, Ford, & Momsen (2004), Purdy & Kane (2004) and Carver (2004) also discuss diversity in engineering topics.

Moreover, many articles addressed programs and courses designed to increase female success in engineering (see Bogue & Litzinger 2004; Diefes-Dux et. al. 2004; Watford & Artis 2004; Pawley 2004, Reisberg et. al. 2004; Wasburn & Miller 2004; Rajala et. al. 2004; and Cano et. al. 2004 for examples). Other articles addressed subjects as various as female engineering student self-presentation (Waller 2004) and fine arts and engineering (Chesler & Riley 2004).

However, many articles at this conference suffer from common methodological problems such as small sample sizes, failure to report response rates, convenience sampling, and reporting on pilot studies which have yet to have time to produce any meaningful results, so readers should be aware of these shortcomings and weigh the results of these articles accordingly.

The 2004 ACM-SIGMIS CPR (Association for Computing Machinery Special Interest Group in Management Information Systems Computer Personnel Research) titled, "Careers, Culture and Ethics in a Networked Environment," was held in April in Tucson, Arizona. Several articles, some discussed elsewhere in this paper, addressed issues of gender, climate and lack of diversity within information technology. Roldan, Soe & Yakura (2004) examine the idea of workplace climate and women's perceptions of these climates as it relates

formation from Texas public high schools about courses taken by 723 white students, 639 black students, and 719 Hispanic students. Data about AP courses in 19 different sub-

to retention and success within IT organizations, proposing a future research design. Ahuja, Robinson, Herring & Ogan (2004) report on research-in-progress regarding an NSF funded pilot project at Indiana University to encourage women and girls to enter into IT fields and careers. Trauth, Quesenberry & Morgan (2004) argue that analysis of individual differences among women is important in understanding women's underrepresentation within IT. They reported on the first phase of interviews done with 44 women IT practitioners and academics in Massachusetts, North Carolina, and Pennsylvania. Though only in its formative stages, the authors are concerned with the effects of personal data (demographic, lifestyle, and workplace information), shaping data (personal characteristics, personal influences), and the informant's environment (cultural attitudes and values, geographic data, economic data, etc.).

Two symposiums were held this year honoring female leaders in science — Marie Curie and Anita Borg. Urry and Thompson (2004) highlight the events and speakers of the Yale Symposium, "Marie Curie Nobel Centennial: Celebrating Women in Science", held in honor of the 100th anniversary of Curie's first Nobel prize. Panels and speakers at the three day symposium spoke about Curie's life and work and the difficulties and inequalities she faced. In addition, the contributions of women in science more generally and the challenges the sciences face were also topics of discussion. Yund (2004) discussed some of the main concepts underscored at the Anita Borg Celebration, held September 9, 2003 at Stanford University. Scientists and engineers in academia and industry spoke about Borg's life and contributions to the field. In addition, Yund emphasized the need for more inclusion of women in science, some reasons women are currently underrepresented, and aspects of changing the climate for women in science, engineering, and technology.

— by Lauren Ketcham

jects were examined. Klopfenstein found that at least 50 percent of the gap between whites and minorities still existed after controlling for human capital factors. The effects of low-income status on the decision to enroll in an AP course were also examined.

Mathematics, Engineering, and Math Anxiety. Mathematics plays a significant role in engineering education. Leuwerke, Robins, Sawyer and Hovland (2004) examined the role of mathematics achievement, interest congruence and retention of engineering students using a local longitudinal data set. The data are from a large database used by institutional research at a large southern university with approximately 19,000 undergraduate, graduate, and professional students. Students who declared engineering as their major when beginning their first semester were included in the study, resulting in the inclusion of 622 males and 222 females. Students' ACT mathematics scores was used as a measure of pre-college mathematics achievement and their level of occupational interest was measured using a standard scale known as the Hexagon Congruence Index. Students with higher math scores were more likely to remain on campus. Engineering majors were more likely to be retained when their mathematical achievement was high. However, those students with lower mathematics scores were retained if they had a high level of congruence with engineering. According to the authors, the best predictor of retention was the ACT mathematics score. Gender, race/ethnicity, age, socioeconomic status and in-state versus out-of-state residence had no significant effect on retention.

Even though the "math gap" in performance has disappeared, many advocates of women in engineering are concerned about how girls' and boys' experiences of mathematics differ. Hence, research on math anxiety, as one dimension of mathematics experience, continues to show interesting results. Haynes, Mullins and Stein (2004) surveyed a stratified random sample, by discipline, of undergraduate students enrolled in

mathematics or statistics classes at Tennessee Technological University. Achieving a 96 percent response rate, they found that males' and females' levels of math anxiety were not significantly different. However, via multiple linear regression analysis, they found that the components of math anxiety differed for males and females. For males, math anxiety was a manifestation of general test anxiety, which was also negatively related to ACT scores. For females, on the other hand, math anxiety was positively related to both test anxiety and ACT scores and negatively related to perceptions of high school math teachers' attitudes, teaching methods, and perceptions of one's own mathematics ability. As a local study, however, it will be important for other researchers to replicate this study to determine whether these results hold true elsewhere.

Miller and Bichsel (2004) surveyed 100 adults that varied in age (18-66) and education levels (high school degrees to college graduates). The participants were tested for 1-2 hours on five measures: math performance, math anxiety, state-trait anxiety (state anxiety can vary over time and in different situations but trait anxiety is relatively stable), verbal working memory, and visual working memory. Math anxiety was determined to be the most important factor in predicting both basic and applied math performance. After math anxiety, both verbal and visual working memories were important in predicting basic and applied math performance. Math anxiety appeared to be predictive of females' performance in both basic and applied mathematics but math anxiety affected males more than females in basic math and was not significant for males in applied mathematics.

A more representative study of math anxiety was reported by Ma and Xu (2004). These researchers performed structural equation modeling on data from the nationally-representative Longitudinal Study of American Youth to sort out the causal ordering of math anxiety and math achievement. Low math achievement was related to subse-

quently higher levels of math anxiety but prior high math anxiety did not necessarily lead to lower math achievement. As with Haynes, Mullins and Stein, Ma and Xu found no significant effects of gender on this causal ordering.

Single-Sex Environments. Over the past several years there has been much interest in determining the merits of single-sex education, especially for girls. The consensus is that in some situations same-sex education may be beneficial to girls, but it may not be ideal for all students. Some evidence suggests that girls and minority males benefit from same-sex classrooms, therefore, the single-sex option should be available but not required across all educational levels (see Frehill, Jeser-Cannavale and Benton-Speyer 2004 for a review of this literature). Robinson and Gillibrand (2004) examined the merits of single-sex schooling for girls in a Church of England urban secondary school. The impact of the single-sex context differed by the level of the science class. In lower level science classes, there were no effects associated with the single-sex model. But in the higher-level science classes girls and boys benefited from the single-sex context. They found that boys in these higher-level classes tended to need the girls to perform a variety of "services" such as help with practice. When the boys were not present, the girls were better able to focus their attention on the science rather than accommodating the boys' needs or adjusting for the boys' lower skills. At the same time, boys were forced to learn the skills that they had relied upon girls to provide.

Another study examined the impact of sex composition on science learning. Matthews (2004) compared 82 children working in mixed gender collaborative work groups with 83 control group children working mainly in single-sex groups in a school in England in one academic year. Using various sources of data (questionnaires throughout the study period and interviews with 40 percent of the students), Matthews found that there was a positive effect on social emotional skills associated with doing collaborative work in

mixed groups. Students' opinions about science improved; with many stating that they intended to take science classes in the future.

Single-sex versus mixed-sex groupings were also examined in a three-year study of the perceptions and behaviors of academically suitable fourth, fifth, and six grade boys and girls who participated in a week-long Science Academy camp (Voyles and Williams 2004). During the first two summers the classes were single-sex, while in the third summer participants were in mixed-sex classes. The researchers observed that while boys volunteered to participate in the camp at a high rate, girls needed to be recruited to the camp. The authors relied upon data from various sources: students' daily surveys about accomplishments; interviews with some participants; and careful observations of videotaped behaviors. Girls showed a lack of interest at the beginning of the week. There was no significant difference in how boys and girls rated their success in the week-long program but over the course of the week, girls' self ratings of success increased until it was slightly higher than boys'. Girls asked more questions of the teachers than the boys, but both boys and girls were equally likely to ask peers questions. Boys were more likely than girls to make assured comments while girls made more failure statements. Because there were no substantial differences in findings across the three years of the study, despite the change from a single-sex to a mixed-sex model, the authors concluded that sex composition had no substantial impact on the students' success — male or female — in the program.

The Science Classroom. Many articles published in 2004 analyzed various aspects of the science classroom. Brown (2004) examined how ethnic minority students' culture and beliefs may conflict with the culture and practices of high school science classrooms. Because these students may have identities or personal beliefs that could conflict with mainstream science-teaching, they may need to negotiate their sense of self in these contexts. Brown held the role of re-

searcher and teacher in two science classes — life sciences and biology — for the 1999-2000 academic school year. He videotaped the classroom, observed and recorded student behavior, reviewed written assignments, and interviewed the students in a large urban high school in Southern California. Brown found that students formed four types of discursive identities: Opposition status (students maintained distance from science classroom content), Maintenance status (students maintained their original identities while also being able to incorporate aspects of the science classroom), Incorporation status (students actively attempted to integrate science content into their personal vocabulary), and Proficiency status (students readily embraced and were proficient in the science classroom). Brown speculates that these discursive identities play a role in the underrepresentation of minorities in science occupations.

Klein (2004) studied the connection between gender and academic achievement in order to determine whether a student's or teacher's gender had any effect on grades. Grades and behavioral marks for 3446 students in grades five through 11 in 110 Israeli public schools were obtained. In addition, the author collected data to control for student and teacher gender, teacher seniority, the instructor's tendency to be more or less lenient, the student's age, class size, class subject matter, school size, and other factors. Approximately half of the grades that were analyzed were submitted by female teachers and half were submitted by male teachers. Klein found that the variance in achievement was a result of the teacher's gender, while the student's gender played only a small role. Moreover, female teachers gave significantly higher grades than male teachers, and both male and female teachers gave higher scores to female students. When accounting for the other variables studied in the research, Klein concluded that female teachers are less biased and are less likely to allow extraneous factors to influence their grading.

Wasburn (2004) gives recommen-

dations on how to make technological classrooms friendlier so that women will not be discouraged from pursuing technology-driven careers because of a chilly climate in the classroom. She also gives a few exercises that an instructor can facilitate to improve gender equity in the technology classroom. Many of these recommendations echo those of previous researchers on the gendered dynamics of classrooms (most notably, the work of Sadker and Sadker 1994). In addition, though, Wasburn has a number of recommendations that relate to how the instructor or teacher can affect the learning environment such as: confronting sexist remarks; taking an active role in establishing teams (rather than letting students form their own teams); and rotating team assignments so that each team-member learns the different duties associated with participating on a team.

Programming for Women and Underrepresented Minorities in Universities

In the past 20-30 years, there have been many programmatic efforts aimed at increasing females' and minorities' participation in engineering. Some "women in engineering" (WIE) or "minorities in engineering" (MIE) programs feature outreach efforts to K-12 students, while other programs focus upon retention of undergraduate students. Knight and Cunningham (2004) address programmatic issues for administrators and directors of WIE/WISE programs. As part of the Women's Experience in College Engineering (WECE) project, telephone interviews and follow up surveys were administered to 26 WIE program directors across the country whose programs had existed for 3 or more years. The authors found that a strong base of support, flexibility, overcoming barriers to reaching undergraduate women, and a willingness to be adaptable and broad-based were typical features of successful outreach programs.

Another useful resource for MIE and WIE directors is an article by Jeffers, Safferman and Safferman (2004), who provide details about

over 55 K-12 outreach programs run by colleges and universities throughout the country. The authors believe one way to improve children's skills in math and science is to integrate these outreach programs into existing core curriculums.

Harris et al. (2004) report on a pilot study dealing with the reasons that the University of Oklahoma is an "outlier" when it comes to gender. One half of the students are female — not unusual in industrial engineering — and 4 of the 10 professors in the program are female. The authors point out some interesting and potentially fruitful areas to which researchers interested in institutional transformation to bring about gender equity might want to attend. First, the authors identified a helpful administrative assistant and faculty who worked with open doors as a particularly welcoming climate for the students. Second, hands-on classroom activities are alluded to as an important curriculum feature that kept students engaged and interested in the field. An issue that the authors did not pursue, but which needs to be given more attention concerns an almost incidental comment in the manuscript about the denigration of industrial engineering. This is a significant issue: according to the sociological literature about occupations (for example, see work by Reskin and Roos 1990), as occupations transition from male to female majorities, it is common for the occupational prestige and rewards to be downgraded, leading to an increasing flight of men from the occupation. The extent to which engineering subfields with significant percentages of women (especially industrial engineering) experience downgrading, needs to be further explored. How do students react to these forces? Are men more likely to leave the field? Does such denigration lead to increased solidarity among students within the major being denigrated? How do racial/ethnic compositions affect these same areas?

An evaluation of a retention program called the Biology Undergraduate Scholars Program at the University of California, Davis was conducted by Barlow (2004). The

397 underrepresented minority students who agreed to participate in the program were compared to the 877 underrepresented minority students who opted not to participate between 1988 and 1994. The program was successful in increasing the retention of underrepresented minorities in biology, and increasing these students' success in basic math and science classes, with program participants more likely to graduate than non-participants.

Fadigan and Hammrich (2004) studied the long-term education and career trajectories of female participants in the Women in Natural Sciences (WINS) program. The authors fail to report a number of important details, and the response rate (51 percent) is unacceptably low, but the study involved an "under-studied" population. The girls had originally been accepted to the program based on several criteria: entering the ninth or tenth grade; C or better in all major subjects; one or both parents absent from household; and demonstrated financial-need. The study is unique in that it focuses on girls from single parent and low-income homes, a vast majority (89.5 percent) of the girls were racial minorities and most attended urban public high schools. Surveys were sent to 152 women who participated in the program between 1992 and 1997. In addition, 12 of those who completed surveys were asked to complete an interview. Prior to the WINS experience, the women held high educational and career aspirations leaning towards SMET-related careers such as scientist or doctor. According to the survey and program tracking records, all 117 participants in this case study graduated from high school and 93 percent of the women enrolled in some type of college program after high school and of those, 45 percent of the women have pursued science into adulthood as their choice of occupation. The majority of the participants perceived the science content they learned from WINS as having an influence on their education and career decisions 5-10 years later. Due to the unstable nature of the women's homes, the museum at which the program was run provid-

ed a secure, safe environment to these women.

Williams et. al. (2004) describe a new educational program funded by the National Science Foundation and developed by the Cornell Institute for Research on Children (CIRC) called "Thinking Like a Scientist." The program targets youth traditionally underrepresented in science and attempts to introduce these students to the process of scientific reasoning, including analyzing data, thinking critically, and reflecting on information. The program accomplishes this by basing its lessons in topics that are of natural interest to youth. Williams et. al. provide examples such as the effects of praise on children or the consequences of playing violent video games on children's behavior. In addition, students were asked to define the problem and consider its different sides, give examples from their own lives, distinguish between fact and opinion, consider what constitutes reliable evidence, weigh the evidence and make decisions about validity, consider what meaning the results may have for society, and reflect on what future scientific inquiry might reveal about the subject. Full evaluation of the program is pending more data and greater implementation.

Gender and Technology

At a more "global" level, there were a number of interesting studies about the relationship between gender and technology. These studies are important in understanding how the structure and content of engineering education might be better configured to appeal to more diverse groups of students. Historical analyses of the gendered construction of engineering and those that examine the role of stereotyping and perceptions of engineering are important subtopics under this heading. Because social structures and culture (which includes stereotypes and perceptions) are socially constructed, they are possible to change. At the heart of the research in this area is the notion that in order to bring more women into engineering, engineering needs to be seen as not just acceptable for young women, but also appropriate or normative for women.

Testing the often posited concept that digital technology may serve to diminish social inequality through greater access to information, Losh (2004) analyzed adult access to and use of computers, the Internet, and e-mail in order to ascertain if educational, occupational, or gender differences in use could be detected. Losh used data from the National Science Foundation's surveys of public use of science and technology conducted between 1983 and 1999, supplemented with General Social Survey's surveys conducted between 1999 and 2002. Losh found that although there has been some progress, considerable digital gaps remain with respect to gender, educational attainment, and occupation. Gaps in computer ownership remained; those with higher educational attainment and more occupational experience were more likely to own home computers than those with less education and less labor-force participation. Additionally, occupational computer use differed by gender, which relates to women's disproportionate employment in clerical work.

A nice literature review on gender, science and technology was provided by Adam, Howcroft and Richardson (2004), who analyzed journal articles published in ten information-systems journals from 1993-2002 to determine the extent to which gender issues have been considered and theorized in this literature. The nine quantitative papers that dealt with gender were simplistic interpretations of research findings about gender differences without much theory to understand the relationship between gender and technology. Hence, while the papers did make recommendations about curbing discriminatory practices in information systems, these were weak and half-hearted. Most of the seven qualitative studies were from international journals. The authors concluded that those interested in conducting research on gender and information sciences need to move beyond essentialist thinking and develop more complete theorizing about gender.

Similarly, Wilson (2004) notes that

theoretical concepts and observations in sociology- and technology-management disciplines would enhance the understanding of information systems processes and gender inequity. Wilson presents data from sociology including the theoretical contributions of critical-mass theory and feminism to explain differences in information systems. A social constructivist perspective on gender and technology suggests that technology is to change, technology and gender are mutually defining and therefore what is deemed technical can alter over time, and technology is a masculine culture and this will affect user interaction.

The History of Engineering. New histories of engineering education are shedding further light on the challenges for those interested in transforming the institution of engineering. Two such articles provide insight into how engineering education was affected by gender in historical perspective. Frehill (2004) documents the early history of engineering as a profession in the United States. Using historical sources like the *Engineering News*, proceedings from conferences of the Society for the Promotion of Engineering Education (now the American Society for Engineering Education: ASEE) and career guidance books, she documents how masculinity was embedded within the discipline as it moved increasingly toward a profession with strong academic requirements. Bix (2004) discusses the history of women's participation in engineering education. Women who sought engineering education struggled within hostile environments and often experienced difficulties in finding employment in the pre-Title IX era. Bix also notes women engineers' resistance to efforts to marginalize their work in the field.

In a more general article by Mraz (2004), in honor of *Machine Design's* 75th anniversary, Mraz interviewed five leaders of engineering organizations and asked them to report on changes the profession has experienced over this 75-year period. The leaders they interviewed were John Brooks Slaughter of the National Action Council for Minorities in

Engineering (NACME), Bill Wulf of the National Academy of Engineering (NAE), Richard Tax of the American Engineering Association (AEA), Betty Shanahan of SWE, and Teresa Helmlinger of the National Society of Professional Engineers (NSPE). In the eight page visually-appealing spread, the subjects of growth in technology, changing faces in engineering, engineering education, the problem of outsourcing engineering jobs, the government's role in the profession, and engineering as a sound career choice are discussed by these leaders of industry.

Stereotypes and Perceptions of Engineering. Research about stereotypes and their impact upon girls was another important theme in scholarly research about why young women are less likely than their male counterparts to choose an engineering major. Gender stereotypes are ingrained into children at a very young age, which are then posited to affect girls' performance and participation in math and science. Heyman and Legare asked 60 kindergarten and first graders and 60 fourth and fifth graders questions to determine the extent to which they stereotyped activities by gender. They found that regardless of sex and age, children indicated that girls were better at spelling and reading and had more pro-social tendencies while boys were more aggressive (physical and relational). Significantly, children did not stereotype math or a host of other activities as gendered.

In 2004, there were several journal articles about stereotypes and stereotype threat and their effect on women and ethnic minorities in science (Ford, Ferguson, Brooks and Hagadone; Pronin, Steele, and Ross; Miller and Bichsel; Bell, Anderson-Cook and Spencer; Hannover and Kessels; Wilkins; Brascoll and LaFrance; Skaalvik and Skaalvik; Schmader, Johns, and Barquissau; Schottenbauer, Rodriguez, Glass, and Arnkoff). Unfortunately, most of these articles use convenience samples, which limit their generalizability. Nonetheless, several studies used larger sample-sizes and provided convincing results.

Wilkins (2004) studied the effects of stereotypes, self-concept, and performance at an international level using data from Third International Mathematics and Science Study (TIMSS) conducted by the International Association for the Evaluation of Educational Achievement. This international project involved over half a million students from more than 40 countries. Wilkins found that the participants' view of their performance was overall quite positive. Students with higher self-concept had greater achievement and students from higher achieving countries on average had lower self-concept. The findings suggested that cultural differences affected the students' self-concept and, therefore, achievement.

Skaalvik and Skaalvik (2004) examined 907 (487 females, 420 males) sixth, ninth, eleventh, and senior high school students' self-concept in math and verbal classes, performance expectations, and the motivation for high achievement. Male students had higher self-perceived abilities and motivation in mathematics whereas females had higher self-perceived abilities and motivation in language. Boys' higher math perceptions occurred as early as the end of elementary school.

What images of engineering are presented to young girls? To what extent will young girls be able to envision themselves as engineers? In a unique article, Steinke (2004) analyzed science and engineering Web sites targeted at girls to assess the information presented, how and in what style it was presented, and how female scientists and engineers are portrayed, feeling that these Web sites may be an important source of information on science, engineering, and technology (SET) for young girls. A total of 27 Web sites were studied and 168 biographies on female scientists and engineers were found. After coding themes from these Web sites, the author found a variety of organizations are responsible for these Web sites ranging from NASA to the Girl Scouts. They were aimed at girl audiences of all ages, and many contained information for parents and

teachers. Many took on a more "hands-on" approach by encouraging girls to try experiments, participate in quizzes, message boards and other educational and interaction-based materials. Steinke found that these Web sites have the ability to increase girls' knowledge about SET, provide career information, and provide girls the opportunity to interact with professionals in these fields. However, the negative, though realistic, depictions of the challenges women face may dissuade talented girls from entering careers in SET.

Elgar (2004) performed a content-analysis of a recently published (1998-2000) series of textbooks entitled, *Lower Secondary Science for Brunei Darussalam*. Photographs and drawings were analyzed and categorized by who was depicted in the picture: male only, female only, and both males and females.

Photographs depicting males were four times as numerous as photographs depicting females only and there were six drawings of males for every one drawing of a female only. Women were not seen when the photographs or drawings were demonstrating scientific principles and procedures, but instead women were seen primarily to illustrate pregnancy, childcare, heredity, the five senses, and concern for the environment. There were only ten images of females demonstrating a scientific principle or procedure. Language was also analyzed to determine how often men and women were referred to in the text. The textbooks only mentioned eleven people by name, and nine of them were famous male scientists while none were female scientists. Male pronouns were six times more likely to be used than female pronouns in contexts not related to sexual physiology. In many instances masculine pronouns were used for all people, which would include females. The author concludes that since women are increasingly represented in the sciences, textbooks should be reoriented to reflect their representation and contributions.

Conclusion

We have used this article to provide a smattering of the literature

that was published in the past year about women in engineering. Given space limitations, we were unable to provide full details about all of the literature that has appeared in the past year and encourage you to make use of our references to obtain articles that are of interest to you.

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Women in Engineering:

A Review of the 2005 Literature

BY LISA FREHILL, PH.D., ABBY JAVUREK-HUMIG, AND CECILY JESER-CANNAVALE

For this year's literature review, we located 374 articles, dissertation abstracts, and books, and of these, used 224 to compile this review.

Consistent with past years, our primary emphasis is on articles that appeared in the peer-reviewed literature because they are more likely to be grounded in sound analytical methods. However, we also discuss small news pieces appearing in various engineering trade publications that may be a bit off the beaten path and less well known to SWE readers.

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

<http://www.begellhouse.com/journals/00551c876cc2f027.html>.

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

Finally, the importance of sound analysis and methodology was well illustrated at the start of 2005, when Harvard President Lawrence Summers offered uninformed

remarks concerning women's suitability for careers in science and engineering.

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

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

Many respected advocates for gender equity in the S/E fields rose to challenge Summers' comments. While many media pundits chose to focus only on the innate abilities issue, there were several women who took a more balanced approach to rebut the comments. Virginia Valian, author of

Why So Slow? The Advancement of Women, professor of psychology, and head of Hunter College's Gender Equity Project, which includes the National Science Foundation-funded ADVANCE program, wrote an op-ed piece that appeared in *The Washington Post* to rebut Summers' arguments with scholarly research evidence (Valian 2005).

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

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

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

More recently, Summers officially resigned his post as president of Harvard University. On Tuesday, February 21, 2006, Summers posted a letter to the Harvard community stating he would resign as of June 20, citing rifts with faculty members in the College of Arts and Sciences as his reason for leaving. Summers' resignation came almost one year

after a vote of no confidence by the arts and science faculty. Derek Bok, Harvard president from 1971-1991, will sit in as interim president until the university finds a replacement. Summers is expected to take a one-year sabbatical and then return to teach at the university (Ryan, 2006).

While the Summers debacle seemed to overshadow most of the year, some less controversial events were already focusing on the problems Harvard was trying to address. To close out 2005 the National Academies hosted the Convocation on Maximizing the Potential of Women in Academic Science and Engineering in Washington D.C. The leading experts on gender and ethnic equity in academic S/E gathered to share cutting-edge research from the biological, social, and organizational sciences to understand the issues that contribute to women's success in S/E. Bill Wulf, president of the National Academy of Engineering, and Donna Shalala, chair of the Committee on Maximizing the Potential of Women

in Academe and a former member of President Clinton's cabinet, welcomed participants and emphasized the importance of women's contributions to and participation in S/E. Closing remarks were made by Denice Denton, Ph.D., who was the dean of engineering at the University of Washington until assuming her duties this past year as chancellor at the University of California at Santa Cruz.

There were four panels:

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

In addition to the panels, 22 posters about research and programmatic efforts underway nationwide

ICWES 13 BY CECILY JESER-CANNAVALE

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

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

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

- ◆ Béraud André from Centre des Humanités discussed a large research project of teams from seven countries in Europe to determine why there are not more women majoring in engineering and working in engineering jobs, what problems women engineers face, and why it is difficult for them to get to

top positions. They also looked at existing best practices in higher education institutions and companies.

- ◆ An excellent paper examining issues facing female scientists and engineers since the fall of communism in Russia was presented by Irina Dezihina. She found that 50 percent of the women surveyed do not want help from funding agencies to address gender issues, but 64 percent of men think there should be special grants to provide support for women. The men in the survey were very sensitive to women's issues and did not see gender issues as negative but rather as something that needs to be overcome.

- ◆ Naoko Tagashira presented a paper discussing how to break the glass ceiling. In Japan, only 6.4 percent of engineers are women so the gender barriers are great. Interviews with seven executive women found that courage and the ability to think through risks were important strengths, but maternity leave was a hindrance for promotion. The old boys' network continues to exist, which makes it more difficult for women to break through the glass ceiling. Tagashira suggested that women choose jobs that do not follow traditional rules, but are new areas where women have a better chance of succeeding because the old boys' network is weakest in these areas.

- ◆ Catherine Didion reported on the Global Alliance, www.globalalliance.org, which is trying to diversify the global S/E workforce. Global Alliance has used strategies such as developing networks, identifying and disseminating best practices, and developing common standards for data collection. The Global Alliance plans to publish outcomes of these strategies and to lobby for press coverage so that gender is not lost in the discussion on improving the S/E work force.

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

provided more examples of successful strategies to increase women's access to academic careers. The conference agenda, available online at the National Academies, www.nap.edu, provides biographical information about the panelists, a list of publications and poster abstracts.

The Importance of Diversity

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

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

Hewlett, Luce, and West discuss several ways that companies could make better use of employees' diverse

backgrounds. Their recommendations were based on results of a 2005 survey fielded by Charney Research under the direction of the Center for Work-Life Policy. The survey included 1,601 professionals between 28-55 years of age with college or professional degrees working in medicine, law, education, and business/accounting. The respondents included 1,001 minority women, 200 minority men, 198 white women, and 202 white men, all from the United States. Detailed reports of findings are available at www.worklifepolicy.org.

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

Who Becomes an Engineer?

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

engineering. For more information about specific colleges, go to www.asee.org/colleges.

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

A second chart also based on data in Gibbons (2005) shows the distribution of bachelor's degrees within gender across nine engineering disciplines. For example, while mechanical engineering accounted for about 22 percent of bachelor's degrees to males in 2003-04, i.e., it was the most popular sub-discipline, the same discipline accounted for only about 14 percent of women's bachelor's degrees in engineering. For women, the most popular field was computer science, with just over 15 percent of all the 2003-04 bachelor's degrees to women. Computer science was the third most popular choice for men, ranking behind mechanical and electrical engineering.

The role of women in academic engineering continues to be an important research issue. Marasco (2005) reports on an annual study by *Chemical and Engineering News* of women faculty at top research universities. In the 2005-2006 academic year, 213 women accounted for 13 percent of the 1,633 faculty at the 50 top research universities ranked by total research dollars, an increase of 1 percent over the previous three years. Rutgers and UCLA had the most women faculty — 10 each — representing 26 percent and 24 percent, respectively, of all faculty in their chemistry departments.

Pennsylvania State and MIT each had six women faculty, who accounted for 21 percent and 20 percent of chemistry faculty, respectively, at those schools. Given that women have accounted for more than a third of new Ph.D.s in chemistry for a number of years, the scarcity of women faculty in top departments was seen as a problem that needed to be solved.

To understand how to solve the problem, it is helpful to look at some of the barriers that women face on the way to success in engineering. The October issue of ASEE's *Prism* magazine was dedicated to women in

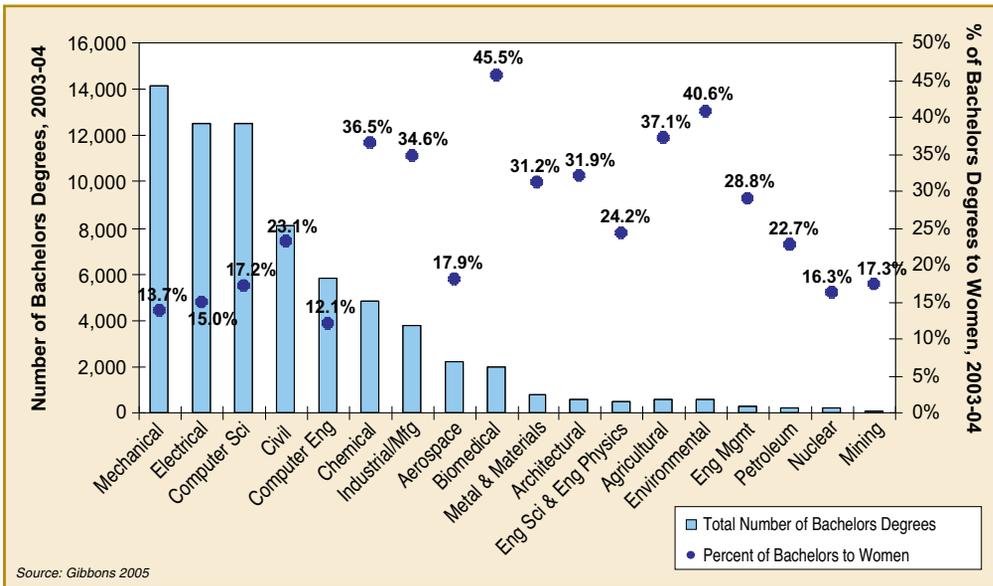
engineering, with a special focus on women engineering faculty members. As any woman who has completed an engineering degree or is working as an engineer already knows, women continue to be pioneers in engineering and the women who have taken up the challenge of pursuing Ph.D.s to become university professors continue to fight an uphill struggle for recognition. In an overview article, Sanoff asserts, "Engineering schools need to do more than simply say they are a good place for women — they need to prove it, and female faculty members offer compelling proof." (Sanoff 2005: 27).

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

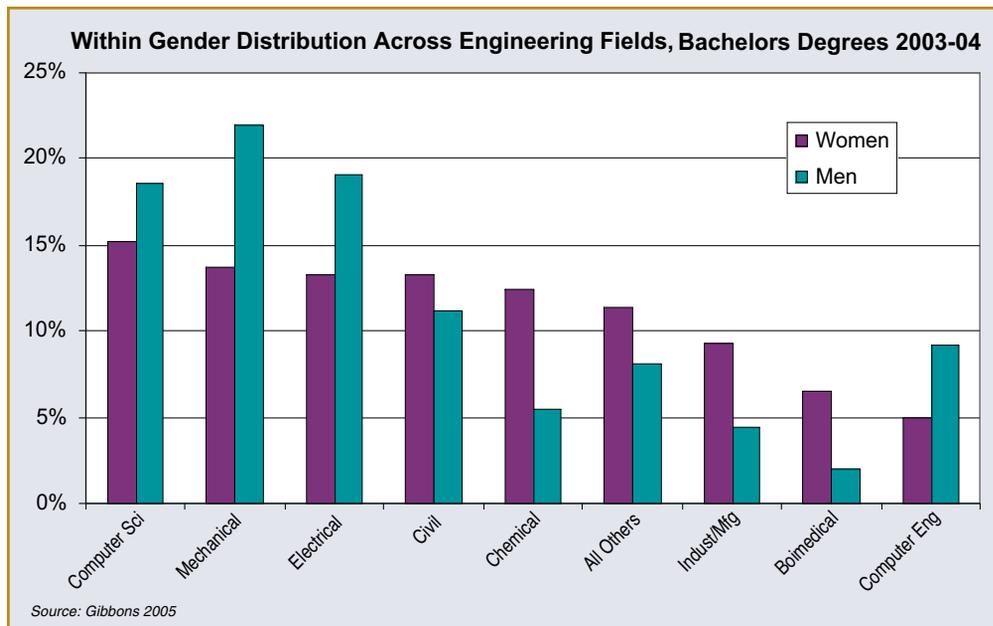
Continuing research by Nelson and Rogers on faculty at top research universities in selected fields of S/E documents the continued lack of women and minorities in these elite

departments. Women account for less than one in five of the full professors in these departments while they are more highly represented among the most junior ranks. Nelson and Rogers conclude that with the rarity of women at these top schools, it is possible that a person could complete a doctorate without ever having worked with a female colleague.

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



Source: Gibbons 2005



Source: Gibbons 2005

them with a better climate.

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

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

school environments.

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

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

Students' unfamiliarity with engineering has long been argued to be at the heart of the steady decline in students' selecting engineering majors (Frehill 1997). Shivy and Sullivan (2005) explored the extent to which 127 students, 28 females, and 99

males, enrolled in engineering courses at a public urban university in a mid-sized southeastern city were familiar with various engineering disciplines. Most of the students, 95.3 percent, were familiar with electrical and mechanical engineering but were less familiar with fields like petroleum engineering, as 51.9 percent indicated. The students' familiarity with a specialty was associated with the student's confidence that their interests were similar to those of actual engineers, so that there was a personal fit with the engineering track or specialty in which they enrolled.

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

Simple one-shot exposure and interest in engineering careers is probably not enough to get more girls involved in engineering programs. If that were true, then we would expect to see young female fans of "Star Trek Voyager," with its strong female engineering characters, flocking to the field. It is also important to ensure that young women are getting the training that they need to succeed in engineering fields. Mathematics is a critical component of engineering education, so many studies that explore gender effects on mathematics achievement provide insight into women's continued low level of representation in U.S. engineering. Erickan et al. (2005) used cross-national data for Canada, Norway, and the United States to show that home environment variables were

stronger predictors of achievement for females than males in all three countries. Home support for learning and parents' highest education level were strongly associated with mathematics achievement for students of both sexes in the United States and for female students in Canada. Students' attitudes about mathematics were very strong predictors of their decisions to take advanced mathematics classes in general, but not for U.S. males. For U.S. males, the father's expectations about the son's higher education were a strong predictor of the son's decision to take advanced math classes. This seems to dispel the notion that there are innate gender differences that cause the gap in S/E fields.

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

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

Award for her work in developing programming and documenting the efficacy of 3-D spatial skills training for female engineering students.

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

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

Advancement in Engineering: Graduate School

While we have focused on some of the issues facing pre-college age women in S/E, it is also important to note the issues that are occurring at the college levels. A Council of Graduate Schools' report released in October 2005 calls attention to the decline in engineering graduate enrollments. In most other science fields, enrollments have been steady or increasing slightly but in engineering there was a 3 percent drop in enrollment in 2004-2005 as compared to the previous academic year. To some extent, the reason for

this decline is itself, another important issue within graduate education in engineering. Half of all engineering graduate students are non-U.S. citizens or permanent residents, which is a far higher percentage than in any other field. When student visas were tightened following 9/11, fewer international students, which had formed a substantial core of engineering graduate programs, came to the United States for studies. Instead, they have begun to pursue graduate degrees in Europe and Australia.

What does it take to do well in graduate school and what are the issues that women engineering students encounter? A study by Litzler, Edwards and Brainard reported at the ASEE conference explored how climate issues impacted students' progress through 18 graduate programs in S/E at the University of Washington. Logistic and multinomial logit regression analysis of survey data from 574 graduate students (47 percent response rate) were performed to study the relationship among career commitment and an array of climate variables. A consistent set of findings about the role of competition was among the most interesting findings. Competition had a negative effect on completion of stages toward the doctoral degree, suggesting that departments or programs with more collaborative environments would provide a more conducive climate for graduate student success. Women in the study continued to report more problems with gender discrimination than did men.

Lange's dissertation used the Survey of Earned Doctorates to examine institutional pathways to the doctorate in S/E disciplines and transitions from master's to doctoral programs by race and gender. The study revealed no significant gender differences in pathways; however, underrepresented minority students took significantly different pathways to the doctorate than white and Asian American students. URM students were more likely to earn the bachelor's, master's, and doctoral degrees at three different institutions, and their path was significantly more

likely to include earning a master's degree en route to the doctorate, which is uncommon in some fields of science. URM students were more likely to experience transition difficulties between the master's and doctoral degrees. Lange concluded that master's degree programs have the potential to be a valuable resource for policy-makers and doctoral programs working to increase URM access to doctoral degrees in S/E.

The Digital Divide

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

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

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

These findings are echoed in recent work by Tillberg and Cohoon (2005) reporting results of 31 focus groups

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

The Value of Mentors

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

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

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

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

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

According to a story by Marasco (2005), in 2004-2005 MentorNet connected:

- ◆ 4,000 students and mentors
- ◆ 1,400 members
- ◆ 800 companies where mentors worked
- ◆ 80 colleges and universities participated.

The Gender Gap in Pay

According to the Bureau of Labor Statistics, among workers aged 16 and older in the full-time work force in

2005, men's median weekly earnings of \$722 exceeded women's median weekly earning by \$137, which translates to \$7,127 per year. The customary way to describe the gender gap in pay is to take a ratio of women's to men's median or mean earnings and then to interpret the ratio as the amount of money the average woman earns for each dollar the average man earns. Here, $\$585/\$722 = 0.810$. Among architecture and engineering occupations women's median earnings of \$945 per week represented \$0.834 for each dollar the median men earned. (Note: Bureau of Labor Statistics data were not available for engineers separately because there were too few women in those occupational groups). Economists split the pay gap into pieces that can be explained and pieces that cannot be explained, which sociologists then usually chalk up to the effects of discrimination.

The gender gap in pay varies substantially across different fields, for workers of different educational levels, and for workers due to experience in the paid labor force. Table 1 shows median annual salaries of engineering doctorate holders employed full time, by age group and sex for 2001.

Notice the gap is non-existent for younger workers but widens with older doctorate holders. The gender gap in engineering pay differs by engineering disciplines. Again, the most readily available data are from the National Science Foundation for employed engineers with doctoral degrees. The data in Table 2 report median salaries for 1997 — which are a bit dated now, but give you a feel for how engineering specializations might impact the gap in women's and men's earnings.

Morgan (1998) used data from the Survey of Natural and Social Scientists and Engineers for the years between 1982 and 1989, and a survey conducted by the Society of Women Engineers to see how the glass ceiling functions to impact women engineers' salaries. Morgan found that especially for older cohorts of women (women who have been in the field of engineering the longest),

Table 1

(Rounded to nearest \$1,000)

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

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

Table 2

(Rounded to nearest \$1,000)

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

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

there is a fairly large wage gap, but that this gap did not increase as time went on. She found that earnings were affected by one's cohort (that is, when one entered the engineering labor force) rather than a uniform across-the-board effect. Women in younger cohorts (those who most recently graduated and entered the work force) had at most a 4 percent gap in their earnings as compared to their male peers and, in most cases, pay gap was non-existent. This led her to conclude that for younger cohorts, there is no longer a glass ceiling in the engineering field, but those women already established in engineering careers can expect to continue to face the same gap they were presented with at the beginning of their careers.

There are many online tools to check salary levels including www.engineersalary.com/ where you enter a number of key features concerning your job, skills, and background, as well as your geographic location, and then a salary estimate is e-mailed to you. Tools like this can help determine whether you are underpaid. Why does it matter if

you are being underpaid? Even small disparities grow to be quite large over time — remember engineering economy class — so that your retirement earnings level and how old you will have to be in order to retire may be impacted. Furthermore, because women's life expectancies are a little longer than men's in the United States, by about four to five years, women need to plan for a longer period of retirement.

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

advanced associate and full professors because of market forces.

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

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

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

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

Table 3

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

Source: Prokos & Padavic 2005.

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

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

untested assumption here is that a highly selective college provides a higher quality teacher, while less selective schools produce lower quality teachers.

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

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

Combining Work and Parenthood: The Mommy Track Revisited

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

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

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

A Closer Look at Some Statistics

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

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

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

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

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

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

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

◆ Caltech's 2005 chemical engineering class of six was 100 percent female. Five of the six graduating seniors plan to continue on to get Ph.D.s in

engineering. Caltech's overall percentage of female engineering graduates is 35 percent, which is a 10 percent increase over the past decade. Caltech and the students credit good teachers, mentors, and a shift in the curricula that focuses more on seeing direct results instead of just theory as reasons for the rise in female engineering participation (Reitman, 2005).

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

Percent Women at Each Career Level

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

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

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

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

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

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

had significantly greater organizational commitment and were less likely to report an intention to quit their jobs.

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

Ransom conducted semi-structured interviews with 37 women who were part of a larger study tracking engineering graduates in Western Canada to examine their attitudes and experiences of balancing the roles of mother and engineer. All of the women without children (n=17) were working in full-time engineering jobs specifically related to their training. Among those who were mothers, five had left the paid labor force to be stay-at-home moms while doing a little consulting, six reported that they abstained from advancement opportunities to juggle their two roles, and only nine, less than half, reported that they had not made any career adjustments to continue working as engineers.

Those women who did not yet have children (n=17) tended to downplay sexual harassment and expressed their desire to be just one of the guys at work even though over

time, some women came to resent this identity. That is, eventually some women felt that by embracing the one of the guys identity, they minimized their status as women. Many of these women expressed a desire to have children at some time but were clear that in order to do so, their spouses would need to be willing to take on some of the care responsibilities. None were ready to give up or jeopardize their careers for the sake of having children but would be content to accept the traditional ideal of a fatherhood role if they were to have children.

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

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

Colbeck and Drago found there were three patterns of behavior: bias acceptance, bias avoidance, and bias resistance. With bias acceptance, people accept that there is anti-caregiver bias with which they prefer not to deal, so they opt out of positions where they suspect there will be problems, e.g., tenure-track positions. The working engineering

women who privatized their family lives in Ransom's study are a good example of bias avoidance. By effectively hiding their role as parents from co-workers, they are able to avoid the problems associated with caregiver bias, which includes suspicions by co-workers and bosses that mothers are incapable of being fully committed workers. Finally, a small number of faculty studied by Colbeck and Drago engaged in bias resistance, in which they diverted time to family and away from work, actively challenging the bias against caregivers. These faculty members brought their children to the office or to social events, making obvious to their colleagues that they were both committed parents and workers.

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

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

Is there a basis for concern about caregiver bias? According to research presented by Joan Williams, at the National Academies Convocation, she documents the rise in maternal wall or family discrimination retaliation lawsuits in which women who have taken advantage of family friendly policies have suffered various types of retaliation by employers. Williams' presentation reported that this new trend in employment law has had a

400 percent increase in the past decade with nearly 250 cases in the 2000-2004 period. These cases have a "higher win rate than in other civil rights suits, 27 percent v. 50 percent." Fathers also suffer adverse effects when they seek an active role in parenting. Williams indicates that in a study of more than 500 employers, "fathers who took parental leave" were "recommended for fewer rewards and viewed as less committed."

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

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

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

then supplemented with other documentary evidence from the four nations. There were many similarities across the four nations:

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

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

- ◆ Sweden had the most generous public provision of higher education but a low retention rate at 43 percent. Students can enter S/E later. Long-standing social welfare policies related to childcare and parental leave is combined with a strong expectation that both parents work in the paid labor force. Nearly two-thirds of women are in the paid labor force and 51.1 percent of families with children are dual-earner families.
- ◆ The Netherlands was the latest of the four nations in addressing the issue of women in S/E and it is still expected that married mothers with young children will not be in the paid labor force. Like Sweden, the Netherlands' funding of higher education enables students to keep a low post-graduate debt burden, especially if they maintain good grades. Sixty-nine percent of students who enter college in the Netherlands complete the bachelor's degree. Students experience strict compartmentalization within higher

education, which makes it difficult to enter a new major once schooling for another major has been completed.

- ◆ Although expensive to students, higher education in the United Kingdom had the highest retention rate of all four countries: 83 percent due, according to van Langen and Dekkers, to the high degree of one-on-one student/faculty interaction, which is a pillar of the British system of higher education. Like in the Netherlands, students move into a narrow range of topics fairly early in secondary and into college education, which, again, makes switching into S/E difficult.
- ◆ The United States has the most expensive system of higher education, relying to a large extent on loans. Retention is on par with that in the Netherlands, 66 percent. In terms of entry to college S/E, late entry is feasible in many subjects except engineering, in which students are expected to be ready for entrance within the first two years of college. A strong expectation of women's labor force participation is not matched by overly generous benefits for new mothers or families. Like Sweden, though, the United States has long had government policies that were aimed at increasing women's participation in S/E careers.

Research Productivity

Other researchers have used large national datasets to understand how parenting impacts academics' research productivity. Women, especially mothers, are often criticized for not being productive. Suspicions about decreased productivity are at the heart of some types of discrimination that women experience in the workforce and in graduate education. Recent research by Mary Frank Fox finds that contrary to the popular conceptualization, mothers with small children are actually more productive than women without children.

Fox's (2005) results are based on a mail survey in 1993-1994 of 1,215 full-time tenured or tenure track professors in doctoral-granting S/E departments, specifically, computer science, chemistry, electrical engineering, microbiology, and

physics. Men's productivity was higher than women's but women who were married, especially those in a subsequent marriage, were more productive than those who were not married. Women were less likely than men to have children or to be unmarried. Interestingly, women with pre-school aged children were more productive than those who had no children or who had older children. To some extent, however, these were also women who had a more research-intensive focus rather than having to balance teaching and research. In short, the common beliefs that married women or mothers are less productive are false according to Frank Fox's work.

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

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

Thursby and Thursby constructed a database that includes detailed information about the research and patent disclosure practices of more than 4,600 faculty members at 11

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

Conclusion

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

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

This year has been an amazing year in drawing attention to the needs of

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

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Women in Engineering:

A Review of the 2006 Literature

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Overview

As in past literature reviews, we identified sources via keyword searches of academic and press databases. In order to cast a wider net, we scanned the tables of contents of 70 peer-reviewed journals in disciplines such as engineering, education, psychology, management, sociology, science and technology studies, women's and gender studies, and general social sciences. The search led us to many sources we might not have found via the keyword searches. In total, we obtained over 400 items and eventually used 168 of these for the review.

We have given priority to identifying and reporting on findings from peer-reviewed journal articles.

Given the broad range of the social sciences from which these findings are drawn, you will see that the scientific approaches taken to understanding human behavior vary dramatically across fields.

Psychologists, for example, emphasize the use of experiments with careful controls in laboratory settings, using as subjects undergraduate students enrolled in psychology classes. With strong attention to the design issues, psychologists trade this internal control against external generalizability.

Sociologists and economists often perform studies using large, national datasets, which, while strong on external generalizability, may be less than ideal in terms of control. Women's studies, anthropologists, and others who use qualitative methods trade both internal control and external generalizability for a deeper understand-

ing of individuals' experiences. Qualitative studies are often limited to a particular geographic region.

Social scientists and educational researchers, therefore, typically search for studies that address the same question using different research methods and different populations. This approach answers these questions more fully while taking into account the strengths and weaknesses of each research strategy.

One recurring theme in the reflective writings and speeches of engineers is concern over the extent to which those outside the profession do not know what engineers do. The *New York Times* initiated the *Science Times* section to provide the public with more dedicated reporting about the work of scientists and engineers and grew from 1.7 pages per issue in 1980 to 5.4 in 2000 (Clark & Illman 2006a). Clark & Illman (2006b) analyzed the *Science Times*' reporting from 1980-2000 to understand how engineers were portrayed, finding that they are often invisible and that no women were shown as engineers. They chose at random one issue per month for each of the five years: 1980, 1985, 1990, 1995, and 2000.

There were 205 articles with a "strong engineering focus" and 40 with explicit references to engineers. They found that overall, engineering was mentioned in only 20 percent of the stories they had selected that had a clear technology component. When engineers were mentioned, the articles portrayed them as useful contributors to society.

Mentoring

In a recent volume by the National Academies Committee on Women in Science and Engineering

(CWISE), it appears that mentoring is the magic bullet to enable U.S. institutions to better recruit and advance women students and faculty in science and engineering. The buzz about mentoring is everywhere. For example, the in-flight magazine for a major airline had an article about mentoring. Academic journals feature items about both program structures and, in rare cases, actual evaluations of the impact of mentoring. Many companies have initiated mentoring programs. Organizations such as NC-WIT and AWIS have assembled tools for mentors, and MentorNet has brought mentoring to tens of thousands of people.

Business Week Online, Ashida's story in *Woman Engineer*, and Kekelis et. al.'s article in *SWE Magazine* all suggest that mentoring women in engineering, as students and in the workplace, is vital to women's success in the field. Burns wrote about how e-mail mentoring in what appeared to be a high school setting improved students' writing skills (2006) while Lokey-Vega and Brantley-Dias focus on overcoming the "friendship barrier" to more effectively mentor K-12 classroom teachers.

Increasingly, studies of mentoring are calling attention to differences in the kinds of mentoring that can be provided. One key distinction is between psychosocial and career mentoring. In a nutshell, career mentoring is fairly similar in content to advising, but also involves elements such as providing the protégé with important networking connections, and collaborating on projects, etc. Psychosocial mentoring involves more of a "friendship" or "family-like" relationship. Here, the mentor

might serve as a role model for the protégé, might share personal stories to illustrate points, and may serve as an important source of emotional support, or in some cases, as an advocate on behalf of the protégé.

What do we know about mentoring? There are a number of key findings about mentoring, but bear in mind that these findings are based on general studies of mentoring rather than those associated specifically with women in engineering. The studies, conducted in non-acade-

mic work settings, found that:

- Mentoring has a significant, positive impact upon job satisfaction in work settings for both men and women (Underhill 2006).
- Mentoring does not appear to positively impact income (Underhill 2006).
- Mentoring can also have a positive impact upon self-esteem, perception of promotion and career opportunities, organizational commitment, work stress and work-family conflict (Underhill 2006).

■ The degree to which the mentor is proactive and the protégés' perception of his or her similarity to the mentor both impact the relationship (Wanberg, Kammeyer-Mueller & Marchese 2006).

In educational/school settings, studies indicate:

- Among graduate students in natural sciences and engineering, psychosocial mentoring had a positive effect on students' self-efficacy, and collaborative mentoring had a positive effect on students' productivity

Outstanding Women of 2006 in Engineering

Compiled by Nicole Di Fabio

American Society for Engineering Education (ASEE) Awards

Sharon Keillor Award for Women in Engineering Education

Sara Wadia-Fascetti, Northeastern University

Section Outstanding Teaching Award

Gulf Southwest Section: Mia Markey, University of Texas at Austin

Rocky Mountain Section: Janet deGrazia, University of Colorado at Boulder

Section Outstanding Campus

Representative Award

Gulf Southwest Section: Jennifer Scott, University of Texas at Tyler

Pacific Northwest Section: Marilyn Dyrud, Oregon Institute of Technology

William Elgin Wickenden Award

Barbara Olds, Colorado School of Mines
Barbara Moskal, Colorado School of Mines

Best Zone Paper

Janet deGrazia, University of Colorado at Boulder

Section Best Paper Awards

New England Section: Kristen Billiar, Worcester Polytechnic Institute

Robert G. Quinn Award

Stephanie Farrell, Rowan University

Section New Faculty Research Award

Second Place: Priscilla Hill, Mississippi State University

Minorities in Engineering Award

Mary R. Anderson-Rowland, Arizona State University

Tony Tilmans Award

Cecelia W. Wigal, University of Tennessee at Chattanooga

Best Paper PIC IV

Harriet Hartman, Rowan University

Tony Tilmans Award

Cecelia W. Wigal, University of Tennessee at Chattanooga

Society of Women Engineers (SWE) Awards

Achievement Award

Elaine S. Oran, Ph.D., U.S. Naval Research Laboratory

Upward Mobility Award

Yukako Uchinago, IBM Corporation, Japan

Work/Life Balance Award

Tawnya Lynn Smart, P.E., Frito-Lay North America

Distinguished New Engineer Award

Elizabeth Bierman, Honeywell Aerospace

Jonna C. Gerken, Pratt & Whitney

Harmony R. Myers, NASA Kennedy Space Center

Alka Patel, J.D., Pepper Hamilton, LLP

Alyse R. Stofer, Transoma Medical

Distinguished Service Award

LeEarl Bryant, Texas Lab Consultants

Nancy Wheeler Nelson, Trimble

Emerging Leaders Award

Anne Kraft, Xcel Energy

Siddika Demir, Bechtel Corporation

Karrie Trauth, Northrop Grumman Corporation

Erika Lyn Edgerly, Intel Corporation

Stacy Kalisz Johnson, Agilent Technologies

Fernanda Philbrick, Intel Corporation

Fellows

Mary Anderson Rowland, Ph.D., Arizona State University

Jane Daniels, Ph.D., Henry Luce Foundation, Clare Boothe

Luce Program for Women in the Sciences, Mathematics and Engineering

Frances A. Ferris, The Boeing Company

Michelle Fitzpatrick, United States Coast Guard, Retired

Margaret J. Lyons, P.E., RCC Consultants Inc.

Suzanne E. Moore, The Boeing Company, Retired

Women in Engineering Programs & Advocates Network (WEPAN) Awards

President's Award

Talina Knox, New Jersey Institute of Technology

Barbara Ruel, Rensselaer Polytechnic Institute

Lisa Gable, IBM

Betty Preece, American Association of Physics Teachers

Founders Award

Brenda Hart, University of Louisville

Research Award

Virginia Valian, Hunter College, CUNY

University Change Agent Award

Eve Riskin, University of Washington

but their mentoring had no impact on a student's career commitment (Paglis, Green & Bauer 2006).

Underhill performed a meta-analysis of 14 published mentoring studies that involved comparisons of mentored and non-mentored people in work settings in which a senior person mentored a junior person. All of the studies measured at least one outcome. Mentoring had the largest and most consistent impact on job satisfaction, which was an outcome measured in most of the studies. In addition, mentoring helped men more than women. Six of the 14 studies found that mentoring had no significant impact on the participants' income. Mentoring did have a positive impact on the participants' perception of promotion and/or career opportunities and self-esteem (four studies each); organizational commitment (two studies); and work stress and work-family conflict (two studies each).

Underhill's study was limited in important ways. First, as a quantitative approach, qualitative studies were excluded from the meta-analysis. Second, Underhill looked only at a very small subset of what encompasses "mentoring" and focused on workplace settings. She excluded mentoring in educational settings, and peer mentoring. She examined 106 studies published from 1988-2004, and included only 14 in her analyses. Among these 14 studies, both variations in the context plus acknowledgement that the later studies quite likely built upon results from the earlier ones, were not taken into account. These factors present some important caveats in considering the results of the meta-analysis. But even with these caveats, the significant and positive improvement in job satisfaction — a precursor of many other occupational outcomes — may provide impetus enough for companies to consider implementing year-long mentoring programs.

Wanberg et al. examined 96 dyads (two individual units, things, or people linked as a pair) who participated

65th Annual Intel Science Talent Search (2005-2006)

1st Place Winner - Shannon Lisa Babb



Shannon Lisa Babb, 18, of Highland, Utah, entered the Intel Science Talent Search with an environmental science project identifying water quality problems along the Spanish Fork River and its tributaries. For six months, Babb collected water samples, measured several chemical and physical parameters, tested for *E. coli*, and collected macroinvertebrates at seven sites. Her data indicated that all seven sites exceeded Utah EPA guidelines for cold-water fisheries at some point during the study. She concluded that human activity was clearly the major factor causing the decline in water quality. She believes the trend can be reversed if proper remediation action is taken.

Babb's interest in water pollution began at age 13 when she tested the rivers near Utah Lake and discovered the most polluted was the Spanish Fork River. First in her class of 482 at American Fork High School, she enjoys choir, piano, 4-H and the fantasy writers club. An avid spelunker, she has volunteered during the past three summers at the Timpanogos Cave. To prepare for a career improving water quality around the world, Babb plans to attend Utah State or University of Utah.

in a yearlong mentoring program at one of nine different work places or organizations. While these 96 dyads represented only 23.4 percent of all eligible respondents, the findings are interesting because (1) the researchers have collected both quantitative and qualitative data about the 192 members of these dyads at three points in time, the start of the program, six months into the program, and after one year, and (2) rewards for both the mentors and protégés were examined, unlike many studies in which mentor rewards are totally overlooked. The program involved formal pairings within each organization based on the protégés' career goals. Protégés and mentors had separate orientations, and the participants met with each other once a month for 90 minutes. The key findings indicated that

organizations interested in establishing mentoring programs should:

- Seek out and encourage proactive mentors.
- Make sure that protégés and mentors have some similar features, but do so by providing a context for exploring commonalities rather than setting up elaborate matching schemes.
- Encourage dialogue between mentors and protégés — what do they feel they are getting out of the program.

Wanberg et al. found that for mentors, psychosocial mentoring, rather

than career mentoring, created a more satisfying relationship with the recipient, but career mentoring was perceived as having a positive impact on the mentors' job effectiveness. Protégés felt that both psychosocial and career mentoring had positive effects on their job effectiveness while career mentoring improved the clarity of their career goals. A study of mentor outcomes by Eby, Durley, Evans & Ragins (2006) sheds further light on these issues. They found that instrumental mentor benefits, e.g., recognition and work performance, were related to improved work attitudes in the short run, but that in the long run, mentors were more inclined to mentor in the future because of the personal relationship with those they had mentored.

Using a longitudinal design, Paglis, Green & Bauer found that collaborative mentoring measured in the second year of graduate school and prior research experience had positive impacts on a student's productivity. Conference papers, book chapters, journal articles and grant proposals increased, becoming most evident after 5-1/2 years. By the third time point, the 130 completed surveys represented a response rate of only 36.4 percent, largely due to panel attrition, which means their results might be skewed. The following lists the positive effects of mentoring to this

Get a mentor:
<http://www.MentorNet.net>

rather select group of people, which persisted through the final year of the data collection:

- Psychosocial mentoring had a positive impact upon research self-efficacy.

- Collaborative mentoring by advisors had a positive impact on students' productivity.

- Students' career commitment was more a function of their initial career commitment, expressed in their first year of graduate school, than of anything associated with their adviser's mentoring.

- The number of papers submitted for publication consideration had increased.

To what extent is it important to match gender in mentor-protégé pairs? Results from a pair of psychological studies reported by Lockwood provide some insight into this common question. Using the usual introductory psychology student volunteers at a Canadian university, Lockwood's studies show that when asked to report about a career-related role model, college women were more inspired by a female role model, while men tended to identify a male. Next, Lockwood found that in a hypothetical situation, women were more likely to identify with a same-sex role model than did men. Even though the respondents were likely to report a same-sex role model, they also indicated that the sex of a potential role model did not matter.

K-12 Education

In the past year, several major reports have called attention to the need for the United States' educational institutions to improve the quality of education in mathematics and science. These publications often take an alarmist tone. For example, two titles, "Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future," and "America's Pressing Challenge: Building a Strong Foundation" reflect this sense of urgency in addressing education in America.

Although very few K-12 institutions teach engineering, they do teach mathematics and science, and

key critical thinking skills students need to be successful in college-level engineering programs.

Articles that appeared in 2006 reported on the following findings:

- Middle school students who watched the film "The Core" were more likely to have misunderstandings about earth science concepts. (Barnett et al. 2006)

- African-American students in an urban school struggled with negative stereotypes as they participated in the "Tomorrow's Teachers" program in learning mathematics and science (Brand et al. 2006).

- Tech-Prep programs are effective in promoting graduation from high school and enrollment in two-year colleges, but may divert students from enrollment in four-year colleges. (Cellini 2006).

- Third grade girls (Eastern U.S., urban and suburban) interviewed by Ford et al. preferred to read nonfiction books about animals, but did not consider these books to be "science" reading. Almost half of the girls — 46 percent — said they were interested in reading science books. Family members, including siblings and parents, influenced their reading choices. The girls reflected diverse racial/ethnic backgrounds.

- Adolescents' (two Midwestern high schools, more than half African-American) perceptions of their parents' job rewards and self-direction have an impact on students' future orientations about work (Neblett and Cortina 2006).

- Middle school students who used "virtual" materials were equally capable as those who used hands-on materials to complete an engineering design project (Klahr, Triona & Williams 2006).

Press coverage of programs to introduce girls to engineering appeared in the *Journal Record* (Oklahoma, author: Page), the *Albuquerque Journal* (author: Schoellkopf), the *Hamilton Spectator* (Ontario, Canada, author: Faulkner), *Deseret Morning News* (Utah, author: Stewart) and *SWE Magazine*.

In recent years, the popularity of the "CSI" television shows has been credited — with no real proof — for college students' increased interest in forensic science. Barnett, Wagner,

Gatling, Anderson, Houle and Kafka (2006) show, however, that popular media can also lead to erroneous ideas about science. Their simple experiment in one school involved showing three eighth-grade middle school science classes the science fiction film "The Core." Two other similar classes did not see the film. Thirty-eight students were interviewed and completed pre- and post-tests at the beginning of the four-week unit and then again at the end. Only two of these 38 students had previously viewed the film. While the groups were comparable on the pre-tests, the post-test revealed that the students who had seen the film were more likely to err on answers to three key questions related to earth sciences than those who had not seen the film. These findings suggest that educators need to be aware of ideas in popular media that could fuel student misconceptions about science and technology.

Several studies focused on how minority students engaged with science and mathematics in pre-college environments. Brand et al. report on results from in-depth, qualitative interviews with five African-American students who participated in a "Tomorrow's Teachers" program. Not surprisingly, the students' relationships with their teachers played an important role in their academic performance.

Disfranchising stereotypes about African-Americans, and about who can pursue science and mathematics, discouraged these students. While students struggled to prevent stereotypes from affecting their self-esteem, their perceptions of teachers' beliefs led them to adopt defensive stances in the classroom. While this study has a small, self-selected sample in only one setting, it is unique in that it gives a voice and discusses the agency of African-American students with the career aspiration of becoming a teacher.

An interesting paper by Baram-Tsabari, Sethi, Bry & Yarden (2006) reports on an analysis of 1,555 fourth – 12th graders' questions sent to the "Ask-A-Scientist" Web site on the MadSci Network. Most of the

questions were from students in the United States — 72 percent — but another 7 percent were from New Zealand, 6 percent from Canadian youth, and 5 percent from the United Kingdom, with the remainder from a number of non-English-speaking nations. Girls asked more than half of the questions (56.4 percent) overall. There was a significant relationship between gender, age, and questions submitted for the U.S. students. As grade level increased, the percentage of questions from boys also increased. For girls, however, while there was an increase in

the relative number of questions submitted by middle schoolers compared to elementary school-aged girls, there was a clear decline in the percentage of questions from high school versus middle school girls. Girls' questions were more likely than boys' to be related to life sciences. In general, kids' topics of interest fell along stereotypical lines indicating, according to the study's authors, that educators need to provide science instruction that encompasses both girls' and boys' science interests.

Just as educators should engage

both girls' and boys' science interests, Buxton's (2006) study suggests that it is important for educators to provide contextually authentic science in urban elementary schools. Contextually authentic would mean, for example, using local environmental themes, emphasizing connections to the family and community in science lessons, making sure that students experience science outside the classroom, and that science is not limited to lectures and labs. Although this article presents no evaluative data, it is a useful tool for those who wish to help children become more interested in learning science.

A current debate about the effectiveness of hands-on strategies in science continues to rage. Many programs such as that by a University of New Mexico faculty member feature hands-on activities (Schoellkopf 2006). Many of the studies that were reported this year are woefully flawed with methodological problems (e.g., Pine et al., 2006 and Ornstein 2006), leading to a lack of meaningful findings. One study by Klahr, Triona, and Williams (2006) appears to have circumvented some of these methodological problems to show that middle school students who used virtual materials were as capable as those who used hands-on materials to complete an engineering design project. In a sense, for children raised in a digital age, virtual materials are akin to hands-on items of a generation ago. In addition, the authors' findings also show that the use of virtual materials does not disadvantage girls.

Finally, an article by Ruby (2006) is essential reading for anyone interested in improving middle school science. Ruby implemented a meticulous quasi-experimental evaluation of a program to improve science achievement in three Philadelphia middle schools. The richly-detailed article describes how the program produced improvements by (1) using readily available NSF materials (2) providing on-going professional development for teachers and (3) using in-class coaches to support teachers' efforts to use the science materials. Over the course of

Conferences on Preparing Women for the Engineering Professoriate

by Ane Turner Johnson

In 2006, several universities conducted workshops and conferences seeking to propel young scholars, both men and women, into careers in the academic sciences and engineering. Virginia Tech, University of Maryland – Baltimore County, and Rice University, each recipients of a National Science Foundation Advance grant, engaged upper level graduate and postdoctoral women and men interested in faculty careers through presentations, interactions with department heads, and discussion groups. Each conference focused on preparing students for academic job interviews, negotiation, thriving in the STEM fields with workshops and talks on topics such as: securing research funding, pedagogy, networking, tenure and promotion, balancing work and life, and career paths in four-year colleges.

Virginia Tech

AdvanceVT, the Advance program at Virginia Tech, hosted in July of 2006 the “Transforming the Professoriate” conference. Sixty-five pre/postdoctoral women and men attended the conference with pre-conference engagement via a Blackboard Learning site that included discussion boards and document posting. One conference participant remarked, “I wish that these types of frank discussions [and] valuable information [were] part of every graduate program. I’ve never been surrounded by so many young talented women, especially minority women scientists. This whole experience has been extremely valuable and inspiring and has taken the frightening stigmas associated with academia far away.”

University of Maryland – Baltimore County

Also in July of 2006, UMBC held the 3rd annual Faculty Horizons workshop for aspiring STEM faculty. Seventy-one graduate, postdoctoral and new faculty women and men attended UMBC's event. The keynote address, “The Success of Women Scientists in the 21st Century,” was given by Dr. Wanda Ward, deputy assistant director for the Directorate for Social, Behavioral, and Economic Sciences, National Science Foundation. Participant feedback included “This was a fantastic overview of seeking and succeeding in an academic position,” and “The information I learned could help so many women and minorities. More of us would become professors if we knew what to expect as a faculty member.”

Rice University

In October of 2006, the newly-funded Advance program at Rice University held Negotiating the Ideal Faculty Position workshop for prospective faculty to learn from faculty leaders across the STEM fields. Fifty-four graduate and postdoctoral women and men attended the annual event. As an output of the workshop, the Rice Advance team created a database that contains information from more than 650 graduate and postdoctoral women in science and engineering interested in academic positions. The database includes CVs, contact information and research statements and can be accessed at <http://www.advance.rice.edu/database/>.

three years, students whose classes participated in the program performed significantly better than comparable students whose classes in similar schools within the same school system were not part of the program. The article includes many "lessons learned" about such programming.

Recruitment and Persistence in Undergraduate Engineering Programs

Only a few recent research results focus exclusively on engineering, with most researchers combining engineering and science. A brief summary of findings in this area includes:

- Women STEM majors have less access to valuable informal exchanges with both faculty members and their male counterparts and are more subdued about asking questions in class (Zhao, Carini & Kuh 2006, analysis of large nationally-representative dataset from 2001-2002).

The entire notion of the "pipeline" in engineering education is being questioned, with calls for a better understanding of students' self-identity and occupational choice development.

- Women undergraduate students recruited primarily from psychology classes at a Midwestern university reported more prior learning experiences in the social domain while similar (but younger) men in the same school reported more prior learning that was investigative or realistic (Williams and Subich 2006).

- Most college students are interested in "gender neutral careers" (i.e., those in which neither women nor men exceed 66 percent of occupants) and relatively few students' career aspirations change dramatically over the course of four years. Evidence in this study indicates that the rate at which women change from aspiring to male-sex-typical jobs is the same as the rate at which their aspirations change to these same jobs (Sax & Bryant 2006,

large national non-random sample).

- Despite "equal opportunity hazing," the bonding that plebes experience as a result of hazing at the U.S. Naval Academy does not persist for women but it does for men.

Women are less tolerant of brutal hazing than are men, and men are more likely to simply see hazing as a "rite of passage." Both men and women believed that it was important to eliminate those who could not perform under pressure (Pershing 2006).

- The processes that affect

women and men when they begin an engineering major at college can be quite different. Hartman & Hartman's study of engineering "stayers" and "leavers" at Rowan University in New Jersey, for example, shows that women are often attracted by other majors while men who leave engineering are "pushed out" by poor performance.

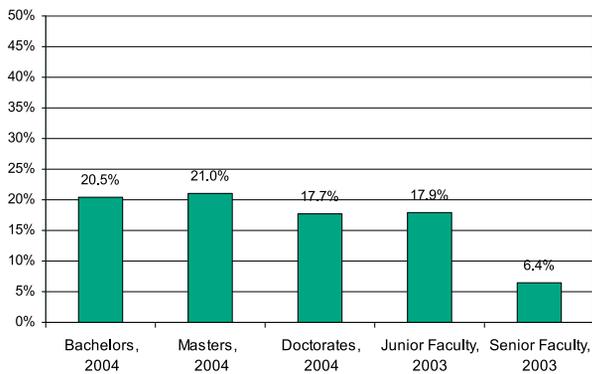
Over the years, women in engineering (WIE), women in science and engineering (WISE) and various minorities in engineering (MIE) programs have sought to recruit and retain students in STEM majors. Recently, many of these programs have evolved to emphasize the institutions rather than individuals as sites for change. Challenges to targeted programming have led to greater emphasis upon curricular and pedagogical reform to improve STEM education as a means of increasing student retention. Powell, Bagilhole, Dainty & Neale's (2004) qualitative interviews of women engineering students in the United Kingdom indicate that the "culture and structure of the engineering education system has been designed for a male audience." (p. 21). This observation has become increasingly common among U.S. advocates of women in engineering. In addition, as discussed in Watson & Froyd (2006), the entire notion of the "pipeline" in engineering education is being questioned, with calls for a better understanding of students' self-identity and occupational choice development.

Unfortunately, it is rare that these programs or pedagogy are evaluated in a systematic way to document effective practices. While we list some of the practices that have been reported in the literature, we provide more detail about those that have had some evaluation or represent dramatically different approaches.

Some of these practices include:

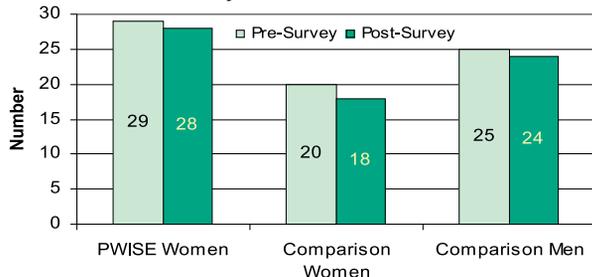
- Peer-review of experiments by physics students (Moran & Van Hook 2006).

"Pipeline" for Women in Engineering, U.S. Colleges and Universities



Note: Senior faculty includes associate and full professors; junior faculty includes assistant professors and lecturers.
Source: CPST analysis of NSF's WebCASPAR database (degree data) and NSF Survey of Doctorate Recipients 2006 (faculty data).

Number of Students Who Said They Intended to Major in a STEM Field



Source: Authors' analysis of data from Kahveci et al. 2006.

■ Undergraduate research communities in biology (Kight, Gaynor & Adams 2006).

■ Designated residence halls (Kahveci, Southerland & Gilmer 2006).

■ Facilitated team experiences (Tonso 2006).

■ Collaborations between engineering and non-engineering faculty members (McShannon et al. 2006, Schneider & Pickett 2006 and Spalter-Roth, Fortenberry & Lovitts 2007).

In the past decade, many programs to retain college women in science and engineering have put in place “living and learning communities,” which are areas of the residence halls set aside for women in STEM majors. They can then easily locate study partners and forge a sense of community outside the male-dominated classrooms prevalent in engineering. Kahveci, Southerland & Gilmer (2006) evaluated the success in retaining women over the course of their first

academic year. The Program for Women in Science and Engineering Majors (PWISEM) involved the residence hall and a one-credit seminar that provided the women with a chance to meet women scientists and engineers from all over campus when they came to speak about their research to the class.

Kahveci et al. used questionnaire data collected from the 35 program participants — who had a 90 percent or better response rate on the pre-

Journal of Women and Minorities in Science and Engineering

by Peggy Layne, P.E.

The *Journal of Women and Minorities in Science and Engineering* continues to be a key source for research on a variety of issues related to underrepresented groups in STEM fields. Volume 11 is dated 2005, but most of the issues actually appeared in 2006. The journal is currently catching up with its publication dates, with the first three issues of volume 12 (including a combined issues two and three) appearing in late 2006.

Pre-college Programs: Thompson & Windschitl found that in order to engage girls in science, science projects need to relate to some aspect of their lives. They studied engagement in high school science activities for under-achieving girls in the Pacific Northwest through in-depth interviews, classroom observations, and teacher surveys. Rascoe explored barriers to black male student achievement in high school and college science classes. Kekelis et al. studied the Techbridge after school program in Oakland, Calif., and surrounding communities by surveying participants at the beginning and end of the school year, and conducting interviews and focus groups. Their evaluation found that social aspects of the program were important in keeping girls involved, that participants tended to split into different groups by race/ethnicity, and that minority girls were more likely to leave the program. The program implemented activities specifically designed to encourage inter-ethnic socializing among the participants in order to increase retention of minority girls. Zales and Cronin conducted a five-week summer residential program incorporating bioinformatics for 16 academically accomplished high school girls in the mid-Atlantic region. Observa-

tions, surveys, and interviews indicated that participants increased their mastery of science content and excitement about science careers, with three-fourths of the participants pursuing natural science majors in college.

Community Colleges: Community college students were the focus of Starobin & Laanan’s research. Using the Cooperative Institutional Research Program 1996 dataset of almost 1,600 first time, full-time students at public two-year colleges intending to major in STEM fields, they developed a model that showed high school grades and attitude toward science predicted self-concept.

Underrepresented Minorities: Lam et al. compared the college graduation rates and grade point averages of black students participating in a minority engineering program at the University of Akron with those of white students. They found that both ACT scores and high school GPA were correlated with college graduation and college GPA for both black and white students, but the high school GPA was a better predictor in both cases. Retention programs for underrepresented minorities in biomedical sciences in the California State University system were studied by Alfred et al. The programs included mentoring, research participation, and other academic enrichment activities. Participants showed higher retention and graduation rates than non-participating minority and majority students. Garrett-Ruffin and Martsolf documented increased freshman to sophomore retention rates for students in a residential science learning community at Kent State University as compared to those in a comparison group matched for gender, ethnicity, ACT scores, and course regis-

tration. Students participated in a variety of academic and social co-curricular programming and were enrolled in special sections of English classes that incorporated scientific content.

Computer Science: Larsen and Stubbs followed up on changes to the computer science program at Carnegie Mellon University described in Margolis & Fisher’s *Unlocking the Clubhouse* (e.g., implementation of first-year programming courses, contextualizing computer science, creating a support organization for women in computing, etc.). Semi-structured interviews of senior computer science majors admitted prior to the program changes showed few gender differences and many similarities in perceptions about the culture and climate in computer science. The relative number of women in the computer science program increased from just 7 percent in 1995 to 42 percent in 2000. Findings support the idea that eliminating gender barriers will also enhance the experience of male students by challenging the “geek” stereotype and encouraging more well-rounded students. Jessup et al. evaluated the impact of a “Technology for Community” elective at the University of Colorado, Boulder, through interviews, observation, and surveys. They concluded that three aspects of the program made it more attractive to women even though there was no increase in women majoring in computer science: design-based learning pedagogy; emphasis on process rather than product, “real-life” projects, and links to other departments; and partnerships with other organizations, including the Anita Borg Institute.

Women Undergraduates: Single et al. presented an evaluation of the first three years of the MentorNet e-mentor-

continued on next page

and post-surveys — as compared to results of the same survey administered to a comparable group of male and female students enrolled in the honors general chemistry class at their institution. Response rates for this comparison group were lower —

64 percent on the pre-survey with an overall 39 percent on the post-survey. A range of STEM majors were included: there were eight PWISEM women who said that they planned to major in engineering at the start of the program with 10 comparison

group men and four comparison group women interested in engineering. Results by major at the post-survey were not reported, so we can not assess the extent to which women were retained in engineering, specifically using these data. The pre-sur-

Journal of Women and Minorities in Science and Engineering *(continued from page 87)*

ing program for female undergraduates in engineering and computer science. Surveys of over 3,700 students and a similar number of professionals participating in the one-on-one mentoring program with response rates of 51 percent to 68 percent showed that participation increased the students' commitment to pursuing STEM careers and over 90 percent would recommend the program to a friend.

Hartman & Hartman studied the participation of female engineering undergraduates in student chapters/sections of professional societies at Rowan University. They found that students who were members of one or more professional societies were more likely to be involved in extra-curricular enrichment activities, had higher grades, were more self-confident and more satisfied with their engineering studies and more committed to an engineering career than students who did not participate in engineering societies. Of special interest to SWE members, Hartman & Hartman found that participation in SWE was associated with greater involvement in study activities, higher satisfaction with course load, and different perceptions of challenges faced by women in engineering. Interestingly, women who participated in discipline-specific societies but not SWE were more likely to see conflict between family and career as a problem whereas SWE members were less likely to see this as a problem. The study raises but does not answer the question of whether students with certain attitudes toward women in engineering choose to be members of SWE or whether SWE membership influences students' attitudes toward women in engineering.

In the classroom: Bauer-Dantoin and Ritch evaluated the impact of a course on "Ethnic Minorities in Science" at the University of Wisconsin-Green Bay on student awareness of minority contributions to science and medicine and appreciation of the culture of science, incorporating a social studies of science approach in presenting the representations and contributions of minor-

ity scientists. Students reported an increased awareness and understanding of the culture of science and the contributions of minority scientists and physicians. Khan reported on a case study of the impact of innovative teaching strategies on retention and grades in an organic chemistry class at a women's college in the northeast. A "contract" between student and teacher, research internships, and confidence building strategies resulted in slightly higher final exam grades and fewer very low grades in the course, improved performance of minority students versus previous years, and fewer course withdrawals or failures.

In the laboratory: Malone et al. studied the interaction of researchers in a majority-female biomedical engineering laboratory at a major research university in the Southeastern United States as part of a larger study on cognition and learning. Using interviews, ethnographic observations, and linguistic analyses, they observed a gendered division of labor (e.g., women ordering and tracking supplies with men lifting heavy things), different styles of communication and knowledge making. They conclude that a "critical mass" of women can result in realignment of traditional gender identities with new behavioral norms that incorporate traditionally feminine characteristics such as looking out for others and cleaning up after oneself.

Faculty: Chesler and Chesler explored the use of theater as a community building technique for nine untenured female engineering professors from different institutions. Follow-up with the participants from the three-day workshop indicated that the community created by the workshop was difficult to maintain at their home institutions. As part of the University of Wisconsin's Advance program, Gunter and Stambach interviewed male and female science faculty about their work environment. Women were much more likely than men to identify communication issues (e.g., being ignored in meetings) and to see gender bias in departments. However, women tended not

to label the climate as "chilly" or to see problems as gender related but tended to look for other explanations for their observations, while most men reported not observing any examples of gender bias. Another Advance-funded project, the Women in Engineering Leadership Institute (WELI), was designed to prepare women engineering faculty for leadership roles in the university. Niemeier and Smith's assessment of the first WELI-sponsored conference included a pre-conference questionnaire completed by all participants and two follow up surveys of participants eight months after the event and then again two years after the event. Their findings indicated that participants were more interested in leadership roles after the conference with 33 percent of participants saying that they had already taken on new leadership roles as deans, vice-presidents, department heads, or other departmental leadership positions.

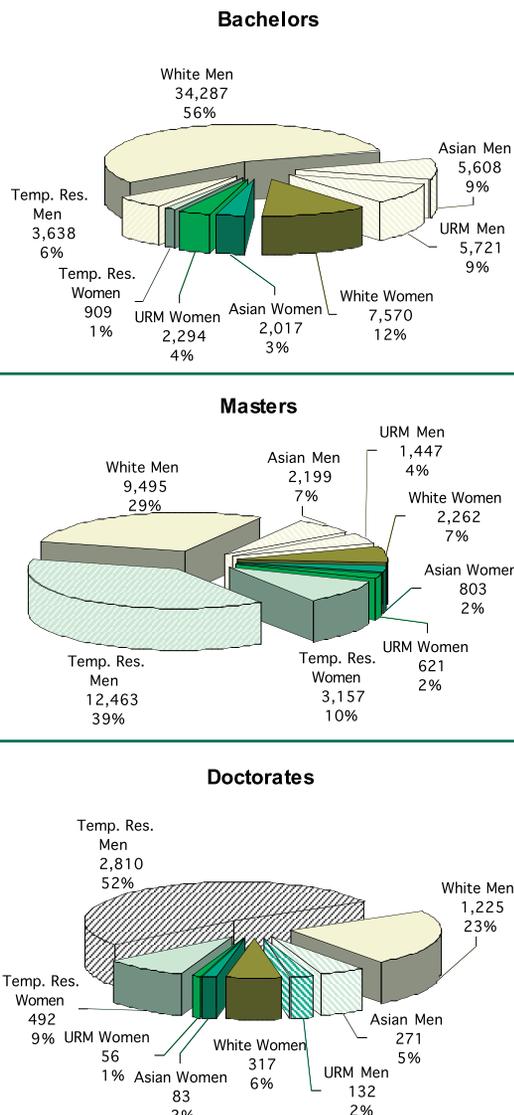
Beutel and Nelson report on women and minority faculty in top STEM research departments (in research funding in 1998-99), compiling data on more than 21,000 faculty members. Overall, 14.8 percent of the faculty in the departments studied were female, ranging from a low of 8.4 percent in physics to a high of 22.6 percent in social sciences. Whites made up 84.2 percent of the faculty in the departments studied, with Asians 11.7 percent, Hispanics 2.3 percent, and African-Americans 1.8 percent.

Information technology workforce: Levin and Stephan examined the National Science Foundation's 1999 SE-STAT database of over one million college educated scientists and engineers in the United States for data on people employed in information technology jobs. Overall, only about one third of individuals employed in IT jobs had formal IT training. The authors found different recruitment and retention patterns for women and underrepresented minorities compared with white males, with women trained in IT more likely to leave IT jobs than men trained in IT.

vey revealed that the three groups of students were comparable (i.e., program women, non-program women and non-program men).

The graph presents the results from Kahveci et al., who concluded that women in the PWISEM program were more likely than women in similar majors and with similar backgrounds to say that they planned to major in a STEM field (i.e., were retained) during their first year of college. Men who did not participate in the program had a similarly high level of retention, although, with the possible problem of response bias (i.e., the much lower response rate among the comparison group), the retention expressed here might actually be overstated for both men and women in the comparison group.

Team projects have become an increasingly critical part of engineering education. Some have asserted that women are more interested in collaboration; therefore, team projects can be an important way to recruit and retain women in engineering. On the other hand, if teams simply recreate competitive hierarchies rather than providing for the kind of collaboration women want, then teamwork can actually have an opposite effect, becoming instead, a part of the "chilly climate." Tonso's (2006) ethnographic work with student design-teams underscores the need for faculty members to effectively facilitate teams to ensure equity. Tonso conducted interviews between 1992 and 1996 with students and faculty, and observed student teams at the first, second, and fourth year levels in classes taught by faculty members known to be supportive of women. She found



Source: CPST (2006), data derived from National Science Foundation, Science and Engineering Degrees, by Race/Ethnicity of Recipients: 1995-2004. URM, White, and Asian are U.S. citizens and permanent residents. URM = Under Represented Minority and includes African Americans, American Indians, and Hispanics. "Asian" includes Asians and Pacific Islanders. "White" are non-Hispanic whites.

that promoting egalitarian social relationships as opposed to the norm of competitive relations increased team effectiveness. She also found that professors needed to understand the social relationships that develop among men, and the ways that men and women interact, in order to better provide guidance to the teams.

Schneider & Pickett (2006) discuss a qualitative analysis of a collaboration between an engineering and an education faculty member and two graduate students at the University of Toledo. The engineering faculty

The pie charts show the relative representation of women, within four ethnicity/citizenship groups in comparison to men's representation at the three major degree levels in engineering. As the degree level increases, so too does the representation of temporary residents of both sexes. At the doctoral level more than half of all doctorates in engineering in the 2003-04 academic year were awarded to temporary resident men with an additional 9 percent to temporary resident women. While a similar pattern is evident in the other STEM fields, in no other field do temporary residents account for such a large percentage of degree recipients at the master's and doctoral levels (CPST 2006). For U.S. women, this means that as they move into graduate degree programs, their classroom peers are more diverse than when they were undergraduates. Likewise, U.S. white men are no longer the dominant group in engineering graduate programs as they had been in undergraduate programs: that position is occupied by temporary resident men. URMs of both sexes accounted for a mere 3 percent of engineering doctoral degrees in 2003-04, which is far below their representation in the U.S. population aged 18-24, of 31 percent. A total of 456 doctoral degrees were awarded to U.S. citizen and permanent resident women in 2003-2004. U.S. women fared better at the master's level, earning a total of 3,686 degrees (11 percent of all master's degrees). With temporary resident women earning another 10 percent of master's degrees, women earned just over one in five (21 percent) of master's degrees awarded in engineering in 2003-2004.

member and graduate student were males while the education faculty member and student were females. The team worked to redesign an engineering design course. The paper was based on meeting records, written communications, classroom observations, course products, and participant-reflection. Due to disciplinary differences, the engineers saw assessment as just the grades, while the educators saw assessment as also embodying what students were thinking — more process oriented. This meant that by the time they

were done redesigning the course, the engineers felt that they had made major changes, while the educators saw more minor changes.

Interestingly, the authors did not comment on the possible gendered nature of the cultural differences.

At another institution, New Mexico State University, the New Mexico Space Grant Consortium has implemented the Gaining Retention and Achievement for Students Program (GRASP) as a way to encourage dialogue between professionals trained in education and faculty in engineering. Since 1999 GRASP has involved individual observations and feedback provided to faculty members by Space Grant team members highly trained in STEM pedagogy and student learning styles. The principal outcomes of the program's success were (1) students' achievement in GRASP courses (n = 1,854 students) versus those who had taken "pre-GRASP" courses (n = 1,658 students) and (2) faculty members' self-reported use of strategies learned during the program.

Faculty responded to the survey with a 72 percent rate (53 faculty and six graduate students): All respondents indicated that they used at least three strategies that GRASP had suggested. Of course, such data may suffer from the tendency on the part of survey-respondents to provide answers to "please the researcher," so McShannon et al. also examined student-outcome data, which showed:

- 7.8 percent increase in retention within the major from the first to second year.
- 5.6 percent increase in the percentage of students earning A, B, or C grades (i.e., student achievement) in first-year courses.
- 12.9 percent increase in retention among second-year students.
- 6.7 percent increase in student achievement in second-year courses.

The American Sociological Association and the National Academy of Engineering (Spalter-

Cohort: a group of people born at about the same time in history.
Some U.S. Cohorts:
Baby boomers (1944-1964)
Baby bust, a.k.a. Gen-X (1965-1980)

New National Science Foundation ADVANCE Awards

The National Science Foundation has made 13 new Institutional Transformation Awards under its revolutionary ADVANCE: Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers program. This is the third "round" of these awards, with awards of up to \$750,000 per year for five years, as follows:

Institution	Principal Investigator
Cornell University	Carolyn Martin
University of Maryland, Eastern Shore	Anna Vaughn-Cooke
Rensselaer Polytechnic Institute	Cheryl Geisler
Cal Poly Pomona	Barbara Hacker
New Jersey Institute of Technology	Nancy Steffen-Fluhr
Marshall University	Marcia Harrison
Duke University	Kristina Johnson
University of North Carolina at Charlotte	Joan Lorden
Rice University	Kathleen Matthews
University of Illinois at Chicago	Mrinalini Rao
University of Arizona	Leslie Tolbert
Brown University	Pamela O'Neil
Iowa State University	Susan Carlson

ADVANCE: IT awards seek to increase women's participation in academic science, technology, engineering and mathematics (STEM) faculty and academic leadership via institutional transformation efforts. The nine first round awards made in 2001-2002 are nearing the end of their five-year grant periods while the ten second round institutions reached their third year in 2006.

Roth and Wolf 2006) undertook a larger-scale effort to connect engineering faculty with faculty members from outside the field. Roberta Spalter-Roth of the ASA and Norman Fortenberry and Barbara Lovitts of the Center for the

Advancement of Scholarship on Engineering Education (CASEE) brought together sociologists with research backgrounds in studying science and engineering with engineering faculty to better explore what lessons could be shared across these two disciplines. While engineers have paid more attention to undergraduate instruction in the past two decades, curricular and pedagogical changes have been slow to be adopted.

Sociologists, for example, pay close attention to how prestige hierarchies and reward systems affect human behavior in complex social systems — like universities and academic disciplines — so they bring a new perspective to engineers interested in

broader dissemination of best pedagogical practices. The papers associated with this project are available from the American Sociological Association on a CD (www.asanet.org).

Graduate School

Very few studies attempt to understand women's experiences in engineering graduate school. In many cases, the very small sample sizes combined with the difficulties of accessing graduate students are barriers to studying this population. Unlike undergraduate students, who take courses across the university, graduate students "live" within a specific program or department, often supported via a graduate assistantship within that same unit. Their academic lives depend upon identifying a suitable advisor, ideally someone who will serve as more of a mentor than merely an advisor. As these students move along a pathway toward establishing themselves as more self-sufficient researchers, they must take on more responsibility for their own work and rely less upon highly-structured classes to ensure regular progress.

Some studies of graduate students are undertaken in conjunction with evaluations of programs meant to impact graduate education, such as the NSF-sponsored GK-12 program. This program provides funds for universities to partner with local K-12 educational institutions to place graduate students in internships with local schools to (1) increase the STEM educators' capabilities by having a graduate student from STEM work with them and (2) increase the skillset of graduate students in STEM, especially with respect to the communication skills essential to an effective classroom teacher at any educational level.

Buck, Leslie-Pelecky, Lu, Plano Clark, and Creswell (2006) discuss one such research study that involved eight women from a number of STEM fields. Only one of the eight women was an engineering graduate student, which is not surprising

Problems with what has often been termed "toxic climate" have a stronger negative impact on women than on men.

given the data in the pie charts (see box). Their study looked at women's experiences within a GK-12 program at a Midwestern university, finding that the program provided an effective means for the students to have a fulfilling experience by working with local educators and children. Program participation increased the women's resolve to become scientists. The authors note that among all GK-12 projects nationwide, 55 percent of graduate student participants are women, which means that these programs may be an effective way to increase recruitment and retention of women in STEM graduate degree programs.

However, Buck et al. noted that participation in GK-12 complicated the women's integration into their departments. Among academics, including those in STEM disciplines, there is a continuing devaluation of any work or time spent outside of what is considered to be the core activity of academicians: research. The

GK-12 program actually pulled women further away from their departments because of their work in settings outside their departments. While the women felt the GK-12 program was a rewarding experience, such programs need to work with faculty in departments to bring them more on

board and to implement strategies to ensure that program participants still

feel connected to their "home" departments. At the same time, the women's participation in the GK-12 program, itself, provided them with an alternative multi-disciplinary supportive community. Each woman might be one of only a few women — or even a solo — within her home department or program, so programs like the GK-12 program provided a context in which women could feel less isolated.

This latter finding was echoed in a paper by Frehill, Jacquez, Lain, Ketcham, Peña, and Williams (2006). These researchers studied underrepresented minority graduate students who had participated in another NSF-sponsored program, the Louis Stokes Alliance for Minority Participation Bridge to the Doctorate Program (AMP-BD). Frehill et al. implemented a multi-year case study design that involved interviews with students and their advisors both prior to and at the conclusion of the two-year program, analysis of students' application materials and program reports, and focus groups. In the 2006 paper, data were presented about the first cohort to complete the program, which consisted of 11 engineering students, including two women. Both women expressed feelings of isolation in their departments, but indicated that participation in the AMP-BD program's weekly seminar and other group activities helped

make them feel less isolated and part of a community in graduate school.

The Academic Work force

Who will teach engineering in colleges and universities? Since 2001, the NSF-funded ADVANCE:

Institutional Transformation initiative

has attempted to level the playing field for women in academia.

Women (60 percent) who earn doctorate degrees in engineering are more likely than men (50 percent) to report in NSF's Survey of Earned Doctorates that they have definite plans to pursue a post-graduate position in academia (NSF 2006).

The first nine institutions have now completed their five-year grants and have learned many lessons, which are the subject of a book currently in production at the University of Michigan Press edited by Abigail Stewart, Janet Malley and Danielle Levesque. A second round of funding to 10 additional institutions in 2003 has passed the half-way point, and in late 2006, with projects starting in 2007, another 12 institutions received funding in the program's third round (see box).

These efforts have been important, with an accumulation of findings and stronger connections between program practices to the body of knowledge being built across these institutions. Engineers have participated in these efforts as principal investigators, co-principal investigators, or key members of the ADVANCE teams at nine of these 15 institutions. Efforts to increase women's representation in STEM faculty such as these ADVANCE programs were reported in *US States News* (reporting about the program at University of Rhode Island), the *New York Times* (Dean 2006), the *Baltimore Sun* (Forbes 2006), the *Christian Science Monitor* (Teicher 2006), and the *Chronicle of Higher Education* (Wilson and Birchard). Following the pre-publication release of "Beyond Bias and Barriers" by the National Academies, additional sto-

If faculty women, the potential role models of women students, are dissatisfied with their jobs and thinking of leaving, it is much less likely that they will be a positive influence on the next generations of young female scholars. (Callister 2006: 374)

ries highlighting these themes appeared in the *New York Times* (Dean 2006), the *Daily Texan* (Muñoz 2006), the *Cornell Daily Sun* (Daniels 2006) and *BioScience* (Gropp 2006). Such “popular press” reports are important in calling attention to the presence and contributions made by women in science and engineering and to the challenges women face in pursuing careers in these fields.

Because women constitute such a small percentage of engineering faculty overall and at the ADVANCE institutions, in general, research findings based on studies conducted at colleges and universities rarely separate data on women engineering faculty from that for other groups of women faculty. On the one hand, this is an essential strategy to protect women engineering faculty from any backlash from their colleagues. On the other hand, it means that it is often difficult to tease out how issues might play out differently for women in engineering as opposed to other academic fields.

Fox and Colatrella (2006) report on interviews they conducted at one of the first round ADVANCE institutions, the Georgia Institute of Technology, where a large percentage of the faculty overall are in engineering fields and more than half of all degrees are awarded in engineering. The 20 interviews (17 face-to-face, three phone) represents an 83 percent response rate, which is considered excellent. In order to provide the respondents with as much protection as possible, Fox and Colatrella took notes rather than tape-recording interviews, and reported results without indicating the field of the respondent. There are several important findings:

The vast majority of women faculty were “moderately” or “very satisfied” with their academic careers (89 percent) with teaching and research

impact cited as two important areas of satisfaction.

While the criteria for advancement from assistant to associate professor were consistently clear, the same criteria for advancement from associate to full professor were quite unclear. Indeed, 95 percent indicated that the standards varied from candidate to candidate.

Even though 65 percent of women indicated that faculty were only “slightly” or “not at all” involved in decision-making in their departments, they did not necessarily see this as a negative: in some cases, they were relieved to not have to be involved in particularly acrimonious decision processes.

Several articles this past year focused attention on the “climate” for women faculty in academia. Bilimoria

et al. 2006 and Callister presented findings of climate studies at their respective second-round ADVANCE institutions, Case Western Reserve University (CWRU) and Utah State University. Due to differences in survey methodology and institutional context, Bilimoria and her colleagues had a 39 percent response rate (not including the medical school faculty at CWRU) while Callister’s survey netted a much higher rate of 74 percent, which is considered excellent in social sciences. Both sources look only at results for tenured and tenure track professors.

Bilimoria et al. model determinants of faculty members’ career satisfaction to show that for women, “internal relational supports” are more important than for men and that “the quality of interactions with immediate colleagues is a critically significant path to how women construct their academic job satisfaction.” (p. 364). Said another way, problems with what has often been termed “toxic climate” have a stronger nega-

tive impact on women than on men. Satisfaction for both women and men was influenced by their perceptions of access to academic resources and a workload conducive to research. This latter finding echoes Fox and Colatrella’s findings from their qualitative interviews at Georgia Tech. In social science research, findings that are consistent across a number of studies, contexts, and methodological approaches are considered strong.

Callister modeled the intention to quit and job satisfaction as a function of gender and department climate. Much like what Bilimoria and her colleagues found at CWRU, department climate impacts both men and women. In fact, even though Callister found that gender was a significant predictor of both intention to quit and job satisfaction, department climate completely mediated this effect. The implications are clear, according to Callister:

If faculty women, the potential role models of women students, are dissatisfied with their jobs and thinking of leaving, it is much less likely that they will be a positive influence on the next generations of young female scholars. (Callister 2006: 374).

Settles, Cortina, Malley and Stewart (2006) report findings from the University of Michigan climate study, which predates those of Bilimoria et al. and Callister by two years. Michigan’s survey was administered in 2001, one of the first administered at an ADVANCE institution, hence the later ADVANCE surveys (i.e., the 2003 surveys at Utah State and CWRU) could be built upon this foundation. While below the desirable 65 percent rate, the 52 percent response rate among the natural scientists and 47 percent among social scientists at the University of Michigan is common for surveys within organizations.

Focusing on the responses of 208 women scientists who responded at Michigan, Settles et al. show:

- Women who report negative work experiences — sexual harassment and gender discrimination — were less satisfied with their jobs.
- Even when they controlled for negative experiences, women’s other

Snowball sampling refers to a way of choosing respondents in which the researchers start with one or more people whom they already know and then ask these people for referrals. Then, as they meet these referrals, these people are asked to make referrals as well, so that the respondents are gathered like making a snowball. This kind of scheme is a good way to

- (1) locate people who might be hard to “catch” in a random population sample because of their small numbers and
- (2) provide social scientists with a personal referral to people who might be more guarded in their answers with a “total stranger.”

perceptions of the work climate had a significantly negative effect on women’s assessments of their influence and productivity.

■ Gender-related experiences were not significantly related to productivity.

■ Effective chair leadership was important in improving workplace climate.

■ Women in the natural sciences (which includes engineering) reported more experiences with sexual harassment and perceived their departments as more hostile than women in the social sciences.

■ There were no differences in job satisfaction, felt influence or productivity for women in the natural sciences versus those in the social sciences, indicating that the women in the natural sciences may have developed strategies to cope with their more hostile environments.

■ Women of color reported having less influence than white women in their departments.

Ginther and Kahn used data from the National Science Foundation’s Survey of Doctorate Recipients (1973-2001) to show that once family, demographic, employer and productivity are controlled, there is no difference in the likelihood of women in engineering faculty jobs earning tenure as compared to men. Single women vs. single men are slightly advantaged in earning tenure in the sciences and engineering, but even more so in engineering. Marriage increases men’s chances of earning tenure in engineering by 12.2 percent but a similar effect is not seen for married women in engineering, except those who remained childless. For men, each additional child increases his likelihood of earning tenure by 4 percent. Children’s ages impact engineering women’s career outcomes in ways that differ from those of men. Engineering women faculty with pre-school-aged children do not experience an impact on the likelihood of earning tenure, but when an engineering female faculty member has grade-school aged children she is 22.8 percent less likely to earn tenure, an effect not noted in other fields of science.

The “Survey of Doctorate

Recipients” is considered reliable data about the work situations of holders of doctoral degrees in the United States. However, the findings associated with these data cannot be generalized to all U.S. postsecondary faculty because faculty with a terminal degree that is less than a doctoral degree are not included. This is important in engineering because some engineering faculty do not possess a doctoral degree. Some, for example, hold a master’s degree along with a professional engineering license. To some extent faculty members’ degrees reflect the highest degree conferred in a program, so that, for example, a faculty member in an engineering technology program that grants a bachelor’s as its highest degree may possess only a master’s degree. In another example, faculty in the growing field of bioengineering may possess M.D. degrees without also holding doctoral degrees.

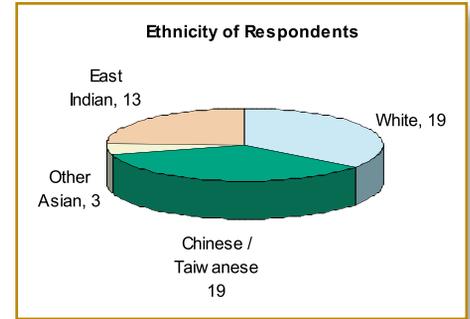
The National Study of Postsecondary Faculty provides more comprehensive data about U.S. faculty in postsecondary institutions. These data are collected about every five years by the National Center for Education Statistics with the most recent data from the 2003-2004 academic year. A report by NCES (Cataldi et. al. 2006) indicates that:

	ENGINEERING	ALL FACULTY
Employed full time	78.2%	56.0%
Tenured	59.1%	47.5%
Not on tenure track*	15.4%	23.7%
African American	4.9%	5.5%
Asian/Pacific Islander	21.7%	8.7%
Latino/a	2.4%	3.5%

* at an institution with a tenure system.

■ Engineering continues to be the most male-dominated field, with men accounting for 90.5 percent of full time and 89.8 percent of part time engineering faculty.

■ On average, engineering faculty earn \$80,100 from their institutions with another \$20,700 annually from



other sources. This was higher than the average income for faculty in any other field except health sciences.

For more specific information about engineering faculty, refer also to the volume *Profiles of Engineering and Engineering Technology Colleges* produced annually by the American Society for Engineering Education (Gibbons 2006).

Faculty salary differentials across fields were examined by Ehrenberg, McGraw and Mrdjenovic (2006). The extent to which engineering faculty earn more money than other faculty varies across institutions: that is, the higher salaries earned by engineers represent a larger or smaller gap with their non-engineering colleagues depending on which institution you are looking at. Using the 1992-93 salary data collected from institutions of higher education annually by the Oklahoma State University Office of Institutional Research and Information Management, Ehrenberg et al. show that faculty quality, based on the 1995 National Research Council ratings, accounts for the variation across the 88 institutions studied for faculty at the full professor level but not at the assistant or new assistant level.

Another study that examined faculty salaries looked at the gap in earnings at Historically Black Colleges and Universities (HBCUs) versus Predominantly White Institutions (PWIs) by race and gender. Using regression models of nationally-representative data from the Integrated Postsecondary Education Data System collected by NCES about faculty in the 2001-2002 academic year, Renzulli, Grant and Kathuria (2006) show that the gap in pay between men and women was \$1,990 narrower at HBCUs in com-

parison to PWIs. But at elite HBCUs, the gap was only \$783 narrower.

The Culture of Engineering and the IT Work force

One of the best sources of information about the U.S. engineering work force is the National Science Foundation's SESTAT database system. The system includes data from three surveys: the National Survey of College Graduates, the National Survey of Recent College Graduates, and the Survey of Doctorate Recipients. Mark Regets' (2006) NSF InfoBrief provides some findings from the most recent (2003) surveys in NSF's SESTAT database system to show:

- Less than one-third of S/E bachelor's degree recipients were working in jobs formally defined as S/E yet 2/3 of these indicated that their S/E degree was related to their current job in 2003.

- Among engineers, the percentage who earned a subsequent degree was lower (42.1 percent) than in all other S/E fields except mathematics and computer science (39 percent).

- Even among those who pursued a non-S/E advanced degree, a majority indicated that their S/E knowledge was critical for their subsequent jobs.

- About 90 percent of bachelor's-degreed engineers within nine years of graduation reported that their job was related to their degree.

- Engineers were more likely than those in other S/E fields to indicate that their job was related to their de-

gree throughout their careers.

Sally Hacker was one of the first researchers to study the culture of engineering workplaces. In the 1990s, McIlwee and Robinson's book about women in engineering provided further evidence about the challenges women faced in engineering workplaces. What about the high tech industry? Perhaps the culture of this relatively new industry that has

developed in the post-Title IX landscape is more friendly for women? According to research by Feyerherm and Vick, that is not the case.

Feyerherm and Vick conducted in-depth interviews with 16 women born 1965-1980 (a.k.a. Gen-X) who are now working at one of seven high-tech companies and identified by company management as "high achieving."

Their findings indicate that the women felt that they were not taken seriously, that they do not receive the same opportunities or recognition as their male counterparts, and that they felt stereotyped, undervalued and under-utilized. Another important finding was that 70 percent of the participants linked personal fulfillment with professional success, a theme that has been identified as a general issue among both men and

women in Gen-X. Feyerherm and Vick suggest five strategies for companies that want to better use Gen-X women's talents:

- Re-examine corporate culture.
- Leverage women leaders in a diverse workforce.
- Provide mentors and/or coaches.
- Provide challenges.
- Promote more women to the executive level.

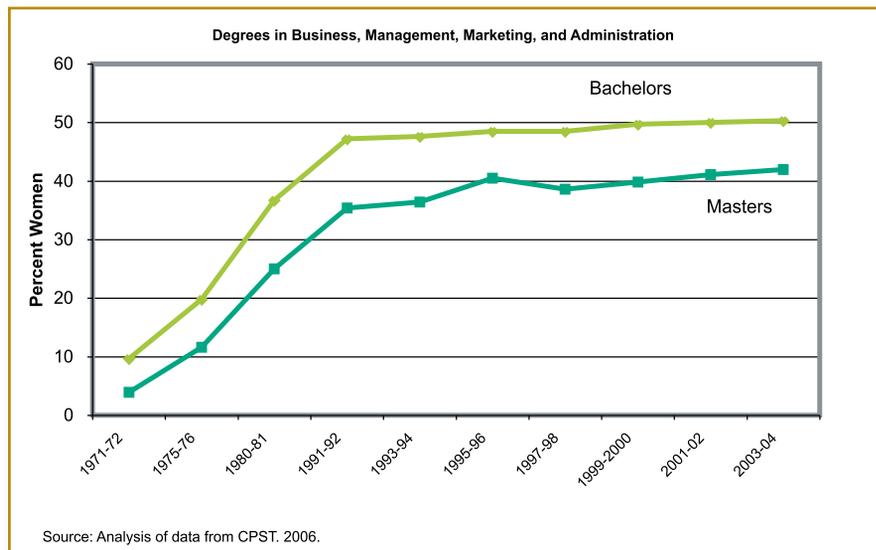
Shih completed an interesting study of 54 people in engineering and engineering-related jobs

(hereafter, we just use the term "engineers") in Silicon Valley that focuses on how the respondents "circumvented" gender and ethnic discrimination. She used snowball sampling (see box) with referrals from universities and engineering societies, including SWE. She was able to access a very diverse group of white and Asian engineers, possibly with an over representation of "successful" engineers. This is a significant study, as one of only a few that focuses attention on the issues that are experienced by Asian-American engineers. The graph shows the ethnicity of her diverse respondents. Some of her key findings were:

- Two-thirds of the respondents indicated that they had experienced ethnic or gender bias at work (e.g., typecasting, glass walls and ceiling or being excluded from the old boys' networks).
- Job-hopping was a strategy to circumvent bias.
- SWE was seen as an important network for facilitating women's career goals.
- An ethic of mentoring is important and is emphasized by the local SWE sections.

Of the many articles that we have reviewed this year, this is one of several that women engineers will probably want to read because of its extended quotes and stories. This is a well-written piece and most academic libraries carry the well-respected journal in which the article appeared, *Gender and Society*, published by the organization SWS, Sociologists for

"Just Be" is an interactive presentation developed by Siek et. al. (2006) designed to dispel the "geek" stereotypes about people who work with technology. The authors use the presentation in schools and report that the students seem excited by the presentation, which is available at: <http://women.cs.cmu.edu/What/Outreach/Roadshow>.



Women in Society. A reprint can be requested from the author via email: socjzs@mail1.hofstra.edu. Other stories about women engineers can be found in *SWE Magazine*, *US States News*, *AWIS Magazine*, *Woman Engineer*, and *Advancing Women in Leadership*.

News You Can Use: Interesting Findings from the Management and Organizational Literature

Many studies use various measures of gender stereotypes to explain outcomes such as women's lower performance in mathematics (Steele and Ambady 2006) or their reluctance to pursue engineering. That is, many people assert that stereotypes affect young people's behavior such that they avoid fields that are not perceived as appropriate for their gender. However, over the past 30 years, the content of gender stereotypes may have changed, so that psychometric scales constructed in the 1980s when people started exploring these questions may no longer hold true.

In the 1970s Rosabeth Moss Kanter penned the classic treatise on women and men at work. Kanter studied workers at the Industrial Supplies Company (INDSCO), where women were just making inroads into managerial jobs previously reserved for men. At the time, a number of stereotypes about women in management prevailed, painting women as micromanaging, irrational, temperamental bosses who would leave work in a heartbeat if they got married and had a baby. Women now earn half of all undergraduate degrees and just over 40 percent of master's degrees conferred in business, administration, marketing, and management (see chart), so the time is ripe for another look at workers' views on women managers.

Using an experimental design with seven versions of a survey randomly assigned to 620 managers and 688 students, Duehr and Bono (2006) explored the extent to which notions about managers, men, and women have changed over the past 30 years.

Their instrument was administered to students in psychology classes at a university, while the managers volunteered to complete the survey at the start of a leadership training program. The instrument included items that were developed in 1973 (the Schein Descriptive Index) which have been used a number of times since then with similar groups. This allowed Duehr and Bono to make some comparisons over time. It should be noted, however, that these comparisons must be viewed with caution because the people who completed the surveys are not, necessarily, representative of managers or students.

SWE was seen as an important network for facilitating women's career goals.

Duehr and Bono show that there has been "striking change over time in the extent to which male managers see women in general as similar to successful managers." Among the male managers, there were few changes in how they viewed male managers, rather, their opinions about women had largely changed. However, it is important to note that successful managers are now viewed as those who are more communal (a characteristic stereotypically associated with women) rather than as agentic, which had been the norm in the 1980s. Some of the communal characteristics include creative, helpful, aware of the feelings of others,

kind, passive, and submissive. Aggressive, ambitious, assertive, analytic ability, self-confident are several of the adjectives associated with the agentic stereotype.

Men persist in holding less than positive views concerning women's capabilities in IT according to Michie and Nelson. They surveyed a convenience sample of 140 graduate students, with a response rate of 87 percent. Students were enrolled in M.B.A. (84 students); M.I.S. (13 students) or telecommunications management programs (43 students). Most respondents (70 percent) were

U.S. students, with another 24 percent from Asian countries, including India, and the remaining 6 percent of other non-U.S. origins. Forty-four of the respondents (31 percent) were female. White and White (2006) used convenience samples of college students enrolled in psychology classes, the usual respondents in psychology experiments. Using the well-known implicit associations test (see box), they showed that college students stereotyped engineering as masculine and teaching as feminine. Interestingly, despite the rapid and large influx of women into accounting, accounting was also gender-stereotyped as male.

The negative views of women's capability for IT jobs and the gendering of engineering as masculine are important according to Kiefer, Sekaquaptewa and Barczyk (2006). Kiefer et al. performed experiments in which a woman's status in a group (i.e., solo versus non-solo) was manipulated in addition to a stigmatizing condition (i.e., in this case, body image). They found that solo status, alone, and the belief that one's body image was stigmatized, alone, had no impact on women's

performance, but when both conditions were simultaneously present, women's performance was negatively affected. These findings were consistent with previous research that has shown that solo status alone does not

negatively impact performance. Instead, solo status in a context in which gender is salient — such as the situation where one's work colleagues believe, for example, that women are not good at IT or engineering — provides the context in which women's performance is impacted. The authors suggest that "Direct attempts to assuage concerns about gender stereotyping and conscious attempts on the part of observers to override their biases may therefore provide a means to improve the rate of women's advancement in traditionally male-

Implicit Associations Tests

help people to discover their own, often unconscious biases in a number of areas.

This is a set of clever, self-administered "tests" that let everyone determine their own biases, available at: <https://implicit.harvard.edu/implicit/demo/index.jsp>

dominated fields.” (p. 85).

Powell, Bagilhole and Dainty conducted semi-structured qualitative interviews and focus groups with female engineering students (26 with and 26 without industrial placements) in the United Kingdom as part of a larger study of the U.K. engineering students’ experiences in the workplace. They found that women engineering students generally accepted gender discrimination, had positive views of engineering, reinforced the masculine culture of engineering, and valued their “novelty” status in the field, being critical of other women.

These behaviors are consistent with Kanter’s early (1977) research that found that back in the 1970s when very few managers were women, those women who were successful acted like “queen bees.” By representing oneself as an “exception to the rule,” one tacitly accepts stereotypes rather than challenging them. Powell, Bagilhole and Dainty posit that given the attitudes held by these young women, that they are likely to serve as gatekeepers for other women into engineering, keeping out those women who might challenge the dominant gendered ideology of the field, which would be essential in attaining a “critical mass.” In short, a gender-based change strategy is unlikely to be successful, and, instead, a strategy that involves men will be important in changing engineering cultures.

The notion that women who are successful are not immune to sexist

beliefs, but instead, provide a convenient way for the sexist status quo to be maintained, is supported in two additional studies. In a study of 192 workers who volunteered to participate in a larger study at a Southeastern U.S. communications company, Baskerville Watkins et. al. (2006) showed that men and women who held “modern sexist” views were more likely to be promoted than non-sexists. Fischer (2006) ran an experiment with undergraduate women in which she manipulated an initial suggestion about the level of hostility they can expect from sex-

two experiments related to the cognitive process by which gender stereotypes are reinforced and essentialized. This research is important to our understanding of why women might behave as Powell, Bagilhole and Dainty’s subjects, as discussed above, and exemplifies strong experimental psychology research, therefore we review this study in detail, below.

Prentice and Miller assigned undergraduate students at Princeton to random conditions in carefully-designed psychological experiments, i.e., had strong internal validity as we

What is Stereotype Threat?

Stereotype threat is the idea that when people internalize stereotypes, either about their gender or race/ethnicity, their performance on tasks associated with the stereotype is diminished in a sort of self-fulfilling prophecy. Researchers have been concerned about women’s performance on math and African Americans’ and Latinos/as’ performance on many standardized tests and generally in school. Task instructions that inform people of the existence of stereotype threat and its effects can mitigate these negative effects.

ist attitudes to show that women will engage in sexist behaviors in response to anti-female hostility.

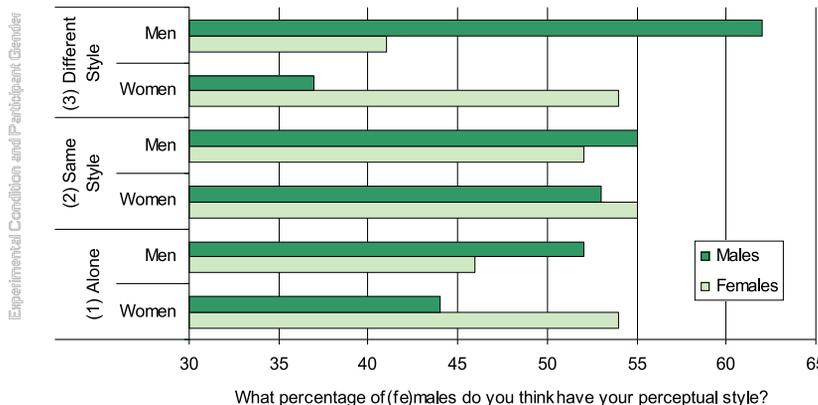
Despite a large body of evidence about the strong similarities between women and men (Hyde and Linn 2006) many people appear more comfortable with “essentialist” perspectives on gender that under-gird gender stereotypes by positing that these differences are rooted in biology. For example, pop psychologist John Gray, with his book, *Men are from Mars and Women are from Venus*, has built a profitable empire based on the idea of essentializing gender differences. Prentice and Miller (2006) report results of a novel set of

would expect in well-crafted designs. The subjects were told that they were participating in a test of perceptual ability. They were asked to estimate how many dots were on slides that had up to 10 dots, which they were shown for such a short duration that they were really just taking a guess. After being shown the slide, they were then told that they either overestimated or underestimated the number of dots and were given another chance to estimate the number of dots. As with most psychological experiments, all of these instructions were manipulated by the researchers as were the conditions under which people made their estimates. In the first study subjects were randomly assigned to one of the following three conditions:

- Alone.
- A female and a male who were informed that they had the same perceptual style.
- A female and a male who were told that they had different perceptual styles.

After making the guesses about dots, the participants were asked two questions: “what percentage of males do you think have your [perceptual] style?” and “what percentage of females have your [perceptual] style?” The graph, at left, is modified from their results.

Prentice & Miller’s Perceptual Style Study Results



Source: Modified from Prentice & Miller 2006, p. 131.

The graph shows that when people are in a situation where a gender difference is presented, i.e., condition 3, they then see that difference as an essential difference between women and men. This is the case — although far less pronounced — when they are presented with the same information without someone of the other sex in the same room (condition 1). In the situation where a randomly-assigned female-male pair are told that they have a similar perceptual style to one another, i.e., condition 2, they are more likely to say that this trait is less dependent on gender as shown by the fairly similar bars in the graph for Condition 2. These results mean that if people are in mixed-sex situations in which a man and a woman express different opinions, they are likely to then see those opinions as associated with gender, regardless of the veracity of the gender claim.

The results of Prentice and Martin's equally careful and clever second study indicate that these beliefs become entrenched in such a way that men and women then believe that these opinions are immutable as a "girl thing" or a "guy thing." By extension, then, women in engineering would be expected to simply accept the culture of engineering as a "given," as did Powell, Balgillhole and Dainty's subjects. The question, then, is how do we avoid this tendency for people to essentialize gender differences? Perhaps it is possible to "inoculate" people against these biases in the same way that people can be "inoculated" against stereotype threat by simply being told that the process exists (Martens, Johns, Greenberg and Schimmel 2006). Another study at a U.S. Southwestern university (Saunders and Kashubeck-West 2006) found that many of their 288 respondents — who were faculty, staff, and students from many backgrounds —

It is important to "nip" bad behavior in the bud and to work with your organization to make sure that harassers are disciplined.

were afraid to self-identify as feminist, reflecting the social stigma associated with the very term feminist. Interestingly, even though the sampling scheme in Saunders and Kashubeck-West was seriously flawed, they found that more androgynous women, i.e., women who had a balance of male and female-stereotypical traits, scored higher on their test of psychological well-being than did women who were more feminine. Such a finding will need to be replicated in many other settings in order to be considered reliable.

Quinn and Radtke's (2006) study shows us just how difficult it would be to bring a feminist point of view into a context such as engineering. They report on research at the University of Calgary to understand how women constructed a feminist identity and discussed feminism in conversational settings. They recruited 18 graduate students — who could volunteer as a pair or who were paired with someone else in the study — to participate in focus groups and then engage in a paired discussion with one of the researchers. All but two of the women were of European-Canadian descent (the exceptions were two women of Asian descent)

between the ages of 23 and 51 with a mean of 30.

The sample was a convenience sample, which is usually fraught with problems that call into question the generalizability of the results. But since the study was exploring how respondents articulated their feminist identity, such a sampling scheme ensured that the volunteers would be able to provide insights about this marginalized position.

Quinn and Radtke show that femi-

nists' discussions of this marginalized identity are context-specific, especially in those settings in which they are concerned about being labeled an extremist. In such settings — which would likely include engineering workplaces as described in Powell et al. (2006), discussed earlier — the women were likely to adopt a liberal feminist position, which emphasizes equality of opportunity rather than questioning existing structures.

A number of studies in the past several years have attempted to come to grips with the various impacts of women's involvement in child rearing on their careers. In 2003, Lisa Belkin heralded an "opt-out revolution" in a *New York Times Sunday Magazine* article. But is there really an "opt-out revolution" going on in which multitudes of young women leave promising careers to be full-time moms? According to Goldin (2006) there is no evidence for such a revolution. Claims about women leaving the work force in order to raise children have long been used to justify paying women less, providing them with fewer training and promotional opportunities and restricting women's entry into graduate and professional programs. Goldin used data from "College and Beyond," a longitudinal study of the graduates of 34 selective colleges and universities to refute these myths. The research was completed in 1995-96 when the respondents were about 37 years old. The respondents were women who entered college in the late 1970s. Her research showed:

- The median woman was never out of the paid workforce for more than six months.
- If you total up all of the out-of-work "spells" over the 15-year period, women were "out" for an average of 1.55 years.
- Women with children were "out" a little more, on average: They averaged 2.08 years out of the paid labor force while women without children averaged just five months.

The real issue is the structure of

Faculty for the Future

is a Web site that provides those looking for faculty jobs with a place to post their vita, and for those in search of candidates to identify a potentially wider pool of candidates for faculty positions. The site is free for both searchers and hiring committees. Since the site was originally co-sponsored by the Women in Engineering Programs Advocates Network, many of the job seekers are engineers. This is a useful tool to demonstrate to colleagues the fallacy of statements like "there are no women and minorities out there."
<http://www.engr.psu.edu/fff/>

work and the mechanisms in place to permit women to effectively manage both paid work and family responsibilities (Acker 2006, Goldin 2006, Drago et al. 2006, Hewlett and Luce 2005).

Observers of the academic workforce have focused much attention in recent years on the unfriendly climate for caregivers at institutions of higher education (Drago et al. 2006), indicating that without supervisor support, juggling the sometimes-competing demands of being a good parent and a dedicated academic can be overwhelming. Development of more family friendly policies, therefore, has been a recent focus area for academia. In another vein, the Center for Work Life Policy Studies, a non-profit research firm in New York has also been trying to help employers develop better "on-ramps" for women who decide to take time away from a paid position to attend to family issues, e.g., children, an aging parent or in-law, etc.

According to research by the Center for Work Life Policy, a "hidden brain drain" of talent reduces U.S. businesses' competitive edge (Hewlett and Luce 2005). Some of the

key findings in this research:

- 37 percent of women and 24 percent of men have taken voluntary time out of work but motivations differ:

- Men: strategically reposition themselves in their careers.

- Women: care for children or elderly relatives.

- 93 percent of women want to return to their careers, but only 74 percent of these "off-ramped" women have rejoined the ranks of the employed.

- 5 percent of women looking for on-ramps were interested in rejoining the companies they left.

- The persistent glass ceiling results in women downsizing their ambitions — an important "push" when the "pull" of family needs can seem like a wiser use of one's time.

What can employers do to reverse the brain drain? Build on-ramps by:

- Creating reduced-hour jobs.

- Providing flexibility in career paths.

- Removing the stigma associated with using flexible work policies.

- Not burning bridges: maintaining connections with employees who "off-ramp."

- Providing outlets for altruism.

- Nurturing ambition.

And now, for something completely different. Two additional studies represent "news you can use" despite defying categorization. The first related to the question: What's the best way to deal with someone who harasses you? According to a study by Lucero, Allen and Middleton (2006) it is important to "nip" bad behavior in the bud and to work with your organization to make sure that harassers are disciplined. Lucero et al. coded qualitative information from 118 published arbitration decisions between 1983 and 2001 to understand how harassers changed their behavior over time. Most of these cases involved various blue-collar harassers but 29 did involve professional/technical or office harassers. Lucero et al. found that male harassers of women develop a repertoire of behaviors that they use over and over again. In addition, they document a connection between the general aggression of harassers and gender harassment behaviors, and that harassers modify behaviors in response to the targets' reactions and the organizations' responses.

International Education and Service Learning

by Nicole Di Fabio

The 2006 annual conference held by the American Society for Engineering Education (ASEE) yielded a high volume of papers. There were a total of 266 papers in the 2006 proceedings, and of these 33 discussed the topics of international education and service learning. Both of these curricular innovations have the potential to make engineering more appealing to young women because they provide connections from engineering to the "real world," which are desired by young women. Indeed, many members of "Gen-Y," which has come of age during this time of globalization, seek such connections.

International Education

International education was a major focus for ASEE, with 21 papers covering this topic. As diversity and global issues are becoming a focal point in engineering departments, institutions are requiring foreign language and cultural studies to be a part of the curriculum. According to the papers presented, China, India, and Germany were the top three countries frequented by U.S. engineering students. Other countries in which partnerships have been formed are:

Europe:

- Ireland
- France
- Spain
- Switzerland

Africa, Asia and the Middle East:

- Kenya

- Tibet
 - United Arab Emirates
- North and South America:**
- Bolivia
 - Brazil
 - Canada
 - Guatemala
 - Mexico
 - Trinidad

Service-Learning

The method of service-learning has also been adopted by quite a few universities in the United States, with 12 mentioned in conference papers. The practice of service-learning allows students to interact with others interested in engineering outside of the university walls, or to engage in projects that take place outside of the classroom. There were a number of different service-learning examples

discussed in the conference papers such as: peer-mentoring programs, outreach, and international services. The conference proceedings papers highlighted efforts at the following universities:

- University of Arkansas
- University of Colorado at Boulder
- Clarkson University
- University of Dayton
- Massachusetts Institute of Technology
- University of Massachusetts, Lowell
- Michigan Technological University
- University of Michigan
- Purdue University
- Roger Williams
- Tufts University
- Valparaiso University
- Virginia Tech

Harassers who had been disciplined engaged in less severe behaviors. Over time, harassers increase the intensity of successful behaviors, i.e., if one is being harassed, it is important to nip it in the bud.

A second study looked at the impact of “negative acknowledgment.” This might be a crazy idea but. . .

does it help to apologize for a shortcoming up-front? A series of three careful experiments by Ward and Brenner indicates that “negative acknowledgment” can be an effective strategy to de-

claw potential critics. They looked at three situations:

- A non-native English speaker who apologized for his accent prior to a talk.

- A written acknowledgement that the paragraph students were to read was confusing.

- A college applicant who acknowledged that his/her grades were not stellar.

In all three cases, the negative acknowledgment led perceivers to evaluate the quality less negatively.

Globalization and the International Dimension of Women in Engineering

There is a growing interest internationally in increasing the participation of women in engineering. There are many dimensions to this interest, including issues about nations producing a diverse pool of technical talent as well as matters related to the international mobility of labor. Here in the United States, as immigration reform debates have been raging in the past several years, an article by Bollag about making it easier for foreign students to stay in the United States after completing their studies exemplifies the generally positive tone associated with reporting on high tech jobs, like engineering.

Drakich and Stewart focus attention on the next wave of hiring expected at Canadian colleges and universities. Between 1999-2004, new engineering faculty accounted for 10 percent of all new faculty hired in Ontario universities. Women achieve tenure at the same rates as men at Canadian universities. The authors

expressed frustration that Statistics Canada, which provides data on students and faculty at Canadian universities, fails to disaggregate by ethnicity, class, and disability status.

Ingram (2006) focused her attention on engineering graduates of Canadian universities. She reports on interviews that she had with three women engineering graduates, each of whom had graduated in a different time period: the 1970s, 1980s, and 1990s. While the study is not system-

Even though women’s representation has inched upwards in the engineering work force, according to these three women, cultural practices and attitudes about women engineers have been quite resistant to change.

atic, the article relies heavily on the voices of these women to tell some interesting stories about their lives as engineers. Consistent with Powell, Bagilhole and Dainty’s research in Great Britain, Ingram’s interviews reveal that even though women’s representation has inched upwards in the engineering work force, according to these three women, cultural practices and attitudes about women engineers have been quite resistant to change. The interviews are instructive as they also discuss the ways that women engineers cope with the negative aspects of “climate” by seeking mentors, networking and gaining acceptance among their male peers.

In Japan, women accounted for only 1.2 percent of engineering professors at the University of Tokyo (Fujita 2006). In contrast, women accounted for 7.7 percent of social science faculty, 3.7 percent of natural science faculty but 31.2 percent of those in home economics and 16.5 percent in the humanities.

Class has an important impact on occupational outcomes for students in Dadar, India, according to a study by Munshi and Rosenzweig (2006). These researchers analyzed survey data collected in 2001-2002 from 4,900 households in Bombay’s Dadar, focusing on the 20 cohorts of young people who had entered schools in the area. Twenty-eight of 29 schools

cooperated to provide additional data. The study found that despite large-scale economic changes in India, working class boys had pre-existing social networks in local working class occupations, so these young men continued to move into these kinds of positions, replicating class. Their female counterparts, however, were drawn into the paid labor force as a result of these same large-scale changes and, as such, tended to take advantage of the new educational

opportunities.

The IT boom in India has also been a major topic in the press in recent years, with some reporting (e.g., Kaur) focusing on the implica-

tions for women. Ilavarasan (2006) used a survey to show that opportunities for women in the booming Bangalore, India information technology (IT) industry were mostly equal to those of men. A large majority — 81 percent of both men and women respondents — reported that they held either a bachelor’s or master’s degree in engineering. While the survey had a good response rate — 71 percent overall — we are not provided with information about the response rate by gender or the separate rates within the two firms at which workers were surveyed. Unlike the study by McKay (2006, described below), the author does not provide sufficient contextual information about the firms. Responses from only 21 women (18 percent of respondents) were compared to those for the 93 men. With this scale difference and the absence of sufficient details about the measurement scales, inferential statistics can be problematic. Even with these weaknesses, it was concluded that women:

- Tend to perform similar job duties as men
- Do not indicate that they feel marginalized more often than do men on work teams
- Work the same number of hours as men on average
- Were less likely to have flexible work schedules than men

■ Were slightly older with concurrently higher annual earnings than men

The study's results suggest a number of other questions. For example, why are women's mean ages and earnings higher than those of men? Do they also have concurrently longer job tenure? If so, why? How do class background differences — considered key in India — play a role in these results? Are there ways that the particular class dynamics and living standards in India provide supports to women engineers to maintain professional positions? In short, the study represents a starting point for understanding women within a rapidly-growing industry.

With methods reminiscent of Fernandez-Kelley's classic study about women's work in Mexico's maquiladoras, McKay (2006) completed an in-depth comparative case study of three multinational high-tech firms in the Philippines. This article is full of rich descriptions of the three firms and useful to those interested in the ways that work is organized and in the process of change occurring in Asian nations. McKay completed fieldwork during an 11-month period in 1999 and returned in 2003 to conduct 50 interviews with human resource managers, CEOs, supervisors, engineers and other staff, along with 75 interviews with workers, generally in their own homes. If done in conjunction with an appropriate introduction of the researcher, interviews in the home setting can provide a context for frank discussions.

Similar to trends that have been seen in the maquiladoras of Mexico, a vast majority of the professional and technical workers are men, while the production workers tend to be women, with employers exploiting rather than challenging existing Philippines' gender norms. In addition, as production workers continue to be replaced via automation, the findings of this study indicate that women are quite unlikely to be given access to the higher-skilled technical positions that are becoming more prevalent in these industries. Rimi's article about women's work in IT in Bangladesh suggests that these same

issues are salient there.

"On-ramping" back into professional positions after time out of the paid labor force has become an important area of research (e.g., Hewlett and Luce 2005). Yu (2006) has examined the issue of married women's employment re-entry in two Asian countries: Japan and Taiwan. Data from large, nationally-representative surveys showed that women timed their re-entry based on their own family-work strategies in both countries. With a lower sex gap in pay in Taiwan, however, women with higher educational levels returned more rapidly to paid labor than in Japan. This also meant that for Japanese women, changes in family structure were an essential determinant of the timing of employment re-entry. Likewise, cohort effects were stronger in Japan than they were in Taiwan, with younger cohorts returning more rapidly to paid work than older ones, consistent with trends in places like the United States.

Two other articles examined the ways that national-level policies impacted women's access to occupations in general. Waylen (2006) compares and contrasts constitutional transformations in Brazil, South Africa, Argentina and Poland to show that favorable constitution-building processes (i.e., that involve women), open, transparent and democratic processes, and the openness of key participants in the constitutional project enable the construction of more open opportunity structures for women.

Skalli's (2006) research supports Waylen's findings within the specific area of information technology in the Middle East and Northern Africa (MENA) by focusing on women's agency in these nations. While the nations in the predominantly Muslim areas of MENA tend to place varying levels of formal restrictions on women, women in these nations are participating in the emergent IT areas. In general, Skalli's article focuses on the ways in which access to broader channels of information and more kinds of information technology are serving to connect women across spaces, even those in which

physical movements might be sharply restricted. At the same time, by engaging with these technologies women are shaping them throughout the MENA area. IT, therefore, has become a critical tool in the struggle for women's rights.

A similar study to the one reported earlier by Duehr and Bono used the Schein index to assess students' views of managers (again, convenience samples) was conducted by Sümer (2006) in Ankara, Turkey. The study found that 806 students there tended to rate women as lower than men on emotional stability and task-orientation. Despite being rated higher than men on relationship-orientation, the lower ratings on the other important features of managers meant that women were seen as less fit than men for management by both male and female college students.

Conclusion

The hundreds of articles we scanned for this literature review are an interesting collection gathered from many disciplines. It is actually rare to find a collection such as this, because all too often researchers in one field are not aware of the work in other fields. The proliferation of publication outlets has meant that quite a bit of published research has marginal methodological integrity, that keywords differ across disciplines, and that it is increasingly difficult to keep abreast of the research in a particular topic area. In addition, as we found, using the keywords "engineer" or "engineering" are less likely to draw one's attention to the many studies that would be of interest to women in engineering. This literature review, then, is a rather unique contribution because of the wide and fine net that we have cast in assembling materials.

However, unlike in previous reviews, conspicuously absent from this year's review are any doctoral dissertations and books. Because we focused on research articles, we were unable to provide details about a number of volumes that were issued in 2006. Instead, we plan to provide information from selected books and dissertations published in 2006 in next year's literature review.

Because women are persistently

underrepresented in engineering, those who are interested in studying the lives of women engineers often rely upon research methodologies that are not considered reliable: convenience samples, limited circles of acquaintances, and personal experiences. While these stories have merit, the extent to which they are representative of women in engineering in general is a question that can only be answered by examining many such studies. It is noteworthy that many of the items cited in this review have been able to develop stronger methodological approaches to locating women engineers to shed light on their lives.

The key to improving the research on women in engineering lies in bringing researchers together across disciplinary boundaries while recognizing the strengths and weaknesses inherent in each discipline's approaches to posing and answering research questions.

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Getting the Most from the SWE 2007 Literature Review

Not just for researchers, the annual literature review offers usable information that is easy to access.

BY BARBARA BOGUE, SWE EDITORIAL BOARD

Q: Where do you turn if you want to know more about leadership trends in industry? Current statistics on engineers in the work force? Research to underpin your next outreach activity or research grant? Ideas on how to improve your parenting?

A: Turn to “Women in Engineering: A Review of the 2007 Literature,” on page 109. Each year, *SWE Magazine* publishes this compendium, otherwise known as the literature review.

Q: But wait, isn't the SWE literature review for researchers?

A: Yes. And every other SWE stakeholder. You'll be amazed at what you can find in this annual box of goodies.

So, the next obvious question is: What's the best way to use this great resource?

First, be aware that the authors seek out and review popular reports and articles, and collect current data on the statistical status of women in engineering in addition to peer-reviewed research.

The authors also identify and expand on trends in current conversations and practice in engineering. For example, this year they spotlight leadership, going beyond the normal women in engineering literature, and tapping into organizational behavior and other resources.

Jane Daniels, Ph.D., program director for The Henry Luce Foundation, Clare Boothe Luce Program for Women in the Sciences, Mathematics and Engineering — the largest private source of support for women in the sciences and engineering — eagerly awaits the annual review because “it organizes

the results of research and practice about women in engineering in a way that is easy to read and easy to comprehend. You don't need to waste time searching for relevant information and you don't need to be familiar with statistical analysis or research terminology. In a manageable amount of time, someone can gather information from a very broad spectrum of journals.”

Here are some tips on how to get the most out of this amazing resource.

Access practical information

“I'm pretty practical,” says Anita Todd, assistant professor of professional practice at the University of Cincinnati and advisor for the UC SWE Collegiate Section. “I like things that provide information I can apply.” For example, Todd followed the sidebar in last year's review on “Just Be” (an interactive presentation to dispel myths about geek stereotypes) to see if “it is something that I

could use in my classroom or when talking to high school girls or to SWE collegiate members.”

Find parenting tips

Really! This year the review features sections on “Catching Them Younger” and “Children's Play” as well as information on early gendering of kids. Did you know that “national studies show that 45 percent of fourth grade children watch four hours or more of television each day”? Or, have you considered, “What messages are sent in the content of video games?” We are also told of a study of 39 girls and 29 boys and their parents in the rural Midwest, which found that if parents (mothers and fathers) play with their children outside, then the kids are more likely to spend more time playing outside. It's all there — and more.

Keep up on the most recent literature

Dr. Daniels notes that in her position, she is often called upon to provide background information and give presentations. SWE members “will never find an easier way to understand the issues facing women engineers and engineering students,” she says. “Information from an extremely broad range of sources is presented in a concise document, written in lay terms, that is organized around important topics or themes.”

Support workplace discussions on diversity

Data, data, data. Whether you are in a corporate, government, or

academic environment, having key stats at your fingertips is important in discussing, forming, and implementing good policies and practices. There are a lot of data in the review — numbers and trends on degrees at different levels, salaries, the composition of the engineering work force, etc., often presented in easy to read and use graphics.

Make sense of your work environment

“People working as engineers have a personal interest in trying to make sense out of their work lives,” notes co-author Lisa Frehill, Ph.D. “So we add sections on news you can use, focus on organizational behavior and how to respond to workplace situations.” They also look again at the poll covered in depth throughout the year in *SWE Magazine* and highlight key findings on work/life balance, the gender pay gap, sexual harassment, and leadership. Snippets concerning these topics include, “the gap in pay has finally started to narrow”; and “as more engineers work in cross-national teams, the gender norms of other nations and cultures are likely to become a potential source of friction for women in U.S. engineering.” On leadership, the authors note, “Senator Clinton’s campaign

is coming at a time when the nation may actually be ready for a woman leader.” Intriguing? Find more in this year’s review.

Create effective outreach programs

K-12 is a focus this year. “It’s important to learn more about the audiences served,” notes co-author Dr. Frehill. “Today the kids are not the same as [organizers’] kids at home. These kids interact with the world in very different ways.” They are also not the same kid you or I were x number of years ago. The review covers studies finding that today’s girls and boys are not as diametrically opposed to, but more separated by, adult perception and practice and, critically, class and opportunity.

In a world where it is increasingly important to reach and encourage a diverse group of kids effectively, the studies in the review point to issues attracting and serving diverse pre-college children and offer important resources to help individuals, SWE sections, industry, and programs shape and form their outreach activities.

Support proposals

The review is a helpful resource when writing grants. “It is really useful to have the SWE lit review

handy,” is a comment often heard from researchers, faculty, and women in engineering program administrators. This is especially true for people who don’t have a lot of time to keep up with the literature.

Prompt rumination (and have fun doing it)

The “Other Interesting Findings about Gender” section offers an enticing menu of tidbits about a variety of literature. The authors discuss findings that “show that there truly are penalties for women who fail to conform to gender stereotypes” and, in reviewing “Where have all the tomboys gone?” (and how can we resist *that* title?) note “interesting vignettes, which provide a richer understanding of how young women form a sense of themselves.”

These are just a few ways to use and enjoy the annual literature review. Let us know if you come up with more. In the meantime, happy reading.

Barbara Bogue is a member of the SWE Magazine editorial board and a faculty member at Penn State University. She specializes in developing assessment tools that determine program effectiveness.

Women in Engineering:

A Review of the 2007 Literature

BY LISA M. FREHILL, PH.D.; NICOLE M. DI FABIO; SUSAN T. HILL; KAREN TRAEGER; AND JESSICA BUONO

Who will be the engineers critical to maintaining U.S. technological dominance? This question drives much of the current discussion and growing national concern regarding the engineering work force. Prominent reports that have come out in the past several years, such as the National Academies (2006a) "Rising Above the Gathering Storm"; the Business-Higher Education Forum's (2007) "An American Imperative: Transforming the Recruitment, Retention, and Renewal of Our Nation's Mathematics and Science Teaching Workforce"; and the more recent "Beyond Bias and Barriers: Fulfilling the Potential of Women in Academic Science and Engineering," another National Academies (2006b) volume, have called attention to science, technology, engineering, and mathematics (STEM) work force issues. The central theme in most of these reports, as well as numerous articles and commentaries, is whether U.S. companies and educational institutions will have the highly trained labor force necessary to thrive in an increasingly competitive, shrinking world. Of special concern is the interplay of demography and large-scale corporate restructuring that has quickened over the last quarter-century and consequently exacerbated the problem.

In terms of demographics, the baby boomers — those born between 1946 and 1964 — are moving toward retirement. Just as they are aging, though, the impact of major changes in the corporate landscape is also being felt. Throughout the

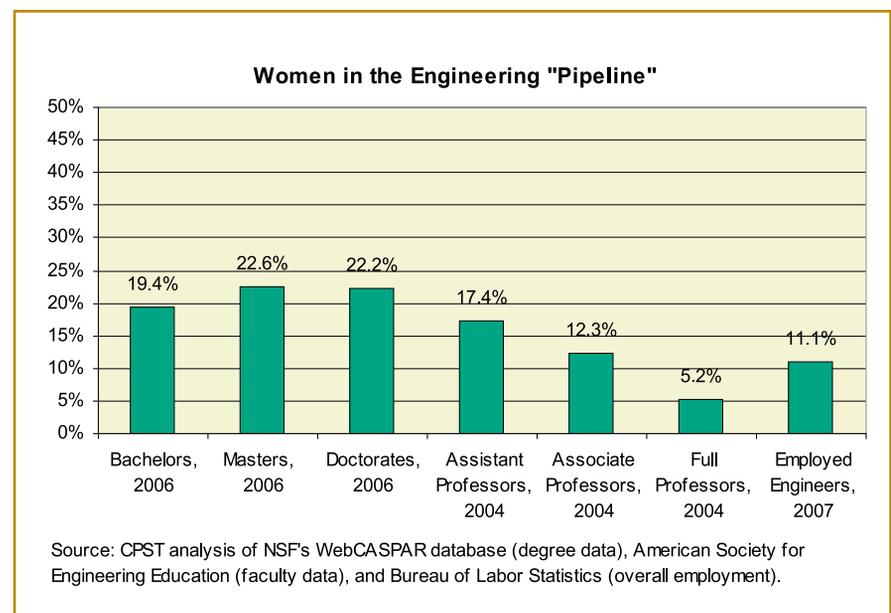
last 20-30 years, the U.S. economy has continued to "de-industrialize" — that is, move further from resource extraction and manufacturing and toward an increased reliance on service production — so that the world of work now is dramatically different from the one that existed when the baby boomers entered the labor force in the 1970s.

These larger social forces have resulted in greater national-level concern about who will be the next generation of engineers and scientists, and created anxiety over whether the United States will be able to compete on a global stage. It is in this setting that issues for women in engineering have moved to the national "front burner."

The Society of Women Engineers has been a lead organization in ensuring that women engineers' concerns are not lost in recent debates about competitiveness and the

STEM work force. For example, in October the spotlight was on the one-year anniversary of the "Beyond Bias and Barriers" report, for which congressional hearings were held. In addition, new data were published by Donna Nelson about the representation of women and minorities on the faculties of selected U.S. research universities and presented at a National Press Club briefing. The fundamental message at these events implied incorrectly that there is no longer a pipeline problem and that women are experiencing discrimination in employment mainly at the doctoral levels. Of course, this is simply not an accurate statement about engineering — or computer science — because in both engineering and computer science there is a persistent pipeline problem for women.

Even though women now earn more than half of all STEM degrees at the bachelor's and master's lev-



els and 45.9 percent at the doctoral level, they are still a minority in engineering. The graph below shows women's relative participation in engineering, which is far from parity with women's representation in the U.S. work force. Women's distribution across engineering specialties differs greatly, as shown in the next chart. It is interesting to note that 77 percent of the nation's 2.6 million engineers and technicians are accounted for in the seven specialties shown in the chart and that the representation of women at different degree levels varies greatly across the engineering fields.

We now turn our attention to the substantive literature on women in engineering that appeared in 2007. As in previous years, we have searched the tables of contents of journals from which preceding years' articles were drawn — about 50 journals from a range of disciplines — and then searched bibliographic databases to make sure we did not miss any articles. These searches were also important in helping us locate news articles about women in engineering or about issues that might be of interest to women working in the field. As always, we have given priority to discussing the findings from peer-reviewed literature that relies on strong research methodologies. While some studies — even articles that appear in peer-reviewed journals — suffer from poor research design, there is also research that is solidly constructed. Consequently, as appropriate, we offer guidance on the methodology of research discussed here.

Catching them younger: engineering and K-12

Most articles about K-12 and gender that appear in both the peer-reviewed journals and the popular press focus on mathematics and science preparation. Four articles discussed the need for role models while another 10 articles referenced the need to encourage girls and young women to pursue engineering. Interestingly, despite the clamor to increase the numbers

of women teaching mathematics and science in middle and secondary schools so that girls will have role models, there is little evidence to date to suggest that having a female science teacher impacts girls' achievement. Indeed, there is mounting evidence that there is no "role modeling" effect (e.g., see Gilmartin et al. 2007). Contrary to popular belief, seeing women as math and science teachers does not mean that more girls will pursue these fields. In many cases, the articles suggest that it is important to increase young women's entry into engineering, science, and other technical fields because of unmet labor market demands and the projection that these demands would become more intense over time.

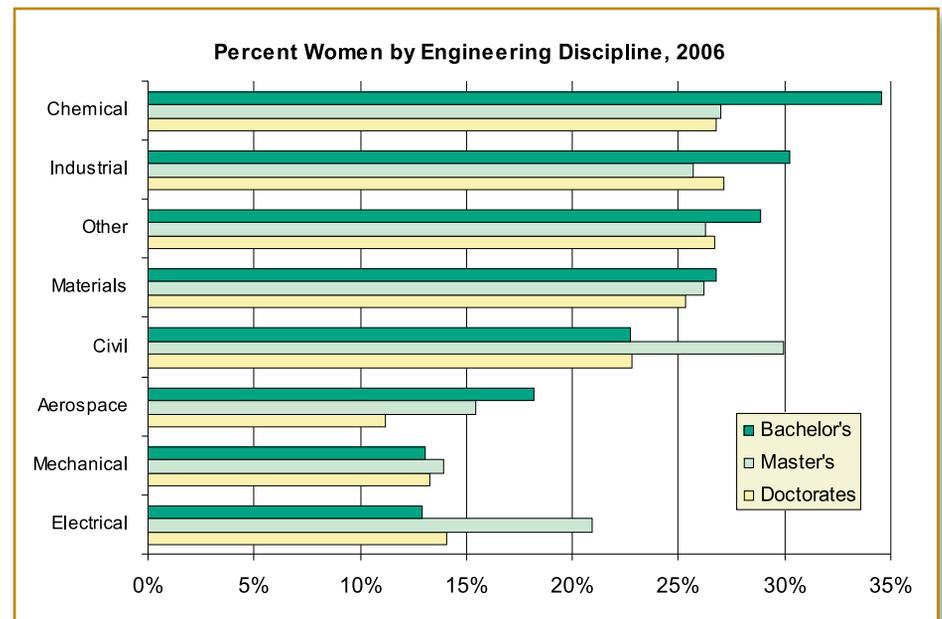
Large-scale national movements to increase students' access to engineering prior to college are a relatively recent phenomenon. There have been a number of efforts, including:

- Girl Scouts (Shallcross 2007), MESA, and Project Lead the Way (Selingo 2007) in the private sector
- "Engineer Girl" work by the National Academy of Engineering (2003) (www.engineergirl.org)
- PBS' "Design Squad" show
- The Engineers in Motion partnership between The Ohio State University and Honda (Kennedy

and La Rue 2007)

- The Engineering Schools of the West Initiative (Plumb and Reis 2007)

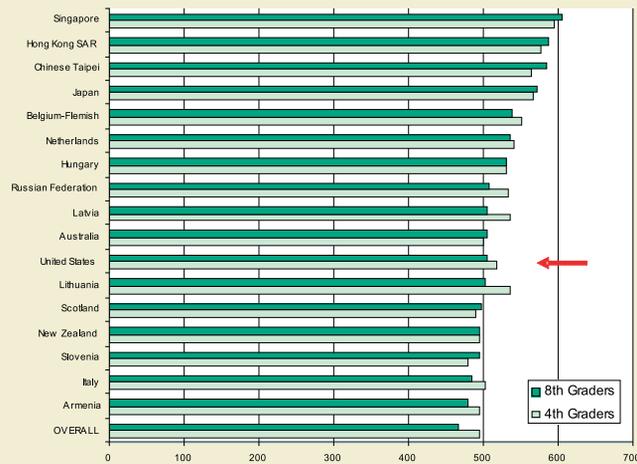
Many of these programs provide training for K-12 teachers and activities in various settings for different lengths of time. The philosophy is that increasing teachers' familiarity with engineering will enable them to better guide students toward engineering programs. Most of these programs target only those students who are already high-performing, so it remains to be seen whether they will be successful in expanding the ranks of new engineering students and, subsequently, of the engineering labor force. For the past 25 years, programs that "cherry picked" girls have resulted in increased participation in the life sciences but have not produced a noticeable impact on women's participation in engineering, as shown in the trend graphs on page 114. Similarly, Bergin, Cooks, and Bergin (2007) used a randomized experiment to show that a program targeted at minority students had no impact on the likelihood of going to college but that the program did increase the chances that the students would attend the college that had run the program. Hence, the programming did nothing to increase the pipeline pres-



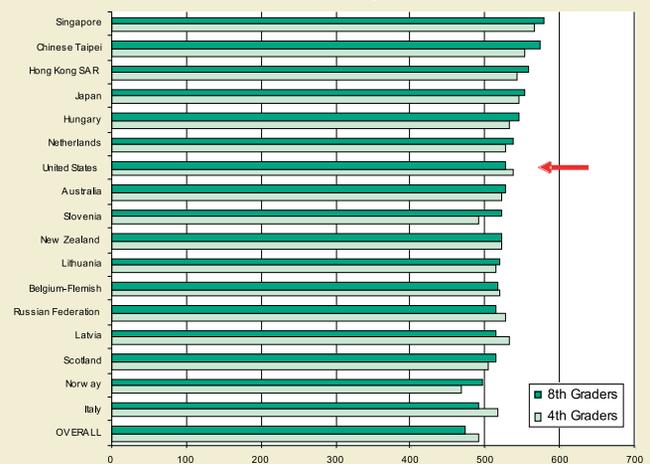
Trends in International Mathematics and Science Study (TIMSS)

Since 1995, the United States has worked with a number of other economies to look at comparative data on students' mathematics and science performances. Data were collected in 1995, 1999, 2003, and 2007. The 2007 data will not be published until December 2008. These studies are the basis for some of the alarmist rhetoric in recent years about the "poor performance" of U.S. students compared with those in other countries. As the following two charts show, the U.S. scores for fourth and eighth graders on the mathematics and science tests are higher than the mean for all participating countries and places U.S. students in the top 11 (mathematics) and top seven (science) among the economies shown here. For more information about the TIMSS project, visit the U.S. National Center for Education Statistics Web site at: <http://nces.ed.gov/timss/> where you will find sample questions, additional reporting on the results across economies, and details of results for various gender and racial/ethnic groups in the United States.

TIMSS, Mean Mathematics Scores, Selected Economies with Means Higher than the Overall Mean for All Participating Economies, 2003



TIMSS, Mean Science Scores, Selected Economies with Means Higher than the Overall Mean for All Participating Economies, 2003



ence of minorities, but such programming might be useful to increase diversity at a specific college or university.

Failure to impact the general school settings in which young women find themselves — let alone impact the gross inequalities in the science and mathematics education in the U.S. school system in general — demonstrates the flaws in individual-based solutions to larger social problems. The involvement of teachers represents an advance in the newer programming such as that reported by Plumb and Reis (2007). Selingo's article in the April 2007 issue of ASEE's *PRISM* magazine (available online at www.asee.org) describes some of these efforts, including the PBS "Design Squad" show, as ways to reach down the pipeline to interest a new generation in engineering and technology.

The Women in Science Scale (WiSS) is an important set of questionnaire items used in many research projects that involve middle

and high school students. The scale was developed in 1984 and has not been updated since.

A paper by Owen et al. (2007) revalidated the scale with multiple middle and high school age groups and updated its construction. The article also has useful appendices that lay out the key factors in some other studies (although not an exhaustive review) that have used the WiSS. Importantly, Owen et al. show that the WiSS can be shortened from 27 to 14 items with two, rather than three, factors measuring "sexism" and "equality."

Attention to the range of issues that can come up in educational settings is critical if more underrepresented groups are to gain access to STEM careers via improved pre-college science instruction. Jones and Eick (2007) completed an in-depth study of two middle school teachers' adoption of inquiry kits for science. They found that the complexities associated with reform necessitate that teachers be provided collective and individual

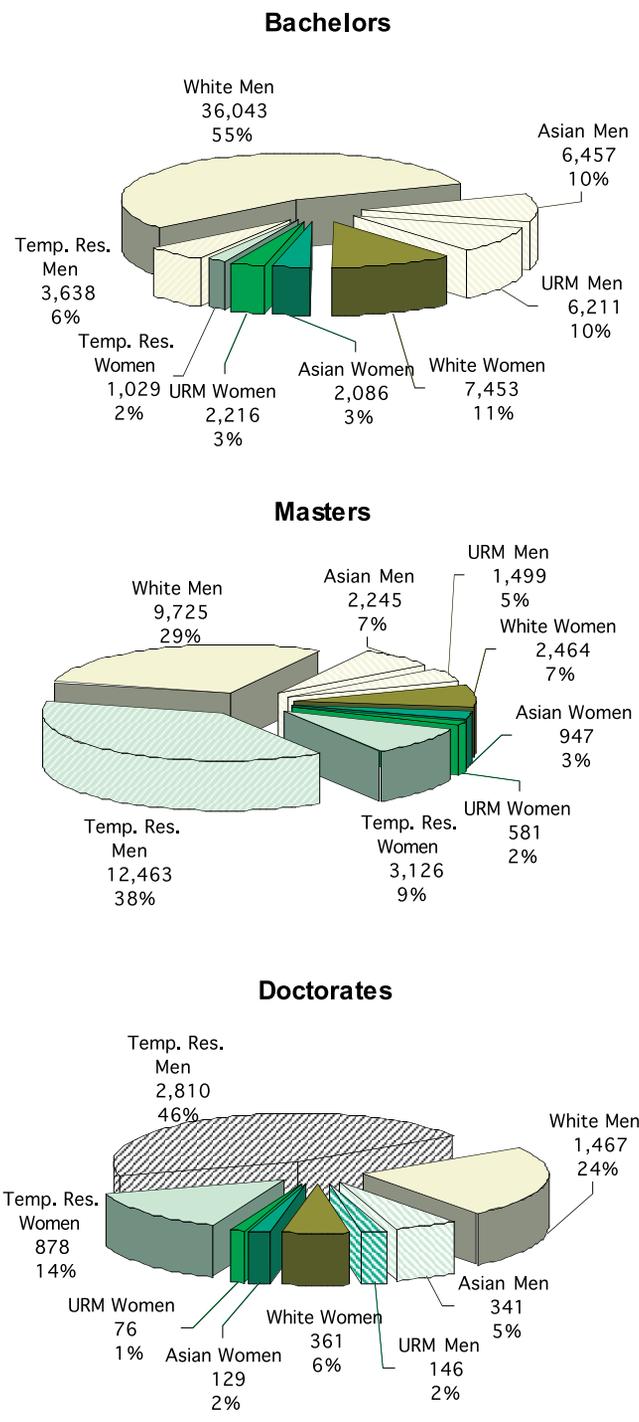
support to implement new approaches to learning science.

Mathematics performance has long been a subject of much debate. Mathematics is a critical area for those interested in pursuing an engineering degree. Earlier accounts of women's underrepresentation in engineering tended to focus on the gap in girls' and boys' preparation, a gap that has now been closed for about 20 years. Interestingly, as shown by Frehill (1997), mathematics to some extent has actually provided the pathway into engineering for young women. The debates now — outside of unfounded suggestions that women lack quantitative skills — are usually about how to improve mathematics preparation prior to college. This is especially true for populations that have long lacked access to high-quality instruction, namely students of color and students from economically disadvantaged areas. In some cases, the performance of U.S. students on standardized tests such as the TIMSS

becomes a basis for alarmist rhetoric that the United States is “falling behind” other nations in the global talent competition (see the sidebar, “Trends in International Mathematics and Science Study [TIMSS]”).

High school preparation for engineering is critical. As discussed earlier, more schools are implementing curricula to increase young people’s connection with engineering and design. To stem the tide of students leaving the natural sciences and engineering and to attend to the issues of gender and ethnic equity, there have been a number of calls to reform high school mathematics and science teaching. Schroeder, Scott, Tolson, Huang, and Lee (2007) have completed a meta-analysis of teaching strategies research, examining the outcomes of 61 studies of various teaching strategies reported in the scholarly literature between 1980 and 2004. The original literature search had identified 390 studies, but only 61 matched the criteria for inclusion in the analysis, such as having a synthesizable measure of impact. As a meta-analysis, this article provides a useful starting point for those interested in examining how to improve teaching strategies or for those looking for in-service training ideas or other programming aimed at teachers. The following strategies were found to have a positive impact on science achievement (effect sizes are in parentheses):

2006 Bachelor’s, Master’s, and Ph.D.s in Engineering



Enhanced context (1.48)
 “Teachers relate learning to students’ previous experiences or knowledge or engage students’ interest through relating learning to the students’/school’s environ-

ment or setting (e.g., using problem-based learning, taking field trips, using the schoolyard for lessons, encouraging reflections)”

Collaborative learning (0.95) “Teachers arrange students in flexible groups to work on various tasks (e.g., conducting lab exercises, inquiry projects, discussions)”

Questioning (0.74) “Teachers vary timing, positioning, or cognitive levels of questions (e.g., increasing wait time, adding pauses at key student-response points, including more high-cognitive-level questions, stopping visual media at key points and asking questions, posing comprehension questions to students at the start of a lesson or assignment)”

Inquiry (0.65) “Teachers use student-centered instruction that is less step-by-step and teacher-directed than traditional instruction; students answer scientific research questions by analyzing data (e.g., using guided or facilitated inquiry activities, laboratory inquiries)”

Manipulation (0.57) “Teachers provide students with opportunities to work or practice with physical objects (e.g., developing skills using manipulatives or apparatus, drawing or constructing something)”

Assessment (0.51) “Teachers change the frequency, purpose, or cognitive levels of testing/evaluation (e.g., providing immediate or explanatory feedback, using diagnostic testing, formative testing, retesting, testing for mastery)”

Instructional technology (0.48)

“Teachers use technology to enhance instruction (e.g., using computers, etc. for simulations; modeling abstract concepts and collecting data; showing videos to emphasize a concept; using pictures, photographs, or diagrams)”

Enhanced materials (0.29)

“Teachers modify instructional materials (e.g., rewriting or annotating text materials, tape recording directions, simplifying laboratory apparatus)”

Physics, chemistry, and advanced mathematics (trigonometry, analytic geometry, pre-calculus, and calculus) are the core building blocks of engineering that students need to complete in high school. Not all U.S. schools offer all of these courses, and it is clear that there are wide variations in the quality of teaching and the type of curriculum. Recent research by the American Institute of Physics (Hehn and Neuschatz 2006) has shown that more high schools are offering physics, and the gender gap in high school physics course-taking has closed. The courses that most students take, however, are not of the quality that is critical for physics and engineering majors in college. Other trends in high school physics cited by Hehn and Neuschatz (2006: 37) were:

- ◆ “The focus is shifting from what is taught to what is actually learned.”
- ◆ “Instructors are increasingly interested in understanding how students learn, and in applying those findings in class.”
- ◆ “There is growing support for a national science-reform effort based on what students should know and be able to do (standards).”
- ◆ “Networks are being developed to promote communication among physics teachers at all levels.”

Hazari, Tai, and Sadler (2007) show that the content of college students’ high school physics curricula has a different impact on college physics performance for females and males. The study is part of a larger one of introductory

college classes. The authors selected a random sample of 150 four-year comprehensive institutions and then limited that sample to only those institutions that offered an introductory physics course in students’ first semesters, producing a final sample of 56 universities. They then recruited faculty participants from these institutions, with about 80 percent of the institutions having at least one willing faculty member. The study looked exclusively at the performance of college students in physics who had taken a high school physics course, regardless of the type of class. Instead of looking at the type of class, these authors looked at how specific course pedagogical approaches and content influenced college physics course outcomes (i.e., grades). In the aggregate, there was no sex difference in the course grades (which were reported by the professor rather than the student), but there was a complicated impact of gender upon these grades nonetheless related to high school physics course content and pedagogical approach. A summary of their findings (again, all of the respondents had taken high school physics):

- ◆ Females who had high school physics classes that stressed learning concepts vs. memorization tended to perform better in college physics.
- ◆ Men who had taken high school physics with an emphasis on memorization did more poorly in college physics.
- ◆ Real-world examples were critical to developing students’ understanding of concepts in high school physics.
- ◆ Females who were in high school physics classes that had long-written problems fared worse in college physics than their male counterparts. The opposite effect was seen for males.
- ◆ Test items that covered material from earlier tests improved test scores for males but led to decreased performance for females.
- ◆ Fathers’ encouragement in science had no impact on males but did have a positive impact on fe-

males’ performances in college physics.

- ◆ The general family attitude that science is “a way for you to have a better career” had a positive impact on males’ but no impact on females’ performances in the college physics course.

This carefully designed study merits a closer read to fully appreciate the nuanced results.

Another interesting study turns attention to high school students’ work in chemistry, with conclusions that echo those of Hazari et al. (2007) and provide support for those in Hehn and Neuschatz (2006). Watanabe et al. (2007) used a rich, qualitative case study approach to understand how teachers at an urban high school were able to ensure student success in “detracked” chemistry classrooms. The study looks at a unique school in Berkeley, Calif., where all students since 1994 have been required to take chemistry, rather than the situation at most U.S. secondary schools where chemistry is an elective. As with other classes, when chemistry is made an “elective,” a majority of students “opt out” without having a strong basis or students are “tracked out” by counselors, who may be operating under race-based, class-based, or gender-based stereotypes and assumptions. Watanabe and her colleagues found that the teachers’ approaches evolved over the past decade so that the chemistry classes included greater attention to student study skills, a more inquiry-based approach with an emphasis on real-world contexts, and fostering a sense of community among the students. This latter issue was significant because these classrooms encouraged students to take responsibility for one another’s learning and rewarded them rather than set them against one another as in a traditional competition for grades.

Children’s play

Many adults have memories of being told, “It’s a beautiful day. You should go outside and play.” Back in those days, there were only

a few TV channels, so going outside to play was often a welcome alternative to watching reruns of "The Three Stooges." Now, of course, children have indoor recreational choices that can be quite alluring, including many more television channels, video games, and the Internet. So, how does one get kids to go outside and play? In a study of 39 girls and 29 boys and their parents in the rural Midwest, Beets et al. found that if parents (mothers and fathers) play with their children outside, then the kids are more likely to spend more time playing outside.

Television viewing patterns for children have changed slightly over the last decade or so. There is a decrease in television viewing in the younger age groups, whereas among older children the opposite is the case. In 1992, 43 percent of fourth grade boys and 39 percent of fourth grade girls watched four hours or more of television each day. By 2000, these numbers had changed, with 40 percent of boys and 31 percent of girls in fourth grade saying they watched four or more hours of television a day. Among high school seniors in 2004, 32 percent of boys and 29 percent

of girls reported watching television/DVDs for three or more hours on weekdays, which represents a substantial increase over the levels in 1992, when 9 percent of seniors of both sexes watched three or more hours of television per day (National Center for Education Statistics 2007).

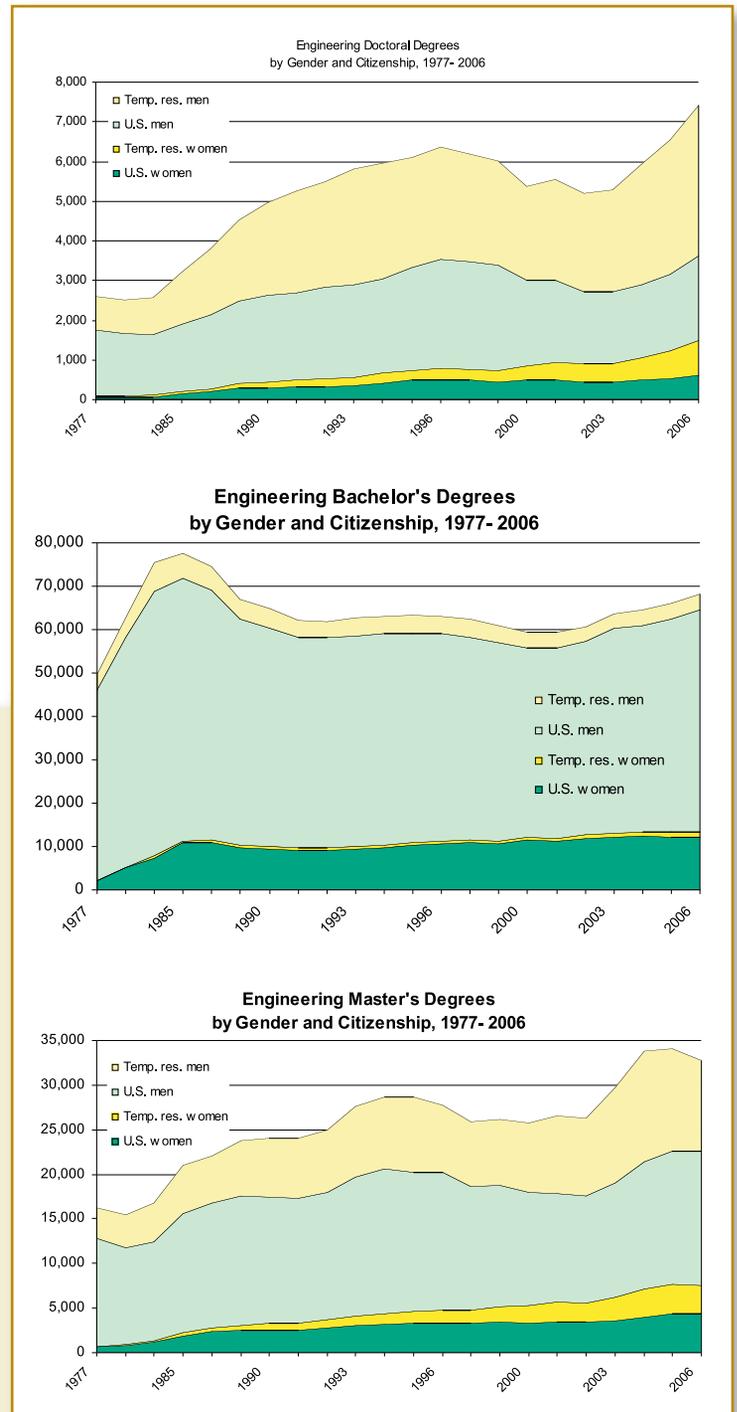
The time spent on computers in general and playing video games in particular (both on computers and with various game consoles) has become an issue of new attention for those interested in various "digital divides." Looking only at high school seniors, for example, back in 1992, 28 percent of boys but only 20 percent of girls indicated they used a personal computer at least once a week. By 2004,

this sex gap had disappeared, with 86 percent of all high school seniors of both sexes indicating they used a personal computer at least once a week. An important sex gap that remains, and has widened, is in the extent to which high school seniors report playing video/computer games. In 1994 only 3 percent of boys and slightly less than 1 percent of girls reported that they played

Trends in women's participation in engineering degrees

Over the last 30 years, women's participation in engineering has grown. As the charts indicate, however, most of the growth occurred during the 1970s, when most colleges and universities and companies were held to strict Affirmative Action guidelines to improve women's and minorities' participation. Women's participation in bachelor's and master's degrees leveled off during the Reagan administration and the "backlash" period (Faludi 1991). The 13,300 degrees awarded in 2006 to women in engineering represented just 1.6 percent of the bachelor's degrees women received, and the 54,821 to men accounted for 8.8 percent of total bachelor's degrees awarded to men (the third most popular major for men). The most popular major for both women and men was business with more than 316,000 bachelor's degrees, or one in five, in 2006.

Who is likely to be teaching engineering in the future? The graph, below, suggests that more faculty are likely to be from outside the United States. In recent years, the largest growth in engineering doctoral degrees has been among temporary resident (foreign) men with only minimal growth for temporary resident women.



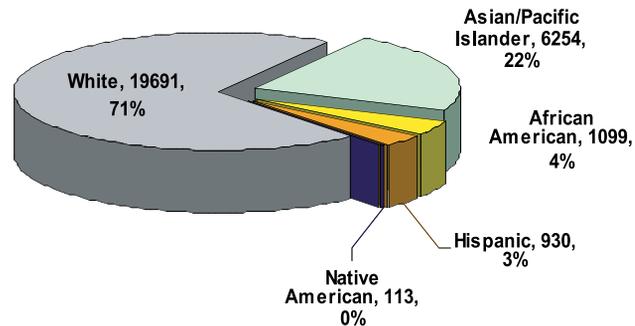
these games for three or more hours per day on weekdays. The percentage of boys playing three or more hours of video/computer games increased to 11 percent by 2004, with an increase to almost 2 percent for girls (National Center for Education Statistics 2007).

With students spending so much time with video games, there has been more public debate about the types of messages included in these games, which can be questionable. Jansz and Martis (2007) report on a content analysis of the introductory films associated with 12 video games. These researchers chose to focus on a specific set of games rather than the most popular games. Their interest in character interactions and in how female characters were portrayed precluded the many popular sports, fighting, or racing games, which usually have little interaction between characters. Their non-random sample included such games as *Final Fantasy X*, *Splinter Cell*, *Charlie's Angels*, and *Tomb Raider: The Angel of Darkness* (as well as eight other titles). While females were the lead in half of the games examined, women were sexualized (e.g., a la Lara Croft of "Tomb Raider"), and most characters and all heroes were white. In short, these games offered fairly mainstream messages about race and gender, which simply reinforce stereotypes.

Stereotypes affect how we view others, but they also can play an important role in how people rate themselves. According to research by Selwyn (2007), females often perceive their own capabilities as less than what they may actually be, while males perceive themselves as competent in their technology usage and "expertise." Men considered themselves to be frequent and expert users of overall computer applications. Anything related to communication, art/design, and studying were considered to be more feminine, while those involving gaming, downloading music, and online banking were seen as masculine.

Such dichotomies reflect gender

Doctoral Engineers as Faculty at 4-Year Institutions by Ethnicity, 2003



Source: CPST analysis of data derived from National Science Foundation, 2003 Survey of Doctorate Recipients, Characteristics of Doctoral Scientists and Engineers in the United States, 2003.

stereotypes and pose challenges to enabling women to become familiar with computers and comfortable enough to define themselves as expert users. In keeping with other feminist ideas, then, this research points to the need to tear down these stereotypes. Consistent with the operation of stereotypes, Lemons and Parzinger (2007) documented that women in IT professions are considered to stray more from traditional gender norms while men in IT fit gender norms. One way to challenge stereotypes is careful highlighting of the presence of diverse women in IT fields.

There were two other pieces this year that showed how stereotypes can cut two ways. Gillard, Mitev, and Scott (2007) report findings from 48 interviews with single mothers in the United Kingdom (specifically, England and Scotland) who participated in a program to reduce their isolation. The program actually resulted in increased isolation for these women because it reinforced rather than challenged stereotypes. Gillard et al. found that it was important to take into account the ways in which these women's lives were different because of their roles as single mothers and that the women would have been less isolated if the program had worked more closely with employers on how to implement more effective work/life balance policies.

Another piece, by Phipps (2007),

looked at the discourse used by programs that have sought to increase women's and girls' participation in STEM. While these programs often decried against the way stereotypes operated against women's entrance into the STEM fields, the programs themselves actually often relied on stereotypes to characterize women's interests.

Diversity and intersectionality

Stereotypes are critical in the literature on diversity and intersectionality. The concept of intersectionality refers to the idea that it is important to consider that the number of groups an individual belongs to can shape his or her experiences. For example, women of color experience the world a little differently than white women because they are both "female" and "people of color," each of which has stereotypes. Further, as discussed in work by bell hooks (1981) and Patricia Hill Collins (1991), among others, there are many stereotypes based on specific ethnic/racial group membership and gender simultaneously (e.g., the African-American woman as a "matriarch" or the Latina as a sultry sex goddess).

As we discussed in the opening to this article, issues about who will be the next generation of engineers have moved to the forefront in the United States. Past attempts to improve the status of women and minorities have often resulted

in approaches that translated to women or minorities, which have been of limited value. The work of social scientists that look at intersectionality (e.g., Hill Collins and hooks, mentioned above) provide

us with tools with which to look more carefully at how barriers to women's participation in engineering are impacted by race/ethnicity as well as by other important factors such as marital status, class

background, and whether one has children or not.

While it is often a struggle for minority women to progress through exclusive STEM disciplines, there are success stories.

International Perspectives on Engineering Education

By Susan Hill and Lisa Frehill, Ph.D.

Engineering, more than any other field, is engaged in international issues throughout the entire U.S. education and employment spectrum. Beginning with classes in engineering, international students are common at all levels. Data presented in the National Science Board report *Science and Engineering Indicators: 2008* show that international students on temporary visas represented significant levels of the engineering degree recipients from United States universities:

- 7 percent of bachelor's degrees
- 44 percent of master's degrees
- 60 percent of research doctorate degrees (or 71 percent if non-U.S. citizens with permanent resident visas are included) (NSB 2008)

Given the demographics, students in engineering classes at the graduate level experience an international perspective by definition, with faculty and peers from many countries. A study by professors at the University of Colorado at Boulder has begun to assess the cultural competency of engineering students in these dimensions: "the engineer's role in serving society; belief that globally people define and solve engineering problems similarly; diversity of contact; relativistic appreciation; and comfort with differences." Bielefeldt and High (2007) report results of a convenience sample of about 300 engineering undergraduates at two universities. The respondents were at the University of Colorado and Oklahoma State University and included first-year students in introductory engineering courses and finishing students in capstone design courses in civil and environmental engineering. These design flaws mean it is unlikely the results can be generalized, but the study may be a useful starting point for further research with more carefully chosen and representative populations to understand how engineering students see international/global issues.

Another research project at Arizona State University (Bernstein, Anderson-Rowland, et. al 2007) was presented at the American Society for Engineering

Education conference reporting results from four focus groups: international women, international men, U.S. women, and U.S. men in science and engineering. The results indicated a need for international students to receive more training about U.S. ethnic groups and women's rights because members of these groups adhered closely to the negative stereotypes about women and minorities. Most of the international students were from Asia, especially India and China. Bernstein and her colleagues also found that international women and men shared similar ideas about family/work balance, with very rigid notions that women needed to have children before they were in their thirties.

Like other members of their generation, U.S. engineering students have become increasingly interested in international issues. Since 2002, engineering students have created 230 chapters of Engineers Without Borders on university campuses in the United States and Canada. They design, fund, and implement engineering projects to improve the lives of people living in other countries. Students serve as ambassadors of goodwill, showing that scientists and engineers can be diplomats as they work on solving engineering problems for communities, often related to sanitation and clean water (Dentel 2007).

Related to increasing faculty involvement in international projects, the U.S. Department of State has created International Science and Technology Fulbright awards and activities to cultivate international networks of scientists and engineers. The Fulbright program provides a variety of awards for students and faculty at most educational levels to go to other countries (U.S. recipients) for a period of study or for international students to be able to come to U.S. universities. For information about the Fulbright program, visit <http://exchanges.state.gov>.

There has also been a lot of interest in examining the situation of women in science and engineering in different countries. This past year saw many efforts targeted at this issue, including:

- The International Conference on Women Leaders in Science, Technology, and Engineering, held in Kuwait City, Kuwait, in January
- A colloquium, "Empowering Women in Engineering and Technology," held in June in Tunis, Tunisia, by the World Federation of Engineering Organizations
- An APEC-sponsored workshop in November, "Participation of Women and Ethnic Communities in Science and Technology in the APEC Region," at Chonbuk University in Jeonju, S. Korea
- A volume edited by Ingelore Welpe, Barbara Reschka, and June Larkin titled, *Gender and Engineering: Strategies and Possibilities*

The January conference was sponsored by the U.S. Department of State, the American Association for the Advancement of Science, and the Kuwaiti government to "promote networks of women scientists and engineers in the broader Middle East" (Lord and Turekian 2007: 770). The conference in June, with much involvement by SWE, brought women engineers together in Tunisia for three days of meetings. With the setting in Tunisia, women from across the Middle East, Africa, Europe, Asia, and the Americas participated in the event. The conference provided an excellent opportunity to learn more about the situation for women in engineering outside the United States and to hear of their struggles to earn recognition for their work. An article in *SWE Magazine* by Peggy Layne ("WFEO International Colloquium: Empowering Women in Engineering and Technology," Fall 2007) provides a nice overview of the event.

Finally, in November 2007, participants from several APEC economies met in South Korea to discuss strategies to increase the representation of women and members of ethnic groups in science and technology. Understanding that women and minorities are a human resource pool for science, technology, engineering, and mathematics, many APEC member economies promote and support policies to encourage women and minorities to choose STEM degrees and careers. Representatives from the following Asian-Pacific

Minority women who have found success in STEM have formed a “science identity” (Carlone and Johnson 2007) of their own that may go against the socially constructed typical image of science.

Carlone and Johnson’s science identity model includes three important aspects that impact the science identity that minority women create for themselves. The three pieces that make up the sci-

ence identity model are performance, competence, and recognition. Gender, race, and ethnicity then all play a role in how an individual perceives these pieces of their science identity.

Economic Cooperation members presented updates from their respective economies on this topic:

- China
- Indonesia
- Japan
- S. Korea
- Malaysia
- Philippines
- Taiwan
- United States

Data from these presentations are available in English by contacting: eklee@chonbuk.ac.kr.

SWE members will be interested in the book, *Gender and Engineering: Strategies and Possibilities* (edited by Ingelore Welpé and Barbara Reschka). The book contains 14 chapters in which the authors discuss a range of topics, including:

- Creating girl engineers: strategies from two U.S. programs (Cunningham)
- Dilbert® in stilettos: the character deterrents facing women in engineering (Cech)
- Masculine engineering, feminine engineer: women’s perceptions of engineering and engineer identity (Chu)
- Is teamwork a female-friendly pedagogy? (Hartman and Hartman)
- Gender in the engineering design context (Kremer)
- Rethinking gender inequalities in engineering (Wolffram)
- Shortcomings on gender aspects in analysis of interventions: patents originated by women in the European Union (Busol, Kugele, and Tinsel)
- Innovative strategies for retention of women engineers in academia: conversation with successful role models (Chowdhury, Hoo, and Pasik-Duncan)
- Gendered organizational engineering cultures in Europe (Sagebiel)
- Challenging the leaky pipeline: cooperation scheme between technical universities and research institutions for excellent female researchers (Leicht-Scholten)
- Assessing the impact of gender training on engineering students (Maree and Maree)
- Gender inequality in environmental research in the natural sciences and engineering: a question of contents (Weller)
- The ADVANCE: Institutional Transformation program’s impact on engineering schools (Frehill)

The chapters report results from research projects in varied traditions. There are a number of convenience-sample surveys of students at the authors’ institutions but also some pieces that are more consistent with a social constructionist view of engineering. With an international set of editors, the papers provide insights about North American and European engineering.

Many of the themes presented in articles based on settings outside the United States echo the same issues women face in U.S. engineering. Adequate preparation for engineering, discrimination, and overcoming stereotypes dominate the international literature. Nhundu (2007) reports results of a social psychology experiment with Zimbabwean elementary school children. Children’s books were manipulated (a set of “Role Model Readers”) so that the experimental group read books that had biographical sketches of females in nontraditional jobs, while children in the control group did not read these books. Engineering was one of the jobs in the list of 12 jobs included in the study.

First, girls were more attracted to the Role Model Readers, themselves. Second, the intervention impacted the jobs the girls said they were interested in, with 69 percent switching their preference from a female-typical job to a male-typical job after they read the book. Indeed, while none of the girls in either the experimental or comparison group indicated an interest in engineering prior to the Role Model Readers, engineering was the second-most popular choice for those who had read the Role Model Readers.

Smith, Kausar, and Holt-Lunstad (2007) studied Pakistani women in gender-atypical fields (e.g., scientists), showing that they had a high level of consciousness about the stigma of gender. Rodari (2007) shares results of a “draw a scientist” activity that is part of the Science Education for the Development of European Citizenship (SEDEC) project. Drawings by children between 9 and 14 years of age in six countries (Czech Republic, France, Italy, Poland, Portugal,

and Romania) were analyzed (a total of 1,102 drawings). In many cases, scientists were shown in stereotypical ways, such as a “crazy, mad scientist.” About a third of the time the drawings showed a person in a white lab coat, glasses, and in a lab. Importantly, though, there seemed not to be any gender bias in terms of the drawings: Girls were quite likely to draw women scientists, indicating that for European girls in these six nations, there was no large stigma for women in science. Many children drew scientists modeled after Albert Einstein.

Gouthier’s article about teachers’ perceptions of scientists shows that teachers’ views are quite similar to those of the European children. In a questionnaire administered as part of the SEDEC project, for example, 277 teachers were asked to list the names of three European scientists. The top three names were Albert Einstein (mentioned by 121 teachers), Marie Curie (63), and Louis Pasteur (47). In general, too, teachers characterized scientists as curious, untidy, and unpleasant. According to the teachers’ assessments, science work is strongly experimental. One question on the survey asked the teachers to rate the trustworthiness of various occupations. The top three occupations were teacher (n=236), doctor (n=200), and engineer (n=123). It should be noted that the questionnaire used gendered pronouns (the masculine) — Rodari had indicated that the term “scientist” in most of the languages was a masculine term — so it would be interesting to see whether the teachers saw this usage as gendered or gender neutral.

In summary, the world has been getting smaller as advances in communications and transportation have given us the tools we need to work with people across the globe. In some circles, the forces of globalization are met with trepidation, as people fear that some distant “other” group will “take their jobs.” But it is clear that globalization provides U.S. engineers with many opportunities to improve lives globally and for U.S. women engineers and SWE to have a positive impact on the participation of women in engineering beyond the United States.

Competency can be measured through GPAs, test scores, and other metric units. However, recognition is dependent upon others' ac-

knowledgment of accomplishments made by minority women in science. It is important that professors and employers recognize that these

women are competent students and workers. Carlone and Johnson found that it was not the tangible evidence of recognition

2007 Outstanding Women in Engineering

American Society for Engineering Education (ASEE) Awards

Sharon Keillor Award for Women in Engineering Education

Julia Ross, University of Maryland

Robert G. Quinn Award

Ann Saterbak, Rice University

Chester F. Carlson Award

Rebecca Rae Richards-Kortum, Rice University

Best Paper – PIC I

Ashley Smetana, University of Michigan

Best Paper – PIC IV

Tammy VanDeGrift, University of Portland
Sheryl Burgstahler, University of Washington
Annemarie Poginy, University of Portland

Outstanding Zone Campus Representative Award

Christi L. Patton Luks, University of Tulsa
Marilyn Dyrud, Oregon Institute of Technology

Section Outstanding Campus Representative Award

Midwest Section: Christi L. Patton Luks, University of Tulsa
Pacific Northwest Section: Marilyn Dyrud, Oregon Institute of Technology

Professional & Technical Division Awards

Aerospace Engineering Division:

John Leland Atwood Award

Helen Reed, Texas A&M University

Biomedical Engineering

Teaching Award

Jenna Rickus, Purdue University

ECE Distinguished

Educator Award

Sarah A. Rajala, Mississippi State University

The National Academy of Engineering

New Female Members:

Wanda M. Austin, The Aerospace Corporation
Cynthia Dwork, Microsoft Research
Barbara J. Grosz, Harvard University
Rebecca Rae Richards-Kortum, Rice University

A.M. Turing Award

Fran Allen, IBM

L'Oreal-UNESCO's 2007 For Women in Science Award

Mildred Dresselhaus, MIT

Society of Women Engineers (SWE) Awards

Achievement Award

Pamela Kay Strong, The Aerospace Corporation

Upward Mobility Award

Sandra Postel, The Boeing Co.

Distinguished Engineering

Educator Award

Mary C. Verstraete, University of Akron

Entrepreneur Award

Kristy A. Schloss, Schloss Engineered Equipment, Inc.

Work/Life Balance Award

Betty Purkey, Texas Instruments

Distinguished New

Engineer Award

Mary C. Clor, Chrysler LLC
Heather Doty, Ball Aerospace & Technologies Corporation
Lana Fountain Flakes, Jacobs Sverdrup-NASA/Lyndon B. Johnson Space Center
Allison Pedersen, Goodrich Corp.
Stacie Suggs, Northrop Grumman Space Technology

Distinguished Service Award

Esther Heller, Consultant
Betty Preece, Retired

Outstanding Collegiate

Member Award

Meredith Caldwell, University of Alabama
Casey Canfield, Franklin W. Olin College of Engineering
Maria Accomando Edwards, University of Alabama
Talia Esser, University of Wisconsin-Madison
Kristen Elizabeth Kesse, University of Cincinnati
Priscila Silva-Araujo, University of Florida
Jennifer Vallero, University of Colorado at Boulder
Amanda M. Wachtel, University of Alabama

Outstanding Faculty Advisor

Cathy Pieronek, University of Notre Dame

Outstanding SWE Counselor

Jennifer Chen Morikawa, General Motors

Emerging Leader Award

Susan A.H. Benysh, IBM Corporation
Ellen Ferraro, Raytheon Company
Lynda Grindstaff, Intel Corporation
Michelle Ivy, Freescale Semiconductor Inc.
Cathy Krier, Medtronic Inc.
Shannon Phillips, Intel Corporation, Vietnam

Fellows

Violettee Brown, Prophecy Consulting Group, LLC
Esther A. Heller, Consultant
Sandra C. Scanlon, Scanlon Consulting Services Inc.
Penny Wirsing, ExxonMobil Corporation

Women in Engineering Programs & Advocates Network (WEPAN) Awards

Founders Award

Sherry Woods, University of Texas at Austin

Betty Vetter Research Award

Barbara Bogue, Pennsylvania State University
Rose Marra, University of Missouri

The Bayer Foundation, Bayer Professorship in Chemical Engineering

Paula Hammond, MIT

Intel Science Talent Search Award

Mary Masterman, 17, First Place Oklahoma

Anita Borg Institute for Women and Technology (ABI) – Grace Hopper Conference

Technology Leadership Award

Mary Jane Irwin, Pennsylvania State University

Social Impact Award

Paula Goldman, Imaging Ourselves

Inaugural Denice Denton

Emerging Leader Award

Rachel Pottinger, University of British Columbia

(i.e., an award) that helped minority women to be successful; rather it was the recognition by professors, and the time dedicated to these women as students or research scientists that helped them to form self-recognition as scientists.

On the other end of the spectrum there are circumstances in which minority women have a much more difficult time forming an identity as a scientist. In these cases, women see their gender, race, and/or ethnicity impeding a professor's or employer's ability to recognize their abilities as a scientist. Essentially, recognition, or the lack of recognition, will affect performance in a positive or negative manner.

A study by Angela Johnson (2007) showed that recognition is an important part of retention and success for minority women. Johnson found that minority women value the ability to know the professor rather than just being a passive student in a classroom. Getting to know the professor equates with classroom recognition, which has been demonstrated as imperative to encouraging students in STEM education settings.

STEM classrooms and workplaces may be uncomfortable environments for women of color, but there are ways to transform and combat such uninviting atmospheres. Creating a positive environment is one of the first steps in attracting and retaining minority women. Such an environment would promote the self-confidence needed for women to self-identify as scientists. Having positive role models or effective mentors also helps to raise self-efficacy of minority women who often feel as though they are on the margins of STEM inclusiveness (Allison and Cossette 2007).

Both women and minorities are challenged in STEM fields simply because of their gender and/or race/ethnicity. Consequently, it is necessary to understand the intersection of gender and race. Minority women have to struggle on two fronts: All women are marginalized and there are additional repercus-

sions experienced by women of color. Politically, it is difficult for women of color because of potentially conflicting goals between women as a larger category group versus women of color as a specific group. Structurally, women and minorities are both in lower-status positions, yet in the United States black women are often represented in popular culture as domineering and hypersexual (Hill Collins 1991). Settles (2007) studied identity issues of 89 black women students at 31 universities. Such negative stereotypes pose additional challenges for black women. Despite the issues of dual oppression, especially when one identity interfered with the other, participants felt pride in being black women. Further, Settles found that older women were less likely to feel the problems of identity interference than were younger women, many of whom were still struggling to construct an identity.

Two other studies shed interesting light on diversity issues. First, Hagedorn, Chi, Cepeda, and McLain (2007) show that Latinos/Latinas student success is higher at community colleges in which Latinos and Latinas constitute a majority of students (i.e., more than half) and faculty (more than a third). In settings with such a predominance of members of the same ethnic group, especially among the faculty, ethnicity-based stereotypes are constantly challenged.

The pressure of global competition and changing U.S. demographics has brought about calls for increased attention to diversity. The representation of various groups within workplaces, and the extent to which members of various groups are promoted into positions of authority, sends "signals" to workers about the real value of diversity to their companies. Research by Avery, McKay, Wilson, and Tonidaniel (2007) looks at nationally representative survey data from a telephone survey administered by the Gallup organization in 2005. A total of 659 cases were used in their analyses, which looked at

racial/ethnic and gender differences in self-reported absenteeism from work. The authors found that the perception of the organizational value of diversity was a significant factor in employees' absentee behavior. Specifically, absenteeism of African Americans and Hispanics was on par with that of whites at organizations that placed a value on diversity. On the other hand, African Americans' and Hispanics' absenteeism rates were higher at those organizations that did not value diversity.

Recruitment and retention to engineering in college

As we saw in the K-12 section, there has been a stronger emphasis recently on bringing engineering "down" from the collegiate to the high school and, in some cases, the middle school level. Further, the need to engage students across the socioeconomic spectrum and among all of the ethnic groups has been clearly recognized. As a result, recruitment has been recast away from research literature that focuses on specific psychometric traits of engineers and how to identify people with these traits. Instead, the more socially grounded approach of increasing the information about engineering and ensuring that the content of these messages is sensitive to younger age cohorts, women, and underrepresented minorities is gaining attention.

Generally speaking, as competition within science and engineering fields continues to grow, the ways in which engineering is taught are heavily disputed. The fact that engineering has a difficult time recruiting and retaining women and minorities is also an indicator that current pedagogical practices are no longer effective. In order to recruit new and diverse people, new and diverse teaching is essential.

Engineering has been typically lecture oriented, but the key to attracting more women and minorities is to make teaching more learner centered. Data indicate that women and minority students pre-

fer environments where they feel as though there is a community, especially one in which they feel involved. Traditional lecture-based instruction impedes recruitment and retention of women and minorities, and students taught in this manner leave college unprepared for their first employment opportunities (Bernold 2007). The standard, passive, lecture-style pedagogy is not consistent with the needs associated with the “engineer of 2020” (National Academy of Engineering 2004). This landmark report indicates that engineers need to become active learners, able to upgrade their skills during the

proaches and would rather keep the engineering status quo (Eskandari et al. 2007).

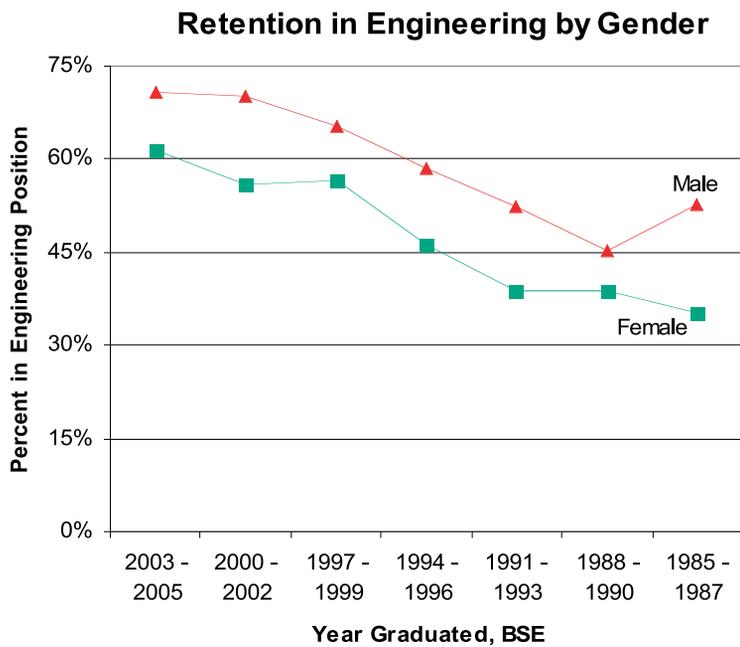
But despite the evidence that learner-centered approaches are important to engage a new generation of engineers, many college STEM teachers have yet to embrace these approaches. Walczyk, Ramsey, and Zha (2007) conducted a highly limited Internet survey of faculty in Louisiana to find that the lack of meaningful value assigned to teaching, in general, posed a barrier to the adoption of new pedagogies. This is not surprising, as we know that people do what they are rewarded (paid) to do. It re-

exam as an outcomes assessment tool. Increasingly, state governments that fund public higher education are holding institutions accountable for their results. Similar to the way in which “no child left behind” evolved into “no child left untested” as a means to assess the quality of the educational institutions that “produced” children, some observers believe that the FE exam can provide a way to assess the quality of the engineering schools from which students graduate. Lawson (2007) provides a review of the literature on assessment and then offers the opinion that the FE exam is not a valid and reliable way to assess programs, but is useful in assessing a minimal technical competency level of the engineers who take the exam. Lawson does not, however, subject this opinion to any scientific test.

Working as an engineer

In 2005 the SWE Corporate Partnership Council provided generous support to the Society to conduct another study like one that had been done in the early 1990s. The SWE Retention Study collected data from more than 6,000 bachelor’s and master’s graduates of 25 engineering schools (24 U.S. and one Canadian) to explore why people left the field after earning their bachelor’s degrees. A series of three articles appeared in *SWE Magazine* last year; here, we have reproduced a few of the charts and findings that were presented in those articles. The chart, left, shows that even upon graduation, there is a gap in women’s and men’s participation in engineering: Less than 71 percent of men but only 61 percent of women who responded to the SWE Retention Study indicated they were employed as an engineer within the first three years of college. By the time we look at people who graduated 18-20 years prior to the survey, only about one-third of women but about half of the men were still in engineering jobs.

The pair of charts on page 122 show that just 48 percent of women were still in engineering jobs, with



Source: CPST analysis of Society of Women Engineers’ National Survey of Engineering, 2005.

course of their careers.

The lack of creativity in engineering pedagogy and practice results in problems with recruitment and retention and inadequate development of appropriate skills. Practicing industrial engineers reported that adaptable problem-solving skills and process evaluation and analyses were critical skill sets for engineers. Rather than executing creative ways to implement engineering applications, professors of engineering are far too fearful of using creative ap-

quires effort to learn new pedagogies, but faculty advancement relies little on teaching quality. Therefore, unless this fundamental lack of attention to teaching is addressed, STEM teachers are unlikely to change. In short, institutional transformation is necessary to make such a radical change (Eckel and Kezar 2003).

The Fundamentals of Engineering (FE) exam is the first step toward becoming a professional engineer. In recent years, however, there has been a trend to use this

men a little more likely to be employed as engineers. Nearly one-fourth of women were either unemployed, not in the labor force, or employed in jobs they saw as very different from engineering. Only 11 percent of men were in these same types of positions.

Why do people leave engineering? According to the SWE Retention Study, men and women who had left the field had some different reasons for doing so. The above chart shows that the majority of people who leave engineering do so to pursue some other career interest. Men are more likely to leave the field for advancement opportunities or “other career issues” (which include salary), but women are more likely than men to indicate they are leaving a negative work climate. Women were also much more likely to cite time and family-related issues as reasons for leaving the field.

Although not shown here, the issues affecting women’s exit from engineering vary for different age cohorts. For example, “negative work climate issues” were less important for those who graduated between 1993 and 2000 than they were for those who entered the engineering work force prior to 1993 or after 2000. The salience of family and time issues in leaving engineering also varied: 26 percent of women in the 1985-1992 degree cohorts indicated this reason, but only 13 percent of those in the 1993-2000 cohorts and just 7 percent of the most recent graduates cite this reason (Frehill 2008).

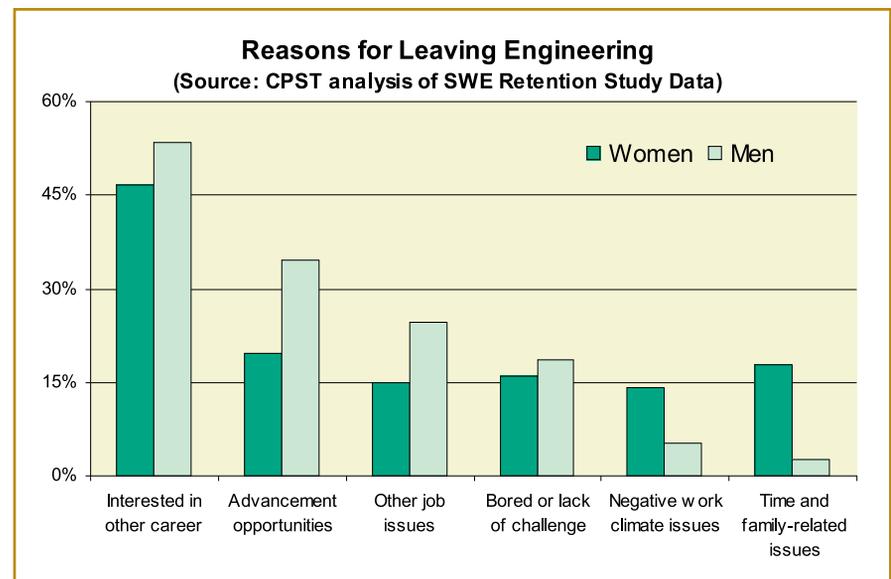
The second of the three articles compared the new data with that of an earlier study of engineers sponsored by SWE in 1992-1993. This article showed that there appears to be a “warming trend” for women in engineering but that there is still far to go to ensure that workplaces are equitable. The data shown in this second article also illustrated a growing gap between female and male perceptions of discrimination in the workplace, with fewer men now than in the early 1990s “seeing” instances of anti-female or anti-minority dis-

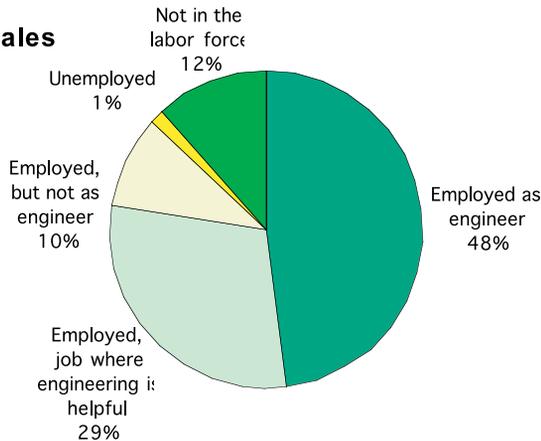
crimination. The chart on page 123 is one of the graphics that appeared in the second article, describing differences across groups in perceptions of discrimination. While there were no differences in men’s perceptions in 1993 versus 2005, women’s perceptions changed over this same time. For women, though, while almost 60 percent reported an awareness of discrimination based on gender and/or race in the 1993 survey, by 2005, slightly less than 40 percent were aware of an instance of this kind of discrimination.

The chart on page 124 shows where women with bachelor’s and master’s degrees in engineering work, separated by gender and ethnicity. The three sectors shown in the chart are very broad, but there are some interesting differences even at this level of aggregation. First, not surprisingly, the overwhelming majority of engineers at both degree levels work in business/industry. Second, at the bachelor’s level, women represent 8.6 percent of engineers in business/industry, but a higher percentage of those in government (13.5 percent) and educational institutions (25.5 percent). Indeed, when we look at the representation of women of color in engineering workplaces, we see that they are the majority of engineers of color who work in “educational institutions,” which include colleges, uni-

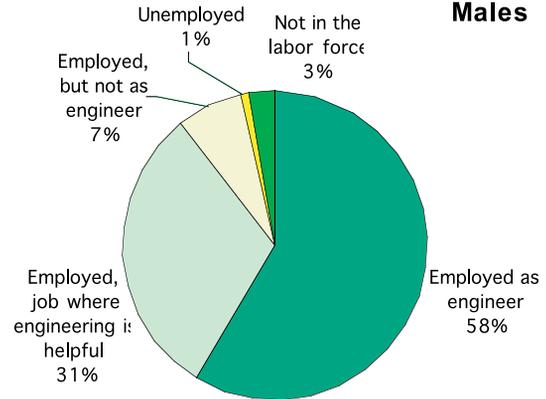
versities, and K-12 schools. More than half of the Latino/Latina, African-American, and Asian/Pacific Islander engineers with bachelor’s degrees who work in educational institutions were women within these groups. Although these engineers constitute a small percentage of all engineers with bachelor’s and master’s degrees, with the new national push to recruit more math and science teachers for K-12 education, this would be an interesting “sub-group” to study. That is, why are women more likely to take jobs in this sector than men among engineers of color? Do women choose this work or do they “end up” in these positions as a result of “off-ramps?” To what extent are educational pathways viable for engineers in general?

Finally, an article by Wendy Faulkner (2007) provides an ethnographic study of building design engineers in two offices of a British firm. Over the course of five weeks of fieldwork, Faulkner shadowed six engineers to observe engineers in their natural work settings. Via this work, she gained an appreciation for the heterogeneity of engineering work and how conceptualizations of gender came to be entwined with the fluidity of the definition of engineering itself in ways that disadvantaged women. This study is particularly useful in describing actual engi-



Females

Source: CPST analysis of Society of Women Engineers' National Survey of Engineering, 2005.

Males

Source: CPST analysis of Society of Women Engineers' National Survey of Engineering, 2005.

neers' work environments; therefore, it could be used in introductory engineering courses to provide a well-grounded understanding of engineering workplaces.

Work/life balance

In addition to the SWE Retention Study findings, a number of other articles provide interesting insights into the world of work for women in engineering. Work/life balance issues were important to the members of the SWE Corporate Partnership Council, providing one of the reasons for the retention study. These issues have become critically important as employers struggle to adjust to a work world designed around men to an environment more suitable to women's needs, and adjust to accommodate desires by younger workers — women and men — for more work/life balance. As we reported last year, a 2006 study by the Center for Work-Life Policy in New York found that many women take "off-ramps" without having adequate "on-ramps" back to their jobs.

A highly recommended article for anyone struggling to balance work and family issues while maintaining an upward career path appeared in the February issue of the *Harvard Business Review* (Esarey and Haslberger 2007). This particular article is an *HBR* case that gives a fictional account of a mother

working in a corporation who is faced with the usual "second shift" dilemmas as she attempts to navigate a course up the corporate hierarchy. After the story, four experts offer opinions about the different actions the fictional character should take, each from a different standpoint. The article is useful reading for those in the role of the mother as well as those who are mentors within corporate settings. The experts stressed the need to present a clear business case for desired schedule accommodations; have clear performance goals and targets; re-evaluate the situation after a specified time; communicate these in writing with your boss; and be assertive about your wants and needs both at work and at home.

One of the solutions proffered by the experts was to speak to an executive coach. A coach is different from a mentor. Mentors are people within your field or your company who work with you to understand some of the unwritten "rules" or culture of the place you work. (Note: Last year's SWE review of literature featured an extended discussion of mentoring and is available online at www.swe.org.) A coach is like a "career therapist" who can provide the guidance needed to move forward, clarify goals, and put together a concrete strategy for achieving those goals. Unlike a therapist or mentor, a

coach is someone with whom one might work in a finite number of sessions — either face-to-face, on the phone, or over e-mail — for a short period of time (perhaps with some short "follow-up" sessions later). Some companies provide access to coaches, but as a relatively new niche, it is unclear yet whether this is a common practice.

Other articles this year looked at the impact of different work/life balance policies. Shockley and Allen (2007) used convenience sampling to locate questionnaire respondents to study how flexible work arrangements impacted family interference with work and work interference with family for women with either high or low family responsibilities. They found that the flexible work arrangements were very important to women with high family responsibilities to mediate the interference of work with family. For women with low family responsibilities, however, the ability to shift one's hours of work really just opened the door for more interference of family with work. The authors' analysis suggests we need to be cautious when crafting solutions to work/life balance so that the solutions fit individuals' needs.

On a related note, Pavalko and Henderson (2006) completed a careful analysis of how a range of work/life balance policies impacted women who were involved

with various types of care work. In this case, the authors used a large, nationally representative dataset (the National Longitudinal Survey of Young Women) and looked at what happened when women became involved with care of family members other than children. This kind of care work has become more common as baby boomers age and our life spans have lengthened. Unlike the care work associated with one's own children, there is a huge variety of ways in which people engage in the care work of their parents. At one end of the spectrum, parents may actually live in one's home and need a high level of daily care. At the other end of the spectrum, care work might involve numerous phone calls to health-care providers located in another city or state. In a nutshell, this kind of work is hard to predict in many ways. As a result of the uncertainty, many people who become involved in providing this type of care for elderly parents end

up leaving their jobs.

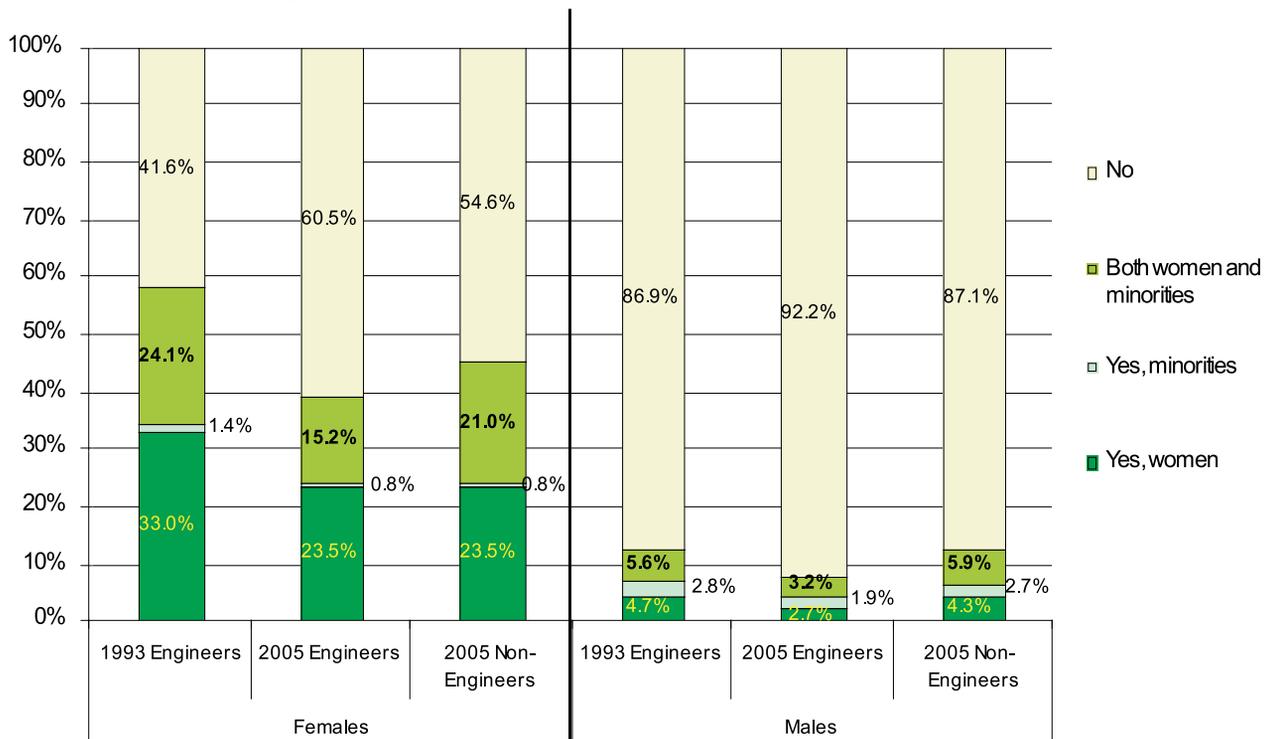
Pavalko and Henderson found that these workers were more likely to be retained if they had access to a range of choices related to work. Specifically, if they had access to flexible hours, unpaid family leave, and vacation time, and could use paid sick leave for this care work, they were much more likely to be retained by their employer than if these benefits were not available. Again, this article points out the need for employers and employees to be able to have an open dialogue about how to manage the work/life balance within a menu of time-balance choices.

De Cieri, Holmes, Abbott, and Pettit (2005) completed a study of work/life balance policies, their usage, and barriers associated with their usage in Australian organizations. The study reports results of three organization-level surveys of work/life balance policies conducted in 1997, 1998, and 2000. Al-

though the surveys had fairly low response rates (less than a third were completed by the target companies), the responses represented a range of industries. In addition, the likely direction of response bias in this case is that those who were more likely to respond are likely to be those companies that have attempted to enact policies related to work/life balance rather than those that have paid this issue little attention. Therefore, the results should be interpreted as answering the question: "Given a company is interested in implementing work/life balance, what are the barriers to effective policies?"

Using the most complete data from the 2000 survey, the authors show that there are two important types of barriers: organizational inaction and organizational values. *Organizational inaction* refers to the situation where new policies may exist but in which one or more of the following situations limits their full implementation for the benefit

Are you personally aware of instances where women or members of minority groups have been overlooked with regard to career opportunities?



Source: CPST analysis of Society of Women Engineers' National Survey of Engineering, 2005.

Employment Sector of Workers with Engineering Bachelors and Masters Degrees by Sex and Race, 2003

	Business/Industry			Government			Educational Institution		
	Females	Males	Percent Female	Females	Males	Percent Female	Females	Males	Percent Female
Bachelors									
All	109,328	1,167,926	8.6%	22,964	147,717	13.5%	9,076	26,449	25.5%
Latinos/as	7,393	68,248	9.8%	1,907	9,903	16.1%	1,813	1,274	58.7%
African American	6,670	33,312	16.7%	1,756	7,752	18.5%	2,270	1,000	69.4%
AI/AN	480	2,806	14.6%	65	726	8.2%	S	S	S
Asian/Pacific Islander	20,825	144,983	12.6%	5,104	15,981	24.2%	1,328	1,136	53.9%
Non-Hispanic White	70,399	901,034	7.2%	13,244	108,977	10.8%	3,665	22,734	13.9%
Masters									
All	45,172	368,516	10.9%	10,379	50,687	17.0%	3,998	20,006	16.7%
Latinos/as	3,277	16,748	16.4%	1,710	2,680	39.0%	644	767	45.6%
African American	1,921	7,601	20.2%	889	1,334	40.0%	238	1,546	13.3%
AI/AN	104	96	52.0%	S	S	S	S	S	S
Asian/Pacific Islander	17,575	90,584	16.2%	810	6,785	10.7%	494	2,187	18.4%
Non-Hispanic White	21,779	248,403	8.1%	6,698	39,313	14.6%	2,622	15,365	14.6%

Note: S indicates suppression (by source) due to the small number of cases.

Source: CPST analysis of National Science Foundation National Survey of College Graduates, 2003, Public Use Datafile via the SESTAT analysis system.

of employees:

- ◆ Lack of communication to staff
- ◆ Failure to evaluate impact of programs
- ◆ Lack of middle management education
- ◆ Failure to get the line managers involved
- ◆ Insufficient involvement or communication with the senior management
- ◆ Inadequate data to build the business case

In a nutshell, once new policies are developed, it is imperative for a company to ensure that everyone in the organization understands these policies and how to implement them on a case-by-case basis. Training and communication at all levels are critical because any arrangements that are crafted between an employee and her supervisor will need to move up the chain of command for approval — everyone needs to be on board. Also, it is important to evaluate and build a business case — a theme that was raised in the *Harvard Business Review* article (Esarey and Haslberger 2007) discussed above.

Organizational values were the

second set of factors that impacted the successful use of work/life balance policies in retaining valuable employees. These factors included:

- ◆ Focus on programs rather than on culture change or the way work is done
- ◆ Increased work demands overshadowed personal needs
- ◆ Restructuring within the organization

These factors relate to the ways in which people “signal” their commitments to their employers. We are probably all accustomed to the idea that when we spend more time at a place, it shows a higher level of commitment. So, naturally, we often apply this idea to work and believe that when we see people at work, they are highly committed, and when people leave work to attend to other matters, they must not be fully committed. These ideas are very hard to change. De Cieri et al. (2005) suggest that to truly implement work/life balance policies, corporate culture needs to accept that there are different ways employees show commitment to employers. Here we come full-circle: It is important to document the business

case for work/life balance, to show that these policies can and do have a positive impact on the bottom line.

One piece of work/life balance considered outside the scope of employers is the division of labor at home. There is a long history of social science research on household divisions of labor. The research has generally shown that when all the different kinds of work done at home are taken into account — including different kinds of housework, yard work, child care, and so forth — that women are more likely than men to do more of that work but not quite a full “second shift” (Hochschild 1989). Instead, women work several more hours per week doing tasks that are more of a daily nature (e.g., preparing meals), while men do more discretionary tasks (e.g., mowing the lawn). Men also take less *responsibility* for child care and have several more hours per week of leisure time than women.

Over the past 40 years, as women’s labor force participation has increased, studies have found that the number of hours spent on

housework has decreased but the amount of time on child care has remained unchanged or increased. Various studies have also shown that men are more likely to do more child care rather than housework even though, as stated above, they take less responsibility for child care. Rewards of child care are more clear and immediate (the love and respect of one's children) than are those associated with having a clean home.

Some authors have found, for example, that women who work in nontraditional jobs actually prefer to do more "female-typical" household chores as an expression of femininity and that this behavior is intensified when they earn more than their male spouses or that male spouses "do gender" in these homes by avoiding housework. Such findings suggest that a purely economic analysis that sees earnings as equated with power within households fails to account for the other kinds of dynamics that exist within a partnership. Exemplar studies in this literature are: Berk (1985), Bianchi and Raley (2005), Bittman et al. (2003), Brines (1994), Coltrane (1989 and 2000), Coltrane and Adams (2001), Dempsey (2002), Mederer (1993), Presser (1994), and Shelton and Shelton (1993 and 1996).

A new article by Mannino and Deutsch (2007) sheds important light on how household and work negotiations shape the division of labor at home. The carefully crafted study looked at a particular group of families: married women who were mothers of 3- to 4-year-old children in one New England town. Once identified, they had a high response rate to the pair of phone interviews completed with these women: 79 percent of eligible participants were interviewed a first time, and 93 percent of those interviewed participated in follow-up interviews. The study is based on the 81 respondents who had completed at least the first interview. This article would be excellent to read because this review only scratches the surface of these authors' findings, which not only

confirm but also extend the findings in this literature (see list, above).

Mannino and Deutsch (2007) showed that the division of child care was not related to women's earning more money, hours of work, or liberal views about gender. But women who were more assertive were more likely to be closer to their ideal division of child care than those who were not assertive. Assertiveness was also related to income, with women at both the high and low ends of the income spectrum being less assertive than those in the middle.

A unique aspect of this particular study was that there were follow-up interviews two months after the initial phone interview. For example, in the first interview, respondents were asked whether they planned to attempt to bring about a change in the division of household labor, with almost half (43 percent) of respondents indicating they planned to attempt a change. Of these, however, only 12 actually did attempt to change the division of labor, but a total of 26 reported there had been a change. And, those who had indicated a plan to bring about a change were no more successful than those who had not actively tried to change. Further, even in cases where a woman saw the discrepancy between the work she did and her husband's as "unfair," assertiveness and change were not necessarily in the offing.

Twenty-six women reported that there had been no change. Some of these women expressed feelings of hopelessness, having tried to get more help and failed. Others indicated that structural circumstances (e.g., husband's hours) affected his ability to help. Another 18 said there was a change and that they now received "limited help," such as assistance on specific tasks when requested, including cases where women provided "to do" lists to their husbands.

Another 26 women indicated that an actual change had happened. Of these, four were not sure about why the change occurred

while eight said there were specific circumstances that brought about the change, such as a change in their husband's work schedule or a pregnancy. Three of the women in the "actual change" group reported that the change was due to their "indirect" appeal for help, such as having their children ask their father for help on homework or making the "I am not a maid" speech to the kids within earshot of their husbands. Finally, 11 of the women who reported actual changes indicated these happened because they explained why the change was needed and made a clear request for additional help from their husbands.

A common theme in these many explorations of work/life balance is the notion that people are not necessarily going to work fewer hours; rather they are going to have more discretion about when those hours occur. It is also important to recognize that there is a gender imbalance related to work that will pose special challenges to women with high career aspirations, related to the Mannino and Deutsch (2007) article just discussed. That is, men who are in upper managerial positions are more likely to have a stay-at-home or part-time employed spouse while women are far less likely to have such a resource. As illustrated in Mannino and Deutsch (2007), the relationships between gender, household work, and earnings are complicated but changeable. However, responsibility still resides overwhelmingly with women for various reasons. Hence, men who are moving up the career ladder are more likely to have a spouse who can devote herself to his care and needs for success, while a similarly situated woman needs a partner with whom she can openly discuss her needs and not count on his anticipating these needs.

As communications technologies have improved, many of the higher-end jobs that engineers do are becoming more decoupled from a traditional "clock" and more dependent on completion of projects. While it is true that there is more

teamwork, it is also true that teams can and do function across space and time without necessarily constant face-to-face contact. On the one hand, these technologies open up more flexibility so that people have more tools to balance work and family. On the other hand, it becomes even more important for employees and employers to manage the work/life balance lest work expands indefinitely.

Gender pay gap

The gender gap in pay is a perennial issue for women in the workplace. Over the last 40 years, as more women entered better-paying jobs in the paid labor force, the gap in pay has finally started to narrow. The popularity of this issue is reflected in several articles about the gender gap in pay that have appeared in local and national news reporting as well as in the scholarly literature. Interestingly, in such high-demand fields as engineering and computer science, these gaps are often much smaller than in fields in which there is a larger supply of workers, even in other STEM fields. The chart on page 127 shows that in some ethnic groups, women earn a little more than men do as engineers (Latinas, African American, and American Indian/Alaska Native women). Non-Hispanic white women on average earned a little less than their male counterparts while Asian/Pacific Islander women and men had the same average salaries. The large disparity in pay for American Indian/Alaska Native women engineers compared with men is most likely due to the relatively small numbers of engineers from this ethnic group.

Hogue, Yoder, and Singleton (2007) completed social psychological experiments — using the usual undergraduate volunteers (in this case, just men) — to understand men's elevated sense of entitlement related to wages. Importantly, these researchers show that this sense of entitlement is *not* related to endorsement of a masculine ideology but is, instead, related to the

privileged gender status position of men. Prior research by two of these researchers (Hogue and Yoder 2003) demonstrated that women do not assume they deserve higher pay: Only as women's education and experience increase do women increase their assessments of what they should earn. Men, on the other hand, feel entitled to high pay and then adjust their self-assessments of skills to match the pay expectation. These findings are important because in efforts to redress the sex gap in pay, employers need to understand that men will often feel entitled to higher pay because of their privileged gender status and consequently assume that women cannot possibly merit that pay. The same sense of entitlement was evident in the past year in a workshop held at the American Enterprise Institute at which conservative analysts *assumed* that women's skills were inferior to those of men simply because they were women. Hogue et al., therefore, suggested that efforts to redress gender pay inequity must be attentive to these status processes among men while also attending to the tendency of women to devalue themselves and their work.

The glass ceiling

Another issue of common concern to women in the workplace is the "glass ceiling." Women continue to be underrepresented on the boards of directors of major companies (Corporate Women Directors International 2004). To what extent do women in engineering face this invisible barrier to advancement? In one of the previous charts showing results from the SWE Retention Study, we saw that women were more likely than men to report that they were "personally aware of instances where women or members of minority groups have been overlooked with regard to career opportunities." Since 1993 the percentage who answered in the affirmative on this item has declined from about 60 percent to 40 percent, but women and minorities still have far to go.

Other evidence of the glass ceiling for women in engineering is in the most recent data on occupations from the Bureau of Labor Statistics (2007). Women account for 11 percent of engineers but only 8 percent of engineering managers, which suggests there may still be a glass ceiling for women in engineering.

Why does the glass ceiling persist? According to a 2005 study by Catalyst, persistent gender stereotypes — held by both women and men — pose barriers to women's movement up the management hierarchy. The study title summarizes the impact of stereotypes on the ways that women and men are perceived as managers: *Women "Take Care," Men "Take Charge."* The study reviews 10 leader behaviors, asking men and women to rate, separately, the effectiveness of women and men leaders on each of the behaviors. On most of the behaviors, women and men had congruent assessments of women and men leaders, reflecting the notion that both women and men accepted gender stereotypes. Of the 10 behaviors, however, the one for which there was actually a divergence in the opinions of men and women — and perhaps the one most important for engineers — was the assessment of effectiveness at problem solving. The table below summarizes the information on these ratings from the Catalyst study. Men were more likely to rate male leaders as effective problem solvers, while women were more likely to rate female leaders as effective problem solvers. Women were also more likely than men to rate leaders of the opposite sex as effective problem solvers.

Effective Problem Solvers:

	Men	Women
Men's ratings	80%	67%
Women's ratings	75%	82%

Source: Catalyst, *Women "Take Care," Men "Take Charge,"* 2005.

The Catalyst study includes a number of recommendations.

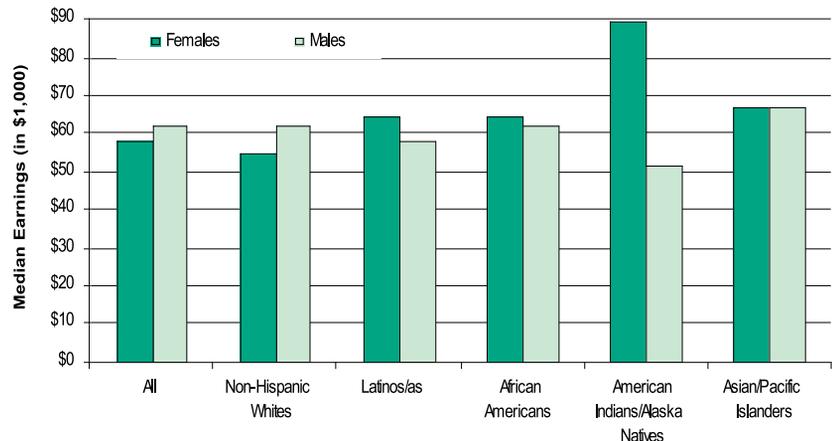
Companies need to educate managers about stereotyping; rely on objective performance evaluations; implement transparent succession planning; and showcase women as managers, especially in nontraditionally female areas, as a way to counteract the tendency to stereotype.

Leadership

With Hillary Clinton in the presidential race this year, issues associated with women and leadership are receiving more attention. Back in 1981, Pat Schroeder, a senator from Colorado, formed a team to explore the viability of a woman president and came to the disappointing conclusion at that time that a broad-enough base of people in the United States still did not believe that women could be effective leaders. Elizabeth Dole campaigned leading up to the 2000 presidential race and, again, dealt with repeated attacks associated with her gender and leadership style. Senator Clinton's campaign is coming at a time when the nation may actually be ready for a woman leader.

The gender biases about women and leadership have been documented in a wealth of psychological experimental research (see Valian 1998 for a review). For example, Valian cited previous research that found when people are shown a picture of a group meeting, regardless of where the man is sitting, he is identified as the "leader," even if a woman is sitting at the head of the table. A new study by Jackson, Engstrom, and Emmers-Sommer (2007) has shown that this is no longer the case. These researchers, using the typical pool of volunteer subjects from the student population at their university, found that when shown a picture of people at a table, men tended to indicate that the man at the head of the table was the leader while women tended to say that a similarly positioned female was the leader. But, whereas men were also likely to indicate any man as the leader, reflecting the persistence of the "male = leader" ideol-

Median Earnings (in \$1,000) for Engineers with a Bachelor's Degree as Highest Degree by Race/Ethnicity and Sex, 2003



Source: CPST Analysis of National Science Foundation public use datafile, Scientists and Engineers Statistical Analysis System, 2003 accessed via SESTAT online analysis system.

ogy, women were more likely to look at multiple cues to identify the leader. And, while women in the past also adhered to the "male = leader" ideology, the evidence from this experiment indicates that women are less likely to see leadership as a male domain.

Increasing women's access to engineering leadership positions is another way to improve the image of the profession for young women. In academic settings, more women are becoming deans (see the sidebar, "Women Engineering Deans") and to serve as department heads/chairs. In nonacademic settings, more women are joining corporate boards or taking the lead in running teams. In the last several years there has been quite a bit of research published about the concept of leadership, its definition, and the roles of leaders in various settings in establishing a climate that welcomes diversity and encourages employees to be creative (Mayer, Nishii, Schneider, and Goldstein 2007).

Military settings are another area in which the issue of leadership has come up recently. These settings are important for engineers to consider because the defense industry, which employs a large number of engineers, tends to recruit managers from the military. Vecchio and Brazil (2007)

studied cadets at the U.S. armed services' summer training camp. Sophomores received basic military instruction generally provided by juniors, who also served as squad leaders so that they could develop leadership skills. This well-executed study provides insights about leadership and the extent to which context supersedes gender in the evaluation of effective leaders.

Of the 1,974 cadets who were asked to complete the authors' survey about the training experience, 1,702 did so (86.2 percent response rate). In terms of gender and roles, women accounted for 252 squad members and 26 squad leaders while the remaining 1,449 squad members and 141 squad leaders were men. The average squad consisted of 11 or 12 people who lived and trained together for four weeks of an eight-week summer camp. The findings indicate that the social context and expectations of the people in that context played a stronger role in assessments of leaders than did gender. In the particular masculine context of military training, women and men were expected to enact the role of leader in a certain way, regardless of gender, and so they were evaluated in a manner consistent with those expectations. The authors' work suggests that this military ex-

ample may be unique in terms of the salience of gender. That is, within contexts like the military setting they studied, which emphasizes unit cohesion, an individual's characteristics are less important than whether the individual is able to fulfill his or her role. Further, the strong top-down norms of military leadership emphasize that the personal characteristics of the leader are less important than the formal position. This means that in contexts where these leadership and behavioral aspects are not normative, gender may be more salient in leader assessments. From a measurement standpoint, the authors also found that leader-member exchange was a useful way to capture variations in working relationships. Exchange was measured using individuals' responses to seven items such as "I could count on my squad leader to 'bail me out' at his/her own expense if I really needed it."

As technological competition has moved onto a global playing field, the importance of being able to effectively lead highly educated, clever people has become more imperative. A *Harvard Business Review* article by Goffee and Jones (2007) provides useful advice to managers who must lead clever people. First, they suggest that there are seven characteristics of clever people that leaders must understand:

- ◆ They know their worth
- ◆ They are organizationally savvy
- ◆ They ignore corporate hierarchy
- ◆ They expect instant access
- ◆ They are well connected
- ◆ They have a low boredom threshold
- ◆ They won't thank you

Clever people generally do not believe they need to be led. Goffee and Jones assert that being a "traditional boss" can drive away creative employees who prefer to be led by a "benevolent guardian."

Several other articles offer excellent advice for leaders and those who want to start preparing for a leadership role. These articles include Sosa, Eppinger, and Rowles' (2007) "Are Your Engineers Talking to One Another When They

Should?"; Eagly and Carli's (2007) "Women and the Labyrinth of Leadership"; Ibarra and Hunter's (2007) "How Leaders Create and Use Networks"; Ghemawat's (2007) "Managing Differences: the Central Challenge of Global Strategy"; and Bennis' (2007) "The Challenges of Leadership in the Modern World." The latter article is from a special issue of the *American Psychologist* on leadership, while all of the others are from the *Harvard Business Review*. To be a leader, an employee must conform to certain expected behaviors and receive recognition for his or her accomplishments. The above sources explore some of the general expectations of leaders. But it is important for anyone seeking leadership to be proactive in seeking out mentors — both inside and outside the company — to help

navigate the labyrinth. SWE sections can provide access to a great support group and mentoring opportunities.

Sexual harassment

Women in engineering workplaces continue to be a minority, and "hostile work climates" are still a problem for some engineering workplaces. In addition, as more engineers work in cross-national teams, the gender norms of other nations and cultures are likely to become a potential source of friction for women in U.S. engineering. Several articles in the last year provide useful insights about sexual harassment.

Sexual harassment's definition as "unwelcome" advances means there is much room for mistaken judgments. Determining "unwelcomeness" can be especially diffi-

Women Engineering Deans or equivalent

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Eleanor Baum, Ph.D.*	Cooper Union
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Leah H. Jamieson, Ph.D.....	Purdue University, West Lafayette
Sallie Keller-McNulty, Ph.D.....	Rice University
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Pamela A. Eibeck, Ph.D.	Texas Tech University
Linda Abriola, Ph.D.	Tufts University
Cherrice Traver, Ph.D.	Union College
Linda C. Lucas, Ph.D.....	University of Alabama, Birmingham
Mary L. Good, Ph.D.....	University of Arkansas, Little Rock
Aicha A. Elshabini, Ph.D.....	University of Idaho, Moscow
Kathleen A. Kramer, Ph.D.	University of San Diego
Zulma Toro-Ramos, Ph.D.	Wichita State University
T. Kyle Vanderlick, Ph.D.....	Yale University

* The first woman engineering dean in the United States, Dr. Baum was inducted into the National Women's Hall of Fame in Oct. 2007. See *SWE Magazine* Spring 2008 issue.

Compiled from data provided by American Society for Engineering Education, 2008

cult in work environments where women are punished for not using conventional

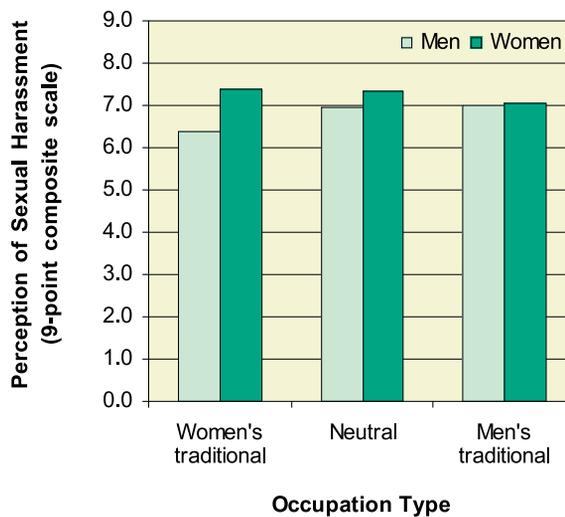
gender-appropriate means of impression management. In the last year, a number of social psychology experiments reported on factors that impacted research subjects' assessments of sexual harassment scenarios. The basic design involves presenting a scenario to experimental subjects. Subjects are usually volunteers but are randomly assigned to read about or, more often now, view a video of a sexual harassment scenario. The researchers alter the scenarios in careful ways

using professional actors in the case of videos. After reading or viewing the assigned scenario, the subjects then complete a questionnaire, which uses fairly standard instrumentation to assess the extent to which: the situation constituted unwelcome sexual conduct; the severity of the conduct; whether it merited an official investigation; and whether the people in the scenario were likeable and believable. The post-questionnaire also usually involves a series of factual items to verify that the subjects were actually paying attention to the video or other scenario presentation.

In one such study, DeSouza, Solberg, and Elder (2007) performed a cross-cultural analysis of Brazilian and U.S. college students at a specific institution in each country. As in other studies of this type, students were shown one of four scenarios and then asked to rate its severity, whether it was a case of sexual harassment, and what the victim should do about it (along with other questionnaire items). The four scenarios were: two heterosexual women; two lesbian women; a heterosexual harasser of a lesbian woman; a lesbian harasser of a heterosexual woman. In all four scenarios, the Brazilian student respondents were more likely

Perception of Sexual Harassment

(Source: Maeder et al. 2007: 808)



to see the incident as sexual harassment and in need of investigation than did the U.S. students. The scenario in which both the harasser and victim were lesbians was most often rated as "harassment" and in need of an investigation by the Brazilian students. Among the U.S. students, however, students were more likely to label as harassment those scenarios in which the harasser and the victim were of different sexual orientations.

Another study, by Maeder, Wiener, and Winter (2007), used a psychological experiment with a sample that was quite different from the norm of college student volunteers earning course credit for participation. In this case, Maeder et al. paid \$30 each for 503 volunteers, all full-time workers from a range of occupations in the Lincoln-Omaha area of Nebraska. This intriguing study of sexual harassment examined how the individual's occupation impacted the usual set of assessments in these types of studies. As shown in the chart above, men and women in men's traditional occupations shared similar assessments of the scenarios, while women in either neutral or women's traditional jobs were more likely than men in those same occupations to assess the scenarios as sexual harassment. It is

also noteworthy that men in men's traditional occupations are more likely than men in women's traditional occupations to have assessed the scenario they were shown as sexual harassment.

Sexual harassment is a particular type of gender-based hostility, one for which there is well-established case law and reporting requirements. But what about dealing with other kinds of gender-based hostility? Hyers (2007) completed a study in which 98 women were recruited to maintain diaries of gender hostility incidents over the course of one week. The use of diaries and the partitioning of the volunteers to be attentive to different types of

intersectional hostilities make this a unique contribution. As discussed earlier, understanding intersectionality is critical, yet methodologically rather challenging. Hyers asked 22 African-American women, 22 Jewish women, and 24 lesbian and bisexual women along with a group of 30 white, Hispanic, and Asian women in a setting around a northeastern university to record instances of bias based on gender and the other dimension of the participant's group. A total of 129 incidents were recorded, with 11 women reporting no bias incidents. Instead of analyzing all 129 incidents, only one for each of the 98 women was analyzed. The most common form of bias reported by white, Jewish, and lesbian respondents was the use of verbal stereotypes, while poor service was most common for the African-American women. More importantly, the participants also discussed their responses and how they felt about the response, with about half enacting assertive and the other half nonassertive responses. Many (37 percent) indicated their responses related to a desire to avoid conflict, with another 21 percent wishing to use the response as a way to educate the

perpetrator, although 13 percent felt trying to do so would be a waste of energy.

Other interesting findings about gender

As we did last year, we have found in our literature search several articles that are “news you can use.” While the findings are not specific to engineering, the issues discussed in these articles relate to being successful in the workplace.

Guadagno and Cialdini (2007) reviewed the literature on impression management, which refers to the way people present themselves in social settings. The impression management literature is important, especially for women in engineering, because of the well-known connections between gender and self-presentation. Several years ago, Babcock and Laschever’s book, *Women Don’t Ask: Negotiation and the Gender Divide*, was all the rage, indicating that women needed to improve their negotiating skills to reap higher salaries and other rewards and resources. Over the last couple of years, though, there have been a number of articles — like this one by Guadagno and Cialdini — that emphasize that just teaching women to act like men may not be the magic bullet to solving the problem of gender inequity. In short, Guadagno and Cialdini provide a concise overview of the literature to date that shows there truly are penalties for women who fail to conform to gender stereotypes.

In the impression management literature, for example, women and men are likely to use gender-appropriate means of impression management. For men this means using such strategies as intimidation, self-promotion, and favor rendering, which result in rewards for men but result in punishments for women who engage in these same strategies. Women, instead, tend to manage impressions by being modest, making excuses or supplication, strategies that are unlikely to win one a raise and a promotion but will keep that person from

being labeled in a negative — gendered — way by her boss and co-workers.

An article by Forbes, Collinsworth, et al. (2007) used the usual psychological experiment (college students at the researchers’ colleges) to show that beauty ideals perpetuate oppression of women via the connection of the ideal with superficiality and objectification. People who endorsed the beauty ideal for women also held more sexist beliefs and were more hostile toward women. These findings suggest the need for women to carefully navigate the professional world when it comes to impression management. If a woman looks stunning, she runs the risk of seeming superficial, consistent with the beauty ideal, which would just reaffirm negative stereotypes held by co-workers or the boss.

On the other hand, as suggested in the impression management literature review by Guadagno and Cialdini, women still need to evoke a modicum of femininity to avoid being punished for gender-inappropriate actions. Furthermore, physical attractiveness — the definition of which differs by gender and age — does moderate others’ assessments of our actions (Madera et al. 2007). In this latter social psychological study, participants — college sophomores completing the study for course credit — were presented with written sexual harassment scenarios and then asked the standard reaction questions (whether it was harassment, how likeable were the people involved, etc.). First, they found that gender affects how people assess complainants and harassers: “Female complainants were believed and liked more and punished less than male complainants . . . [and] male harassers were evaluated more negatively in terms of likeability, believability and punishment than were female harassers.” (p. 229). Attractive complainants were liked and believed more than unattractive complainants, which also interacted with gender (i.e., attractive female complainants were best liked and believed, while unattrac-

tive men were least liked and least believed).

Another piece that looks at the issue of gender-appropriate behaviors, by Carr (2007), was titled, “Where Have All the Tomboys Gone?” Carr used retrospective interviews with women in lower-middle-class jobs who were 25-45 years old to understand how women’s identification with being a tomboy was experienced during adolescence. In her case, 11 of the 27 interviewees had maintained their identities as tomboys during adolescence, while 10 ceased being tomboys at that time in their lives (the others gave ambiguous answers). The reasons for stopping being a tomboy varied, with each person giving several reasons. Most commonly, respondents indicated that physical or emotional maturity or parental or peer pressure led to the change. It is in the description of how some women had maintained the tomboy identity through adolescence, however, that makes this a unique piece of research. “Common wisdom” is that women discard the tomboy identity along with the other aspects of childhood as they come of age. Some people have argued that the adherence to a feminine identity is why young girls suddenly do worse in school (even though the data do not support this assertion). The article is full of interesting vignettes that provide a richer understanding of how young women form a sense of themselves that goes beyond the usual battery of psychological scales.

Ollilainen and Calasanti (2007) examine how gender remains salient in self-managing teams to show that it is important for organizations to pay attention to how organizational culture is gendered. They studied four mixed-gender teams in three different companies using in-depth interviews, careful observations, and review of team reports and meeting notes. Each team included 7-12 members from various functional areas who had worked together for about a year and a half when they were studied

in 1997. A key metaphor that emerged was “family” as a way of describing the team’s work and relationships and that this metaphor then reflected how people’s experiences within the team setting were gendered. For example, women often assumed a “mothering” role: Age and experience were important in the groups, but the way to wield the power associated with these attributes was via the mother role. Related to this, women tended to complete work that was “gender-appropriate” within the teams and younger women were expected to already know how to complete tasks. In contrast, men were provided either more guidance or not required to do these same tasks. Women, therefore, did more of the instrumental tasks associated with the teams’ work and were also held more accountable for the emotional stability of the team.

Conclusion

To understand women’s underrepresentation in engineering, this year’s literature has turned our attention toward larger structural issues. Stereotypes, including those related to women of color, are larger cultural notions that are internalized by members of society and guide behaviors. As shown throughout this article, those who do not “fit” a stereotype are seen as “exceptions,” while the few who fit are held up as evidence that the stereotype is correct, making it difficult to bring about real change. However, it is critical to counter the tendency to take such analytical shortcuts and to examine the actual characteristics and behaviors of individuals. Such action is necessary for individuals to be able to envision themselves in nontraditional roles — as engineering is for women — and for members of the group for whom the role is traditional to understand how those different from themselves are potentially as capable as they are in the position.

Another important theme covered in this year’s review is the need for clear and consistent com-

munication. Articles on implementing new work/life balance policies indicate that once new policies are developed, their success hinges upon people implementing them effectively across all levels of the organization. Good leaders communicate well to those who work for them and to those to whom they report. Assertiveness in communications was a key but traditionally has not been a skill women have been taught. Thus, taking an assertiveness training class might be highly beneficial. That is, assertiveness does not need to be “aggressiveness,” which, as some of this year’s literature revealed, can be a double-edged sword for women in the workplace. Communication at home is also important as shown in most of the work/life balance articles.

Finally, more attention is being paid to increasing the reach of engineering education down to the K-12 grades and to excite a new generation in the potential of an engineering career. Many of the articles provided strong support to ideas we have suspected to be true: that making mathematics and science a requirement rather than an elective can work; that girls can be enthusiastic about doing engineering; and that engineering faculty who embrace different pedagogical styles can help retain students.

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Getting the Most from the SWE 2008 Literature Review

BY BARBARA BOGUE, SWE EDITORIAL BOARD

It's that time of year again. Spring blooms are everywhere, community pools are spiffing up, and we're surfing the Web for vacation ideas. It's also time to reenergize and update your outlook on women in engineering with the 2008 SWE literature review, which begins on page 138.

The annual review has something for everyone — whether working engineers, managers, moms and dads, teachers, office holders, faculty members, or college presidents.

For example, do you know that:

- New fathers' productivity increased when they took advantage of work/life policies? And what the downside of that is for new mothers?
- Women are not opting out of the workplace for the "mommy track" in large numbers (despite what the popular press leads us to believe)?
- African-American women more often come home from work to do a "second shift," at home?
- There's a key childhood toy you should be encouraging girls to use?
- Boys may be the greatest discouragers of girls in academics and athletics?
- Some negotiating styles work better than others?

Each year the SWE literature review offers research on all these topics and more. Where else would we find this much information, addressing such broad interests, in one place!

"The literature review is one of the most valuable things SWE does," said Betty Shanahan, SWE executive director, who underlines the value of the review for audiences beyond researchers. "It's our contribution to the full community

of women in engineering and has far-reaching impact. It makes the wealth of research generated each year accessible to those who don't have the resources to do an exhaustive search to find what is relevant to them."

With so many literature reviews out there, the question is: "What's unusual about *this* review?"

While the obvious answer is that this one focuses on women in engineering, the more important response is that the authors look at a broad range of materials, seeking out and reviewing popular reports and articles as well as traditional research papers. They also collect and report current data that show the status — and progress — of women in engineering in all sectors and identify and report on trends that impact our lives.

Following are tips on how this outstanding resource can help you:

Save time

"I look forward to the SWE review every year because I often don't have time to keep up with the literature," said Lisa Norwood, assistant dean for the School of Engineering and Applied Sciences at the University of Rochester. "To have it all in one location is really valuable." Norwood also uses the review to bring the students who run her Women in Science and Engineering (WiSE) programs up to speed on relevant issues, passes it on to faculty members, and mines it for ideas for developing program activities. For example, she follows up on hot topics to identify invited speakers.

Stay current

"It's a great way to get a quick synthesis of what the literature has been for the last year," said Cather-

ine Didion, senior program officer at the National Academy of Engineering, director of the Academies' Committee on Women in Science, Engineering, and Medicine. In her position, Didion often mentors or advises people "newly interested in this topic. It's a great way to give them a resource that is approachable and covers a lot of issues. For those who are already engaged and knowledgeable, it's a great way to learn about topics outside your specific areas of expertise."

Understand issues that impact our lives

Work/life balance continues as an important theme in the review and in our lives. Looking at policies, literature review author Lisa Frehill, Ph.D., cited research indicating that while men are low users of family leave opportunities, the impact on their work may be higher. A Georgia Tech study found that fathers who used these policies increased productivity. Good news, but the negative aspect is that women may be expected to show similar productivity, even though their load at home would be arguably heavier.

A study of law firm practices found that fathers benefit more than mothers from work/life policies. The big issue here — no surprise — is who is most heavily invested in childcare. An intriguing finding is that "as the percentage of women in an occupation increases, women report less and men more work/family conflict."

Dispel prevailing myths

In the "opt-out revolution," the authors note that large-scale data studies reveal that a working mother exodus from the workplace

just hasn't happened. *Some* women are choosing to opt-out and that decision has its costs — literally, in lower earnings. On the other hand, many women, in research cited, take advantage of changes in work/life perceptions and are developing ways to manage careers and family. The greater burden — cited in yet another paper — is carried by African-American women who are less likely to “emphasize the joys of caretaking rather than the burdens” because they [women in the study] more often worked the “second shift,” i.e., remaining employed while taking care of family members in the hours after work.”

Enable our girls

What can you learn about girls this year? “The math and science preparation gaps have ‘fundamentally’ disappeared,” according to the authors. The news may not all be good, however, as at least one study indicates that girls are taking more high school physics at a time when those courses are less effective in preparing them for STEM careers. As critical, the large gaps in preparation remain along race and ethnicity lines rather than gender.

Understanding what girls experience in the classroom is essential to ensuring they achieve their potential — and enter a nontraditional field like engineering. Melissa Storm, Ph.D., senior research analyst, American Institutes for Research, is not a SWE member or engineer yet finds the review complements her knowledge in various ways, particularly in her work on behalf of children. “A lot of what I do in my work focuses on meeting students where they are,” she said. “When talking about girls in STEM, it’s even more important to focus instructional methodologies and meet girls where they are, rather than use a one-size-fits-all approach.”

A good example of this is the growing use of LEGOS® in classroom activities. The authors point out that adults in charge assume LEGOS are “gender neutral,” when, in fact, they are still viewed by girls as boys’ territory. Understanding this can change how teachers and classrooms operate. Until this happens, though, make sure you get down on the floor and play with LEGOS with a little girl whenever possible!

Respond when someone says, “Girls just don’t volunteer.”

This phrase is often spoken by people offering outreach activities or educational curricula related to engineering. The answer? “Invite them in!” One study finds that girls may need more focused recruitment for activities that appear to be for boys — activities the boy volunteers will happily fill. The implications? For a discipline like engineering, girls are actively recruited only when they have proven excellence in math, while “average” boys are empowered to choose engineering without recruitment.

“Make sure the learning environment is friendly” is another answer. Other studies indicate that problem-based learning and learner-focused classrooms work better for girls, but that a conservative backlash emphasizing more traditional and inflexible training may inhibit our move in this direction. Boys’ behavior is another aspect. While girls report fathers encouraging them in academics and athletics, 32 percent of girls in one study “reported that ‘other boys’ ... had discouraged them ‘several times’ in the academic realm” and 54 percent reported it in athletics.

Lead and succeed at work

Effective negotiating is a key skill for both employers and employees. One study compared the

negotiation viewpoints and found that negotiation based on perspective rather than empathy was more successful. In other words, understanding what the other person’s interests are works better than developing an emotional connection with him or her.

“The literature review is a great resource for business,” said Sandra Scanlon, P.E., president of Scanlon Szynskie Group Inc., Aurora, Colo. In the past, she’s found the work/life balance information particularly useful. “We have more women working for us than is typical and they encompass a wide range of ages — taking care of parents as well as kids. I deal with these issues on a day-to-day basis, so it’s great to find out what’s going on in industry across the country and how it relates to women in engineering and women business owners.” Scanlon also uses the review in her SWE outreach activities. “I can talk to companies about what motivates girls to pursue STEM education when I fundraise.”

There’s so much more in the review: the rising acceptance of sexual harassment among teenagers, women’s progress in corporate leadership, and more. Do you have time to read it? The real question is: “How can you NOT have time?”

Barbara Bogue is a member of the SWE Magazine editorial board and a faculty member at Penn State University. She specializes in developing assessment tools that determine program effectiveness.

Women in Engineering:

A Review of the 2008 Literature

BY LISA M. FREHILL, PH.D.; CAROLYN BRANDI; NICOLE M. DI FABIO; KATELYN KEEGAN, M.P.A.; AND SUSAN T. HILL, M.S.

The Commission on Professionals in Science and Technology (CPST) team scanned more than 50 publications' tables of contents and completed extensive keyword searches to identify 300 articles for inclusion in this year's literature review. We read and summarized the articles within various thematic categories paying close attention to the research methods. The guidelines for implementing strong research are well-formed, yet evolving based on experiences and careful analysis of methodological efficacy.

On the one hand, the social scientist's methodological toolkit includes a plethora of qualitative and quantitative approaches, with some of the strongest research implementing mixed methods to capture multidimensional answers to research questions. Mixed methods is a social science research strategy in which several different methodologies (e.g., survey, interview, participant observation, etc.) are used to "triangulate" findings about a group. On the other hand, there continues to be some especially weak research. As in past literature reviews, we have emphasized articles that implemented strong methods and rejected, outright, those that were methodologically weak, with questionable reliability and validity.

While our focus is on women in engineering, we cast a wide net to capture related research that would be of interest to all working women, advocates of women in engineering, and those who work at all levels of programming to im-

prove women's access to, and preparation for, engineering careers. We have organized the review thematically, starting with the research on work/life balance. We then move through the pathway one takes to an engineering career, followed by a look at work force issues that impact women engineers. We close with a review of the international literature on women in engineering, a topic that has become increasingly important.

Front and center: work/life balance

Work/life balance was an important theme in many articles this year. Employers are interested in improving employee retention, so work/life balance policies have become as common as health coverage at most companies, large and small, and in the private, non-profit, and government sectors. In particular, younger workers, even those without children, expect to be able to maintain a "life" outside of work. Therefore, work/life policies are not exclusively about childcare — or the growing needs for employees to provide eldercare — and are more about how employees can balance their non-work needs and desires with their workplace requirements and expectations.

There is a common misperception that work/life policies are solely about helping mothers through the birth or adoption of a child. Occasionally attention is also paid to the attachment needs of fathers, but, for the most part, these policies are implemented with the intention of helping

women. Casper and Harris (2008) found that men saw little self-impact in work/life balance policies. Interestingly, a growing body of work documents the benefits that accrue to men as a result of these policies. Georgia Tech's ADVANCE: Institutional Transformation team (a program funded by the National Science Foundation to increase women's representation in academia) completed an analysis of the use of policies such as "stop the tenure clock" and modified duties during parental leave. They showed that new fathers' productivity increased when men used these policies, which led to expectations by promotion and tenure committees that mothers' productivity would also increase when they too received paid "time off." Georgia Tech found it necessary to train promotion and tenure committees in the differences in the gendered implications of policy implementation. For certain types of awards under these policies, Georgia Tech also implemented a step in which the person requesting an accommodation had to document that (s)he was the actual primary caregiver in a particular household. "Stop the clock" and modified duties were meant to provide relief to employees who were under additional family-based stresses: They were not intended to provide a "bonus" to those who were not experiencing these same time pressures.

A study of 670 law firm lawyers in Alberta, Canada, provided consistent findings that fathers experience greater benefits from

work/life policies than mothers. Not surprisingly, the gender gap in the actual time spent on childcare was a critical issue, as indicated in the graph below, which shows lawyers' average daily hours spent on parental responsibilities during the workweek by gender and children's age. Consistent with past research, Wallace and Young (2008) show that on a daily basis mothers spend much more time than fathers on parental responsibilities and that as children get older, the average number of hours spent each day on parental responsibilities declined for both mothers and fathers. Using the standard productivity measure for the law — billable hours — Wallace and Young show that women with children have lower productivity than do women without children and *all* men. Men without children had lower productivity than men with children. Men with children were able to draw upon family resources (i.e., a spouse) to increase their productivity while, at the same time, increasing their leisure time as a result of the implementation of family-friendly policies.

Three articles dealt with various aspects of how the structure of work impacts work/life balance. All three provide strong support for the positive impacts that result from greater employee control over work hours, and are evidenced by workers' increased commitment to the organization and ability to better manage work/life. Lambert et

al. (2008) surveyed employees (78 percent response rate, reduced to 68 percent due to skipped questions by some respondents) at two finance/insurance companies to show how the utilization of flexible work arrangements varied. They found that those employees who had worked for the company longer, had supervisory authority, had co-workers who used flexible work arrangements, and had quite a few "personal lifestyle preferences" (i.e., up to 12 reasons an employee might want flexible work arrangements) were more likely to utilize policies than those who had been with the company less time, did not have supervisory authority, did not perceive a receptive climate to using flexible arrangements, and had fewer reasons to want these arrangements.

Another article by Casper and Harris (2008) used an online survey of 286 workers who averaged 43 work hours and 17 family-care hours per week. Women, regardless of whether they needed to use scheduling flexibility or dependent care benefits, were favorably disposed toward these policies and demonstrated higher levels of employer commitment because of these benefits. Men, however, tended to view the policies with some suspicion, being concerned with whether they might replace other benefits.

The need to be attentive to men's opinions about work/life balance was also emphasized in a study by

Cook and Minnotte (2008), who used data from the 2002 National Study of a Changing Workforce (2,810 respondents, originally conducted by the Family Work Institute). Cook and Minnotte show that as the percentage of women in an industry increases, women perceive more while men perceive less co-worker support, and that as this occurs, women see more support for a work/family culture. Also, as the percentage of women in an occupation increases, women report less and men more work/family conflict. Cook and Minnotte conclude that women are generally "rewarded" with stronger work/family cultural support by being in female-dominated industries and occupations even though these occupations and industries, on average, pay less and have shorter ladders of opportunity.

Moen, Kelly, and Huang (2008) examined work styles and habits of

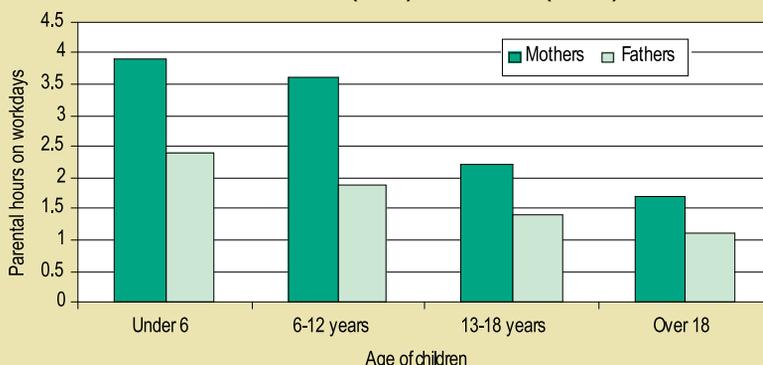
CATEGORIES		Job Demand	
		High	Low
Job Control	High	A	B
	Low	C	D

917 white-collar employees at Best Buy's corporate offices in Minneapolis-St. Paul. Employees fit into one of four categories, as shown in the above chart:

Workers in groups A and B — those with high control over work hours — were more likely than other workers to use control over hours to reduce work/family conflicts and therefore had a higher level of work fit. Regardless of family status — so it was not just mothers who experienced these issues — workers who had lower levels of control generally had higher levels of work/life conflicts.

Another article (Kuperberg and Stone 2008) looked at the "opt-out revolution" — a term coined in 2003 by Lisa Belkin, a writer at the *New York Times*, who had several friends who left lucrative careers to be full-time mothers. Of course, larger-scale data reveal that there has not been an "opt-out revolu-

Average Hours on Parental Responsibilities by Age of Child for Mothers (n=90) and Fathers (n=255)



Source: Wallace & Young 2008: 120

tion," but the portrayals of women who leave the work force are nonetheless interesting. In the past, common perceptions were that women who got married while working would leave work to be full-time wives. Now this image is largely absent. Instead, portrayals of women who leave work are almost entirely about women choosing to be stay-at-home moms. These findings are interesting for two reasons. First, family-friendly policies provide the mechanism by which the male lawyers with children, whom Wallace and Young studied, were able to reap family resource rewards that enabled greater productivity, in contrast to their childless brothers in the workplace or mothers who used these resources to take care of children. Secondly, children become the mechanism by which women leave the workplace — in order to provide the best possible care to children — but it means that they are now also available to complete supportive tasks in the household for their husbands or partners.

Consistent with Kuperberg and Stone, Settles et al. (2008) found that white women were more likely than African-American women to emphasize the joys of caretaking rather than the burdens, due to perceived options. That is, while white women might be able to choose to be full-time mothers or might be able to reduce work time because of their connections with affluent men, African-American women in Settles et al.'s focus groups more often worked the "second shift," i.e., remaining employed while taking care of family members in the hours after work. The Settles et al. article reports on an interesting study that used a series of six focus groups with 14 black women and 17 white women, recruited via newspapers, flyers, and other participants' referrals in a mid-size Midwestern community. In addition, two focus groups of psychology students were recruited. This qualitative strategy produced rich data about the perceptions and meanings of womanhood as well as how women cope

with work/life balance issues (although this was not the central role of the research).

"Opting out" is not without its consequences. Valcour and Ladge (2008) showed that earnings were higher for those women who: (1) chose to have children at an older age; (2) had fewer children; (3) had few career gaps or part-time work periods; and (4) fewer job/company changes. Those women who had children and placed higher priority on their husbands' careers had lower wages.

Many women choose not to "opt out." In an article in *Fortune* magazine, Sellers (2008) describes how female COOs and CEOs of large technology firms in California's Silicon Valley are managing their careers and their families. Through personal stories, they relate how networking with other mothers in their field has helped them to build good work/life balance skills as they share best-practice tips and techniques. Although not discussed in the article, it was clear that many of these women had delayed childbirth until they were settled in their careers. This is consistent with findings by McQuillan et al. (2008) who found that situational factors played a role in whether women had children or not, regardless of their desires related to having children.

Other women with highly demanding careers, NCAA Division I coaches, were also found to have developed effective methods for balancing work and family. Bruening and Dixon (2008) found that the 17 NCAA Division I head coaches they studied often made many sacrifices while they and their families were faced with extraordinary choices. The coaches frequently felt that the university male athletic department heads did not understand their plight of balancing both the hectic schedule of a coach and raising a family. Prior to motherhood, coaches traveled quite often for games or to recruit new players.

But when their children were born they had to scale back their time away from home. Several of

the women said that after the birth of their first child they found that the team and the university became a strong support for them. This support, in addition to having a husband/spouse willing to change their own career trajectory in support of hers, made it possible for several coaches to maintain their positions. Those coaches who experienced no support from the university, even if they had support from their families, felt that they needed to either change universities or leave coaching altogether for the sake of their families.

Because professional women "have options" — i.e., if they are married/partnered to professional men, they can choose to stay home with the children — how can such women be on-ramped back into engineering positions as children grow and need less parental care time? A 2002 report in the United Kingdom addressing this issue led to the development of an online, 100-hour course titled, "Science, engineering, and technology: A course for women returners." More than 700 women have taken the course since it was implemented in October 2005. Herman and Kirkup (2008) completed a program evaluation on the course using course evaluation questionnaires (response rate of about 62 percent of course completers); phone interviews with 10 survey respondents of various ages and occupations; 16 "critical incident" reports; and 19 discussion board postings by course participants.

The 10-week, 100-hour online class included construction of an ePortfolio using *Profile* software. By using the *Profile* program, participants were able to save the ePortfolio on their hard drives rather than having them hosted by an institutional Web site. While ePortfolios have become a popular final "capstone" activity for students, many students do not continue to use their ePortfolios because they no longer have access to the original Web site. A ma-

majority of the participants (73 percent) indicated that they found the ePortfolio and *Profile* program as “fairly” or “very” useful and most (77 percent) indicated that they planned to continue to use it as a personal/professional development program. Unfortunately, because this evaluation covered merely the ePortfolio and *Profile* aspects of the class, there were no data on the relative success for the women in returning to work. The article would be a useful starting point for a company that was interested in providing a structured transition back for employees who took time out of their careers or for colleges or universities to develop a similar class.

Trends in Participation by Ethnicity and Discipline in Engineering

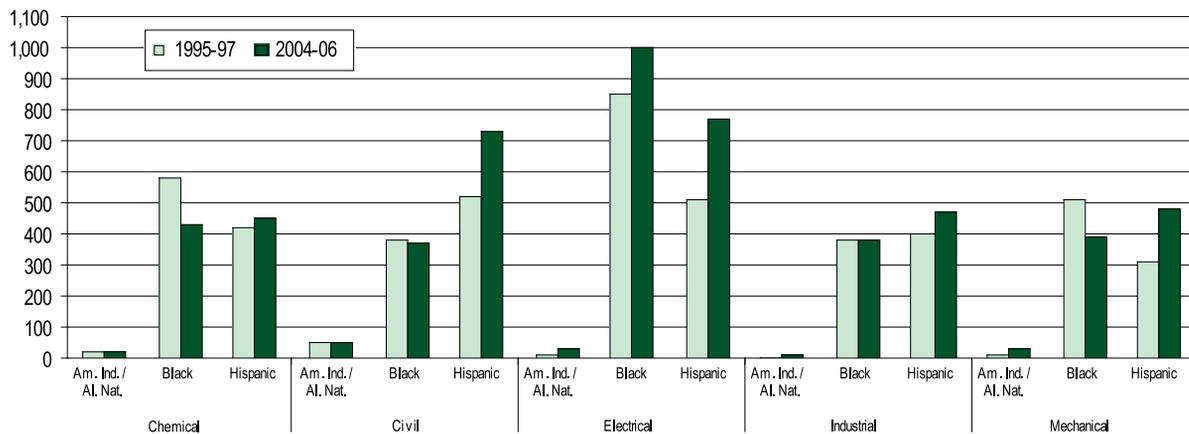
By Lisa M. Frehill, Ph.D.

The two graphs here show the total number of bachelor’s degrees awarded in the three-year periods 1995-1997 and 2004-2006. These data are from the Integrated Postsecondary Education Data System (IPEDS), analyzed using the National Science Foundation’s WebCASPAR database system. Collected annually from all Title IV colleges and universities, IPEDS provides the most complete data on degree completions. Title IV institutions are those that participate in federal student aid programs (i.e., almost every college or university in the United States). These data differ from those available from the Engineering Workforce Commission and the American Society for Engineering Education in that these other sources collect data from engineering colleges and therefore may not include all engineering degrees (although they often get close to complete participation). Typically, these other sources can provide more rapid estimates of degrees and enrollments and provide member institutions with data-cutting tools to obtain estimates for groups of engineering schools.

Here we have aggregated three years of degrees at two points in time. The 1995-1997 years were the first years that the completions by race and subfield

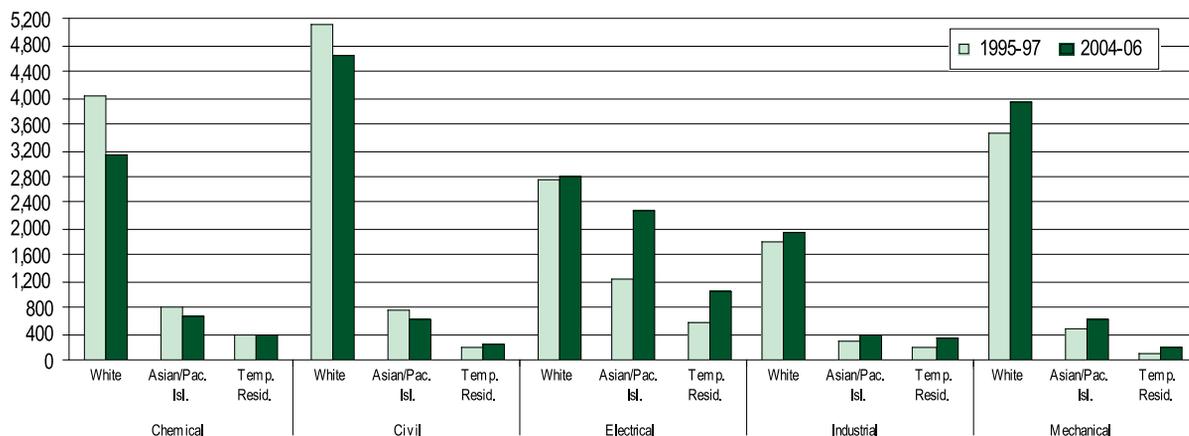
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**Underrepresented Minority Women’s Bachelor’s Degrees in Engineering, by Discipline, Ethnic Group:
3-Year Totals for 1995-1997 and 2004-2006**



(Source: CPST analysis of IPEDS Completions by race data accessed via National Science Foundation WebCASPAR database.)

**Women’s Bachelor’s Degrees in Engineering, by Discipline, Ethnic Group:
3-Year Totals for 1995-1997 and 2004-2006**



(Source: CPST analysis of IPEDS Completions by race data accessed via National Science Foundation WebCASPAR database.)

The pathway to engineering: K-12 education

K-12 education represents the initial step along the educational pathway to an engineering career. The mathematics and science preparation “gaps” have fundamentally disappeared with a couple of exceptions: Girls are much more likely than boys to take high school chemistry, while boys continue to be slightly more likely than girls to take physics, according to the data in the graph on page 36. More recently, the American Institute of Physics reported that high school physics education has expanded. More students, overall, are taking a class in high school physics and the sex gap has disappeared. But even though more students are taking physics, the content of high school physics classes has also changed, providing less of the foundation needed for college-level physics study (Neuschatz 2007).

While the gaps in preparation have narrowed by gender, persistent, wide gaps in high school preparation exist across race/ethnic groups. In particular, Asian/Pacific Islanders are more likely than students from any other race/ethnic group to have completed analysis/pre-calculus, calculus, chemistry, or physics. Next most likely are white (non-Hispanic) students. Fewer than one in five Hispanic, African-American, or American Indian/Alaska Native students had completed pre-calculus and fewer than 10 percent of these students had taken calculus according to these 2005 data. Lowered expectations by teachers and the lack of course availability play a significant role in maintaining these race/ethnic gaps. Among Asian/Pacific Islander students, there is a far stronger cultural norm that mathematics is a skill that requires persistent effort. This cultural norm is directly in contrast to the dominant belief in the United States that mathematics is an “ability,” which means that a student who does not do well in mathematics is often “excused” from working harder because they just “can’t

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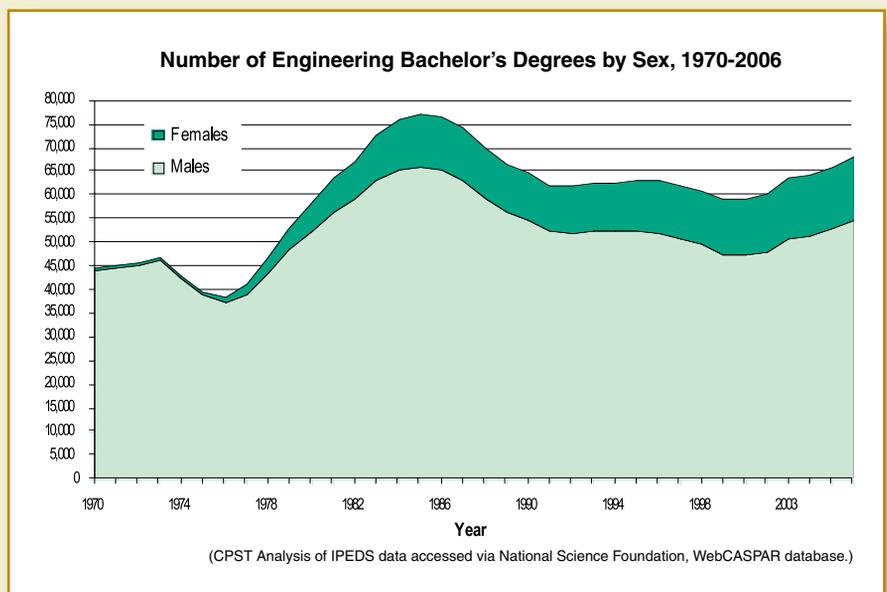
data were available in WebCASPAR, and 2004-2006 are the most recent three years.

There are a number of noteworthy points in these graphs, including:

- With the exception of Hispanics, all groups of women earned fewer degrees in chemical engineering in the most recent period than in 1995-1997.
- Participation in electrical and industrial engineering increased for all six groups of women in 2004-2006, in contrast to the 1995-1997 period.
- Only black women’s participation in mechanical engineering declined while all other women’s participation increased in this subfield.
- While there were declines for white and Asian/Pacific Islander women in civil engineering, the participation of underrepresented minorities (URMs) and temporary resident women in this same field increased.
- For white women, civil was the most popular engineering subfield, while for Hispanic and black women, electrical engineering occupied the top spot.
- Although there were relatively few engineering bachelor’s degrees awarded to temporary residents (which exceeded the number of engineering degrees awarded to American Indians and Alaska Natives), electrical engineering was the most popular subfield for these women.

Prior to Title IX in 1972, engineering schools were legally able to shut their doors to women, and many did so. As shown in the graph below, women’s participation in the field was negligible prior to this momentous year. In 1970, of the nearly 45,000 engineering bachelor’s degrees awarded, women earned just 337 across all fields of engineering. As early as 1976, we can see an important effect of this barrier’s removal to women’s entry to engineering in that the number of women earning engineering bachelor’s degrees nearly quadrupled. But we also see the start of an alarming trend for engineering schools: Men’s awards in the field had declined, indicating that men’s interest in the field had begun to wane. While men earned 44,433 engineering bachelor’s degrees in 1970, their participation reached the nadir shown in the chart (37,473 degrees) in 1976, after which their participation rebounded. Perhaps men’s participation rebounded as a result of increased active efforts by engineering schools to recruit women? This would make an interesting research question.

One of the graphs on page 143 shows the trend in women’s participation in engineering disciplines since 1970. Even though data on completions by race are not available earlier than 1995, if we look at women’s aggregate participation in engineering, we are able to use IPEDS data back to 1970. All of the engineering subfields saw increases in women’s participation, but chemical and industrial both showed the largest increases over the last 36 years, reaching what many scholars consider to be “critical mass” of 30 percent or more. Women’s movement into civil engineering started a little later than in chemical and industrial and has not yet reached that critical mass level. Finally, change in women’s participation in electrical and me-

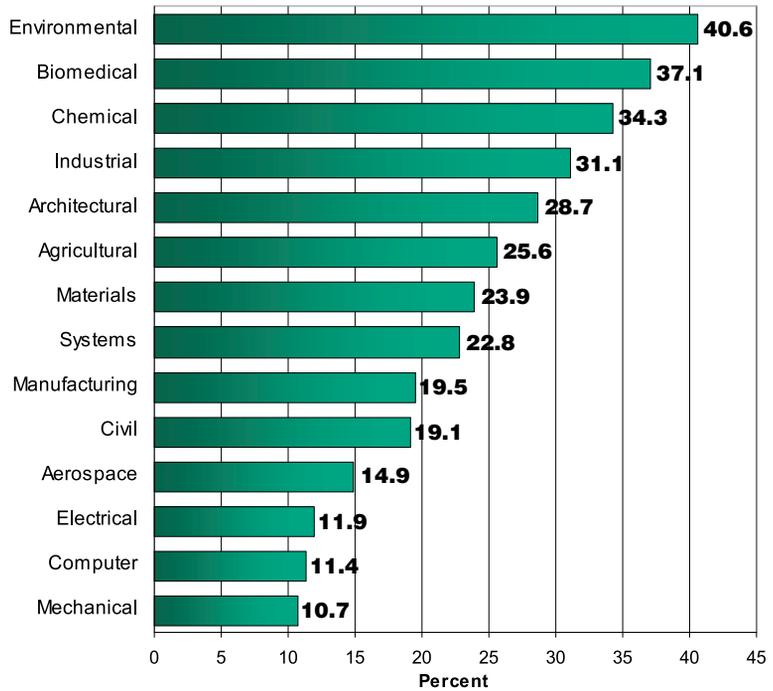


chanical engineering has been at a snail's pace, with women continuing to be far outnumbered by men in these, the largest engineering subfields. All five fields show a slight downturn in women's participation since 2000, which may be due to the rise since 2000 in three important engineering subfields: aerospace (which should be characterized as a resurgence), environmental, and biomedical engineering.

According to these data, there were slightly more than 68,000 new engineers produced in 2006, of which marginally fewer than one-in-five were women. A number of observers in the past year have suggested that the United States is not producing enough engineers, with estimates that rather than the 65,000-75,000 new engineers, we really need 115,000-125,000 to fuel our economy. Indeed, even during the recent economic downturn, jobs like mechanical engineering have been cited as "recession proof." If engineering demand has essentially "topped out" for men — especially white men — then it will be imperative for engineering schools to do a better job of appealing to young women if we are to produce the engineering talent we need.

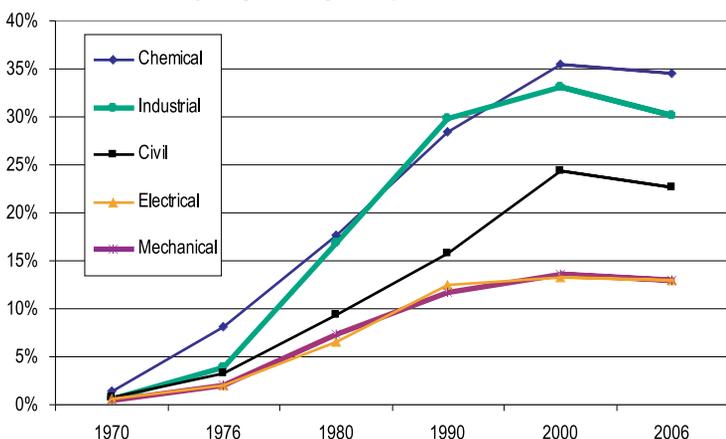
These final charts report 2006 undergraduate engineering enrollment by three main URM groups. Women account for a "critical mass" — 30 percent or more — of engineering undergraduate students in environmental, biomedical, chemical, and industrial engineering. Environmental leads the way with 40.6 percent women. Among URMs, manufacturing engineering is the top subfield with 17.4 percent Hispanic, 12.5 percent African-American, and 0.7 percent American Indian students. It should be kept in mind, however, that manufacturing engineering is a relatively small field, as is industrial engineering, the number two field for URMs.

Women as a Proportion of Total Undergraduates in Selected Engineering Disciplines, Fall 2006



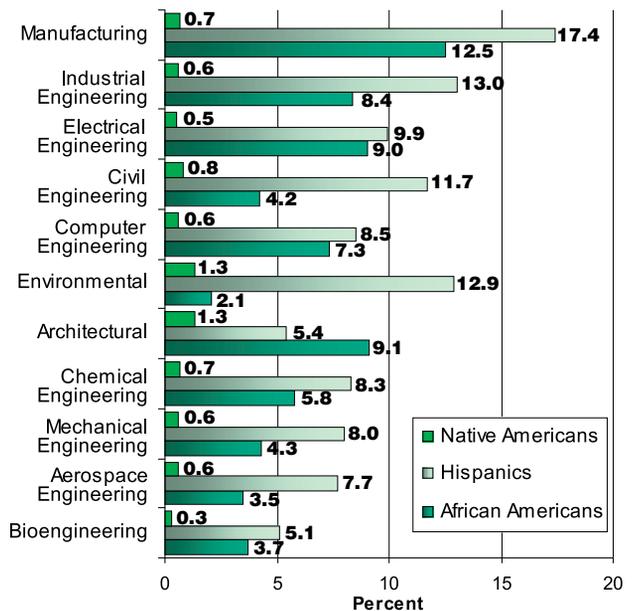
Source: CPST, data derived from Engineering Workforce Commission, *Engineering & Technology Enrollments, Fall 2006*.

Percent Women Among Engineering Bachelor's Degree Recipients by Engineering Discipline, Selected Years



(CPST analysis of IPEDS data accessed via National Science Foundation, WebCASPAR database)

Underrepresented Minorities as a Proportion of Total Undergraduates in Engineering Disciplines, Fall 2006



Source: CPST, data derived from Engineering Workforce Commission, *Engineering & Technology Enrollments, Fall 2006*.

do" mathematics.

Improving STEM education has been increasingly important with new policies, programs, and pedagogy being put in place throughout the country. Wolf explains how elementary school teachers have been known to teach students, while middle school teachers teach subjects. Wolf (2008) reported that National Assessment of Educational Progress (NAEP) scores have been dropping for 4th, 8th, and 12th

the use of problem-based learning to solve problems by applying math and science, especially in engineering. The integrative PD&I approach not only crosses disciplines, but shows students how math and science concepts are the core of engineering education.

Have we really seen differences in science teaching in K-12? With increasing pressures associated with global competition, are U.S. students being prepared to com-

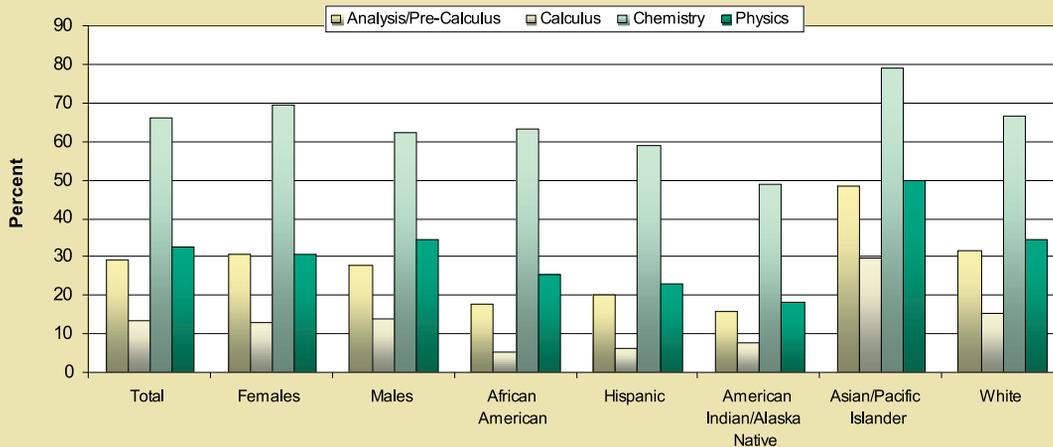
Problem-based learning approaches have become more popular in shorter-term classes for children held during vacation periods. Voyles, Fossum, and Haller (2008) report on a study that uses LEGOS® programmable robotics to engage students in a one-week technology-based project. Using a single-sex format, students worked in triads to build and program a robot constructed from LEGOS. Girls sought more interaction from teachers,

sometimes as a means of building a relationship and, sometimes, because they appeared to need approval and encouragement. The girls had less experience with LEGOS, so there were legitimately more questions and some tasks took them a little longer as they were learning for the first time, while boys were more likely to have had past experience with the toy. This is an important note because LEGOS are used in many college

classrooms and many professors may believe that they are a "gender neutral" toy, when, in fact, they are still more likely to be used by boys. Therefore, Voyles, Fossum, and Haller suggest that it is important to acknowledge such functional differences between boys and girls as a viable partial explanation for why teachers differentially interact with girls and boys in these settings.

Another interesting point about this particular program was that ample boys volunteered for the available "slots" while girls needed more focused recruitment. Once again, we see a replication in microcosm of the processes that operate in later grades, whereby girls are "recommended" to fields like engineering only once they have proven themselves in advance mathematics, while the average

High School Graduates' Science and Mathematics Course Taking, Selected Courses, 2005 by Gender and Race/Ethnicity



(Source: CPST analysis of data derived from National Center for Education Statistics *Digest of Education Statistics, 2007.*)

graders, even with the increased number of states that require three years of both math and science (38 and 35 states, respectively).

The Bush Administration's No Child Left Behind Act attempted to target issues related to the quality and credentials of science and math teachers in K-12 schools, but not much has been done to address curriculum and teaching methods for these subjects. Taking integrative and interdisciplinary approaches to teaching science and math courses was a key theme in this year's K-12 STEM education literature.

Sanders (2008) breaks down the efforts made in the past two or three decades to advance science education, with an emphasis on integrative STEM education using purposeful design and inquiry (PD&I) teaching methods. PD&I is

pete? According to Carter (2008), while there may be some signs of progress and renewed interest in science pedagogy, there are also some reactionary movements afoot.

On the one hand, there are movements that aim to place a rigid structure on science education using old-school models in which students would be expected to learn a core of knowledge. On the other hand:

... pedagogical and curriculum practices that implemented authentic science experiences better akin to globalization's science are Problem-Based Learning (PBL) approaches. ... Teachers work as facilitators with fewer learning goals/standards/concepts defined in advance and less direct instruction, while students work in small groups to share their prior knowledge and develop strategies to progress their task. (Carter 2008: 627)

boy is just as likely as the most talented boy to select the field (Frehill 1997).

Cavanagh (2008) reported on Kentucky schools that joined the Commonwealth Institute for Parent Leadership, which helps parents, administrators, and teachers work together to make STEM education more effective for students in their school system. Through recruiting and newspaper and radio advertisements, 58 parents applied to become part of this STEM Institute. These parents helped create new programs with teachers and administrators to improve students' understanding of science and math. While this small group of parents is working toward improving science and engineering education at the K-12 level, public opinion is not completely in their favor. Cavanagh cited a 2006 survey by Public Agenda, which found that parents were satisfied with their children's math and science instruction in school and parents' concern about this issue had fallen. This suggests that continued parental recruitment may become problematic for institutes of this type.

Although NAEP scores do not show significant differences by gender, Dentith (2008) interviewed high-achieving males ($n=24$) and females ($n=21$) who had enrolled in two or more AP courses in their final year of high school in a Midwest suburban school district. The girls found themselves in heavy competition with female rather than male peers due to the lack of openings in AP math, science, and computer programming courses for women. The subject of self-confidence arose in every interview with the girls because they felt their male peers had higher academic abilities. These self-confidence concerns led the girls to worry about earning any grade of "B" or lower because they thought it would tarnish their reputation as a good student. Boys, on the other hand, were less worried about earning a B. But even as they worked hard to maintain high grades, the girls felt a lack of recog-

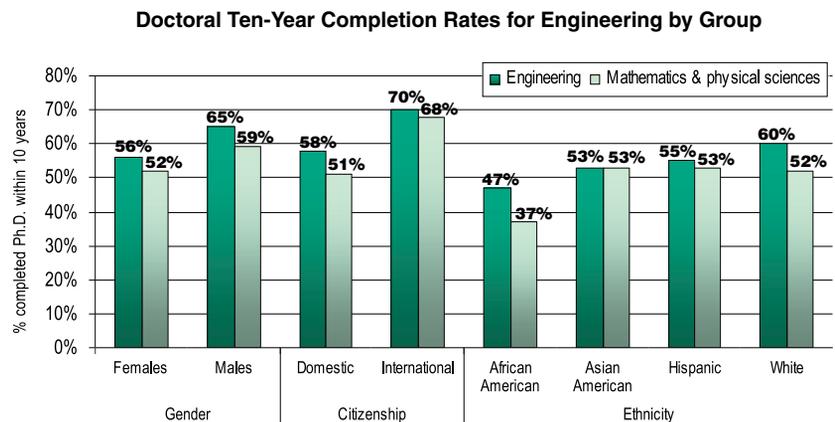
Ph.D. Completion for Engineers

Lisa M. Frehill, Ph.D.

With funding from Pfizer and the Ford Foundation, the Council of Graduate Schools (CGS) has obtained demographic completion data for 24 institutions covering 12 academic years. Data were provided to CGS on students who entered graduate school any time between the 1992-93 and the 2003-04 academic years (inclusive) so that they could assess how long it took students to complete their doctoral programs. Then they determined the extent to which students completed a doctoral degree within 10 years of initiating graduate study. The CGS baseline analysis had shown that 80 percent of students who do complete a Ph.D. do so within seven years of entering a program. Therefore, the 10-year completion time frame most likely captures a vast majority of those who enter graduate school and complete the doctoral degree.

While the study is based on data from only 24 institutions, these are some of the largest and most well-funded research universities in the nation. These institutions have some of the largest enrollments in graduate programs and high production of doctoral degrees. To some extent, as the largest institutions with generally high levels of research funding, the information based on an analysis of outcomes of students at these institutions may overestimate retention. That is, consistent funding for graduate education may be more likely at these institutions in stark contrast to the situations at smaller or less research-focused universities.

The graph provides a summary of the data related to engineering and mathematics and physical sciences as provided in the CGS report. Overall (not shown in the bar chart), 55 percent of women and 58 percent of men completed a doctoral degree within 10 years with 54 percent of domestic and 67 percent of international students completing a doctoral degree in that time frame. Engineering women complete doctoral degrees at about the same rate as women in all fields. However, engineering men complete at a higher rate — 65 percent versus 58 percent — most likely because of the predominance of international students in engineering, which is a group that has a higher completion rate than domestic students overall. In 2007, according to the most recent data from the *Survey of Earned Doctorates*, 62 percent of engineering doctoral degrees were awarded to non-U.S. citizens.



Whites had the highest doctoral completion rate in engineering (60 percent) within 10 years, while African-Americans had the lowest rate (47 percent), with Asian-Americans and Hispanics between these extremes. The 10-year completion rates for both whites and African-Americans were higher in engineering than they were in mathematics and physical sciences. Indeed, there is no substantial difference between Asian-Americans, Hispanics, and whites in mathematics and physical sciences, which are 52-53 percent, so that the 37 percent figure for African-Americans in these fields poses a stronger contrast than in engineering.

dition for their achievements.

The awareness of the need to fix science and math has gone beyond the No Child Left Behind Act, and will hopefully propel STEM education at the K-12 level to prepare young students for STEM disciplines at the college level. Unfortunately, even if high school students of both genders earn grades at the same level, girls still feel out of place in certain classroom contexts, especially in STEM, and still hold the misperception that their male peers are innately higher achievers.

The movement toward more inter-disciplinarity could help, as courses in which female students feel comfortable are integrated with those in STEM fields in which they may feel less comfort-

able or confident.

Sexism continues to pose challenges for young women in middle and high school. Leaper and Brown (2008) examined the extent to which 600 adolescent 12- to 18-year-old girls experienced different kinds of sexism. The table provides an overview of Leaper and Brown's findings. Some of the girls were from Georgia but most from California. They were somewhat diverse: 49 percent were Latina, 22 percent white, 9 percent African-American, 8 percent Asian, and 12 percent multiethnic or other. As with many such studies, this one used a convenience sample, meaning that the authors surveyed girls in places that were "convenient" for them. Therefore,

the results cannot be generalized to the larger population.

Parents have become more supportive of their daughters, as shown by the relatively low levels of discouragement girls reported. That is not the case with male peers, however. While 85 percent of fathers were reported as never discouraging a daughter in academics and 70 percent never discouraged a daughter in athletics, 32 percent of girls reported that "other boys" (i.e., besides relatives or close friends) had discouraged them several times in the academic realm, and more than half (54 percent) of girls indicated this discouragement by boys in athletics. In short, Leaper and Brown's findings (2008) suggest that girls face the greatest amount of sexism from their male peers.

Sexual harassment and bullying were the focus of a study in a suburban New England community by Gruber and Fineran (2008). In a survey of more than 500 middle school and high school students on the frequency of sexual harassment and bullying and their consequential health effects, Gruber and Fineran found that bullying was a much more common experience, with 52 percent of students reporting incidences of bullying and 34 percent reporting incidences of sexual harassment (Gruber and Fineran 2008). Furthermore, 79 percent of gay, lesbian, or bisexual students experienced bullying and 71 percent experienced sexual harassment, compared to 50 percent and 32 percent, respectively, of heterosexual students. Both bullying and sexual harassment were found to have poor health effects on the victims, yet sexual harassment, although less frequent, played a greater role in poor health outcomes.

York's (2008) study of the intended careers of high school valedictorians in the North Carolina Research Triangle area reveals the persistent gap in talented girls' and boys' likelihood of choosing a career in engineering. York used local newspapers to identify valedictorians in the 10-county area who

Girls Who Report Experiencing Personal Sexism (Percents)

Sexism Experienced	At least once	Several times	Never
Sexual harassment			
Given/unwanted/inappropriate romantic attention	66.5	26.6	33.5
Called nasty or demeaning name	62.1	12.9	37.9
Teased about your appearance	58.1	12.3	41.9
Given unwanted physical contact	51.1	14.6	48.9
Told an embarrassing/mean joke	67.1	14.7	32.9
Teased, bullied, threatened by a male	28.4	5.2	71.6
Discouragement in academics			
By teachers/coaches	22.8	2.5	77.2
By father	15.2	3.7	84.8
By mother	12.2	1.0	87.8
By close male friends/brothers	24.8	2.3	75.2
By other boys	31.8	4.6	68.2
By close female friends/sisters	18.4	2.0	81.6
By other girls	21.5	3.5	78.5
By other family members	16.5	2.6	83.5
By neighbors	10.5	1.0	89.5
Discouragement in athletics			
By teachers/coaches	27.9	2.3	72.1
By father	30.0	5.6	70.0
By mother	24.7	3.4	75.3
By close male friends/brothers	44.8	5.1	55.2
By other boys	54.1	9.4	45.9
By close female friends/sisters	31.1	2.3	68.9
By other girls	37.8	3.7	62.2
By other family members	31.4	3.2	68.6
By neighbors	21.0	1.6	79.0

Note: "Several times" is more than "once or twice."

Source: Leaper and Brown 2008: 692

graduated in 2003-2005, obtained GPA and SAT data from guidance counselors, used data on college/university selectivity from the *US News and World Report's* 2005 "America's Best Colleges," and obtained salary statistics on occupations from the Bureau of Labor Statistics. There were no differences in the boys' or girls' average GPAs or SAT scores. One in five boys but just under one in eight girls who graduated at the top of their classes indicated an intention to pursue a career in engineering. The top choice for girls was "healthcare field, but not a physician or surgeon," while for boys, almost one-third indicated a plan to pursue a career as a physician or surgeon. Girls were more likely to choose almost any other career other than engineering, with the exception of law. When we look at the median salary of valedictorians' intended careers, we see that boys are more likely to choose careers with much higher median salaries than those chosen by girls.

Making STEM higher education more accessible to diverse groups

College is the next step along the educational pathway to engineering. To produce the new engineers our economy needs to maintain its edge in the global market, it is critical to find new ways of recruiting and retaining women and underrepresented racial and ethnic minorities. As literature on this topic continues to emerge, the importance of groups and group learning, mentors, and self-efficacy correspond to choice of major and career path for those who have any interest in STEM.

Freeman, Alston, and Winborne (2008) used quantitative and qualitative methods to assess how learning communities created an atmosphere in STEM disciplines conducive to attracting and retaining minority students. The Learning Communities for STEM Academic Achievement (LCSAA) program was used at Howard University and Talladega College, both historically black colleges/univer-

sities (HBCUs), to facilitate a curriculum where specific science and math classes overlapped. The overlap of courses allowed each discipline to focus on an issue (e.g., global warming), and each class would gauge their learning on this issue (Taylor et al. 2008). In instances without a special focus, courses like chemistry, biology, and pre-calculus would be taught to students illustrating the commonalities conveyed through each.

The students at Howard and Talladega took surveys in the fall of 2006 evaluating the LCSAA program, and in the fall of 2007 to assess motivation in the college classroom. The evaluation results of this multidisciplinary approach concluded that the marriage of course topics and a familiar group of classmates fueled interest in STEM studies and increased students' levels of achievement. Students agreed that having the same classmates throughout their courses made it easier to communicate in class.

Although the sample is small, 19 of 20 (95 percent) Talladega students would recommend these "linked" classes. Howard students gave an average rating of 3.6 on a 5-point scale saying that they were more likely to attend graduate school and pursue a STEM field because of linked courses. In addition, the success rate in their pre-calculus class in fall 2006 yielded a 61 percent success rate in comparison to the 45 percent success rate in non-linked classes.

Another article provided additional insights into the Howard University learning communities. Despite the methodological flaws, the careful and thoughtful discussion of the issues that arose in developing the learning communities approach is useful for anyone who wishes to implement a similar program at their institution. Smith, McGowan, et al. (2008) report on the challenges associated with recruiting and retaining students, faculty, and graduate students as well as the institutional challenges associated with linking the classes. They recommended

careful work with the registrar to address these challenges. Providing clear rewards to faculty who participate and carefully documenting learning communities' positive impacts on students are ways to address the challenges they faced in recruiting and retaining faculty members.

The community college environment has been shown to provide a level of comfort similar to that achieved in the LCSAA programs. Starobin and Laanan (2008) conducted interviews of women studying STEM at three Seattle community colleges, with plans to transfer to four-year institutions. The interview process revealed the shortcomings in exposure and preparation that is vital to pursuing any STEM field. Starobin and Laanan revealed the lack of early exposure in recorded sentiments such as:

I wish somebody had told me about it [engineering] earlier. Until I took physics I did not know, you know, I did not know engineers existed. I did not know who designed those buildings ... I think if somebody had communicated to me personally in middle school in one of my math classes or science classes, I think I would have probably been thinking about it [engineering] a lot earlier. (Starobin 2008)

In addition to not being educated about engineering as a career possibility, these women said that community college helped them prepare to catch up with math and science courses at an older age, and provided an atmosphere with diverse students. This diversity helped create a foundation of positive self-efficacy by providing them with a way to "fit in."

Furthermore, the women indicated that mentors carved a clear pathway to a bachelor's degree by providing resources, information about the transfer process, and financial aid, all in an engineering 101 class at one of these three colleges. The resourcefulness of the professors, as well as continued positive messages, helped to catapult these community college women into STEM majors at the

2008 Outstanding Women in Engineering

By Carolyn Brandi

American Association of Engineering Societies

John Fritz Medal

Kristina Johnson, Ph.D., Johns Hopkins University; and nominee for undersecretary, U.S. Department of Energy

Chair's Award

Suzanne Jenniches, Northrop Grumman

Kenneth Andrew Roe Award

Priscilla Nelson, Ph.D., New Jersey Institute of Technology

American Society for Engineering Education (ASEE) Awards

ASEE Distinguished Service Citation

Susan Kemnitzer, Division of Engineering Education and Centers, National Science Foundation

DuPont Minorities in Engineering Award

Stephanie Adams, Ph.D., University of Nebraska-Lincoln

Sharon Keillor Award for Women in Engineering Education

Sue Ann Allen, Ph.D., Georgia Institute of Technology

James H. McGraw Award

Patricia Fox, Indiana University-Purdue University

Fred Merryfield Design Award

Linda Schmidt, Ph.D., University of Maryland-College Park

William Elgin Wickenden Award

Cynthia Atman, Ph.D., University of Washington

Robin Adams, Ph.D., Purdue University

Monica Cardella, Ph.D., Purdue University

Jennifer Turns, Ph.D., University of Washington

Susan Mosborg, Ph.D., University of Washington

Best Paper - Pic II/Best Overall Paper

Linda Kehr, Klamath County School District

Catherine Lanier, Oregon NASA Space Grant Consortium

Best Paper - Pic III

Janet Meyer, Indiana University-Purdue University

Nancy Lamm, Indiana University-Purdue University

Best Paper - Pic IV

Jeanne Hubelbank, Ph.D., WPI Evaluation Consultant

Chrysanthe Demetry, Ph.D., Worcester Polytechnic Institute

Shelley Errington Nicholson, Worcester Polytechnic Institute

Stephanie Blaisdell, Ph.D., Independent Consultant

Paula Quinn, Independent Consultant

Elissa Rosenthal, Marketing Research Consultant

Suzanne Sontgerath, Independent Consultant

Fellow Member Honorees

Marilyn A. Dyrud, Ph.D., Oregon Institute of Technology

Lakshmi Munukutla, Ph.D., Arizona State University

Gloria M. Rogers, Ph.D., ABET Inc.

Outstanding Zone Campus Representative Award

Susan McCahan, Ph.D., University of Toronto

Section Outstanding Campus Representative Award

Illinois/Indiana Section: Sharon G. Sauer, Ph.D.,

Rose-Hulman Institute of Technology

St. Lawrence Section: Susan McCahan, Ph.D.,

University of Toronto

Other Section Awards

North Midwest Section:

Outstanding New Educator Award

Kristyn Masters, Ph.D., University of Wisconsin-Madison

Best Paper Award

Michele H. Miller, Ph.D., Michigan Technological University

Debra D. Charlesworth, Ph.D., Michigan

Technological University

Best Paper Award

Cecelia Wigal, Ph.D., University of Tennessee at Chattanooga

New Faculty Research Award - First Place

Adrienne Minerick, Ph.D., Mississippi State University

Professional & Technical Division Awards

Aerospace Engineering Division:

John Leland Atwood Award

Awatef A. Hamed, Ph.D., University of Cincinnati

Biomedical Engineering Division:

Theo C. Pilkington Outstanding Educator Award

Mary C. Verstraete, Ph.D., University of Akron

Biomedical Engineering Teaching Award

Kristyn S. Masters, Ph.D., University of

Wisconsin-Madison

Chemical Engineering Division:

William H. Corcoran Award

Nancy Thompson, Ph.D., University of South Carolina

Chemstations Chemical Engineering Lectureship Award

Jennifer Sinclair Curtis, Ph.D., University of Florida

Joseph J. Martin Award

Lisa Bullard, Ph.D., North Carolina State University

Civil Engineering Division: Gerald R. Seeley Fellowship

Tanya Kunberger, Ph.D., Florida Gulf Coast University

Diane Bondehagen, Ph.D., Florida Gulf Coast University

College Industry Partnership Division:

CIEC - Best Session Award

Carol B. Muller, Ph.D., MentorNet

Continuing Professional Development Division:

Joseph M. Biedenbach Distinguished Service Award

Helene Demont, University of Wisconsin-Madison

CIEC - Best Workshop Award

Patricia Hall, University of Tulsa

Nancy Kruse, University of Tulsa

Certificate of Appreciation

Nancy Kruse, University of Tulsa

Sally A. Coover, Ph.D., University of South Florida

Kim Scalzo, Rensselaer Polytechnic Institute

Helene Demont, University of Wisconsin-Madison

Linda Krute, Ph.D., North Carolina State University

Lynette Krenelka, Ph.D., University of North Dakota

Certificate of Merit

Sally A. Coover, Ph.D., University of South Florida

Educational Research & Methods Division:

Best Paper Award

Ashley Ater Kranov, Ph.D., Center for Teaching,

Learning, and Technology

Laura Girardeau, Washington State University

FIE - Helen Plants Award

Maura Borrego, Ph.D., Virginia Tech

Lynita Newswander, Virginia Tech

Lisa McNair, Ph.D., Virginia Tech

Electrical and Computer Engineering Division:

ECE Distinguished Educator Award

Karan Watson, Ph.D., P.E., Texas A&M University

Engineering Design Graphics Division:

Distinguished Service Award

Sheryl Sorby, Ph.D., National Science Foundation

Engineering Libraries Division: Best Publication Award

Megan S. Nelson, Purdue University

Engineering Technology Division:**CIEC Best Session Award**

Anne Spence, Ph.D., University of Maryland

CIEC Best Speaker Award

Anne Spence, Ph.D., University of Maryland

Environmental Engineering Division:**Outstanding Presenter Award**

Gloria Dall'Alba, Ph.D., University of Queensland

International Division: Best Paper Award

Chelita Pate, Brigham Young University

Mechanics Division: Ferdinand P. Beer and E. Russell**Johnston, Jr. Outstanding New Mechanics****Educator Award**

Andrea Surovek, Ph.D., P.E., South Dakota School of Mines & Technology

James L. Meriam Service Award

Renata Engel, Ph.D., Pennsylvania State University

The National Academy of Engineering**Bernard M. Gordon Prize**

Jacquelyn F. Sullivan, Ph.D., University of Colorado at Boulder

New Female Members

Watson M. Austin, Ph.D., The Aerospace Corporation

Cynthia Dwork, Ph.D., Microsoft Corporation

Barbara J. Grosz, Ph.D., Harvard University

Rebecca R. Richards-Kortum, Ph.D., Rice University

Dame Ann P. Dowling, University of Cambridge, United Kingdom

L'Oreal-UNESCO 2008 For**Women in Science Award**

Elizabeth Blackburn, Ph.D., University of California, San Francisco

Society of Women Engineers (SWE) Awards**Achievement Award**

Melanie Cole, Ph.D., U.S. Army Research Laboratory

Upward Mobility Award

Florence Hudson, IBM Corporation

Entrepreneur Award

Carol Craig, Craig Technologies

Work/Life Balance Award

Kate Quinn, Ph.D., University of Washington

Emerging Leader Award

Kimberly Smieja, Intel Corporation

Ramune Nagisetty, Intel Corporation

Jada Phillabaum, Caterpillar, Inc.

Amy Herbert, P.E., Fluor Corporation

Lt. Cmdr. Camille Garrett Flaherty, United States Navy

Sandra K. Edmonds, Fab Sort Manufacturing

Fellows

Lisa Bird, United States Army

Christine Cathcart, P.E., Lee Products Inc.

Nora Hsu Davis, Central Intelligence Agency

Lucy Hsu, NVIDIA Corporation

Marcia Lampela, Borg Warner Inc.

Anne Lucietto, Caterpillar Inc.

Charlotte Wagner, P.E., Cogent Energy Inc.

Distinguished Service Award

Terri Morse, Boeing Company

Charlotte Wagner, P.E., Cogent Energy, Inc.

Distinguished New Engineer Award

Jennifer Braganza, University of North Carolina

Irene Hodor, ExxonMobil

Hayley McGuire, Boeing Company

Jennifer Chen Morikawa, General Motors

Erin Penne, General Dynamics Advanced

Information Systems

Outstanding SWE Faculty Advisor

Beth Todd, Ph.D., University of Alabama

Outstanding SWE Counselor

Heather Doty, Ball Aerospace and Technologies Corp.

Collegiate Member Award*Undergraduate:*

Christine Cabrera, Bradley University

Brittney Elko, Trinity University

Kate Van Dellen, California Polytechnic University

Graduate:

Jessica Kiefer, California Polytechnic University

Rashi Tiwari, University of Nevada-Reno

Women in Engineering ProActive Network**(WEPAN) Awards****Distinguished Service Award -****WEPAN Communications Advisory Committee:**

Sheila Edwards Lange, Ph.D., University of Washington

Carlie Bower, IBM

Janel Barfield, IBM

Cathy Pieronek, J.D., University of Notre Dame

Kristina Kennedy, The Ohio State University

Serita Acker, Clemson University

Founders Award

Bevlee Watford, Ph.D., Virginia Tech

University Change Agent Award

Nancy Steffen-Fluhr, Ph.D., New Jersey Institute of Technology

Women in Engineering Initiative Award

University of Houston "WELCOME" Program -

Julie Trenor, Ph.D. (director)

Women in Engineering Program Award

Women in Engineering Program at Rochester Institute

of Technology - Margaret Bailey, Ph.D., P.E.

(executive director)

Intel Science Talent Search Award

Shivani Sud, First Place, North Carolina

Anita Borg Institute for Women and**Technology (ABI) Grace Hopper Conference****Social Impact Award**

Elisa Camahort Page

Jory Des Jardins

Lisa Stone, BlogHer

Technical Leadership Award

Elaine Weyuker, Ph.D., AT&T

Denice Denton Emerging Leader Award

Naomi Chesler, Ph.D., University of Wisconsin-Madison

bachelor's level.

While much attention has focused on the barriers to STEM fields for women and minority students, it is equally as important to understand how these fields can be made attractive. Wessel et al. (2008) conducted an interest inventory among 198 undergraduate students at a U.S. institution. The respondents were overwhelmingly women (n=160) and white (n=146) with 28 black, 16 Asian, four multiracial, one American Indian/Alaskan Native, one Pacific Islander/Native Hawaiian, and two unknown. This pool of students represented 34 different majors within the university with the majority coming from psychology and medical disciplines. Wessel et al. found that if a student perceives that they are better at certain tasks, or feels their personality more closely aligns with an academic major, the perceived fit plays an important role in the commitment they make to their studies as well as their self-efficacy, regardless of the "actual" fit. Furthermore, if a student is more adaptable to other environments in which they may not initially perceive themselves to be an appropriate fit, they have a greater chance of feeling a sense of belonging due to their flexibility, and in turn, their GPA will be higher, as will their satisfaction with the institution.

Trenor et al. (2008) illustrate how barriers to STEM differ by race/ethnicity at the University of Houston. In their two-phase study, 350 students were invited, first, to respond to an online survey, and then to respond to interview questions that were prompted from survey answers (n=160 in phase 1, n=37 in phase 2). The very low response rate of 46 percent in phase 1 raises concerns about the reliability of the study's findings.

Trenor et al. found that members of all groups experienced similar issues related to finances, dealing with barriers, the idea of "belonging" within the engineering discipline, and that family influences were important in students' decisions to go into engineering. But

Significant Conferences

By Nicole M. Di Fabio

Lille, France

International Conference of Women Engineers and Scientists, 2008

The 14th International Conference of Women Engineers and Scientists (ICWES), organized by the International Network of Women Engineers and Scientists (INWES), took place July 15-18, 2008, in Lille, France. The theme of this year's conference was "A Changing World: New Opportunities for Women Engineers and Scientists." The conference drew more than 500 participants from 60 countries around the globe.

ICWES 14 concentrated on how to recruit and retain more females into scientific education and career slots through 140 session presentations and 50 poster presentations. Both CPST and SWE played an active role in these sessions.

Surprisingly, many of the issues facing women in science and engineering spanned the globe, demonstrating that women within different cultural contexts have similar barriers put before them. Jane Daniels, Ph.D., of the Henry Luce Foundation, and a CPST board member, presented her work on "Individual and Institutional Strategies for the Advancement of Women in Science and Engineering." Her talk focused on institutions tracking and changing policies to be more inclusive of women's needs and for women to speak up in order to be a part of the solution rather than perpetuating the problem.

ICWES 15 will be held in 2011 in Australia. More information on INWES and the ICWES conferences can be found at: <http://www.inwes.org>.

Taipei, Taiwan

International Conference on Women Scientists, 2008

The 2008 International Conference on Women Scientists, held Oct. 28-31, 2008, was hosted by Yang-Ming University in Taipei, Taiwan. The conference addressed the challenges, opportunities, and choices for women in Taiwan and was keynoteed by Evelyn Fox Keller, Ph.D., of the Massachusetts Institute of Technology, and Jacqueline Whang-Peng, M.D., of the Taipei Medical University-Wan Fang Hospital. Both of these scholars spoke about younger women being introduced to science and science careers and the accessibility of these options to females.

Lisa Frehill, Ph.D., executive director of CPST, also contributed to the talks presented at this conference with a focus on Advancing Women in Science and Engineering via Organizational Change. Dr. Frehill also served as a member of the consultative committee.

St. Louis, Mo., USA

Women in Engineering Proactive Network, 2008

The Women in Engineering Proactive Network, better known as WEPAN, held its 2008 conference from June 8-10. The conference began with a keynote address by Sonya V. Stewart, vice president for diversity and equal opportunity programs for Lockheed Martin Corporation. Her talk was titled "Diversity: A Journey of Cultural Transformation Practice."

Prefacing the first day of these sessions, WEPAN held afternoon workshops on Sunday, June 8. The spectrum of session topics included institutional and organizational change, innovative and effective recruitment and retention strategies, market research and branding, and gender equity.

The next annual conference will take place in Austin, Texas, June 17-19, 2009. To find more information, please visit: <http://www.wepan.org>.

Baltimore, Md., USA

WE08, Society of Women Engineers, 2008

The Society of Women Engineers national conference took place in Baltimore Nov. 5-8, 2008. The theme of the conference, Women Leading a Technical Revolution, formed the foundation for three days of networking, workshops, sessions, and other activities for the 6,000 attendees. Highlights included Capt. Paz B. Gomez, P.E., of the U.S. Navy, as the keynote breakfast speaker, and a plenary session featuring leading women executives discussing women engineers' role as change agents. Another plenary session provided advice on advancing one's career.

The next SWE conference will be held in Long Beach, Calif., Oct. 15-17, 2009.

the way these family influences operated was different depending upon one's ethnic group. Hispanic students found that encouragement at school was important in pursuing engineering because Hispanic parents generally do not emphasize a particular major when encouraging their children to earn a degree. Asian parents expected their children to go into engineering or a medical field, consistent with Hanson and Meng's study of Asian-Americans and the pursuit of science (2008). White and African-American students used parents as a positive role model, but not particularly in the field of engineering. African-Americans also said their parents inspired them to overcome obstacles, echoing findings from the focus groups Settles et al. (2008) had conducted with African-American women.

Several articles in the *Journal of Engineering Education* shift our attention away from individual attributes of women in educational settings — which are increasingly indiscernible from those of men — and toward issues within engineering itself. Some researchers have noted the greater prevalence of women in specific engineering disciplines (see sidebar on page 141) to suggest that engineering disciplines with lower proportions of women could learn how to appeal to women's interests from the examples of bioengineering and environmental engineering (Chubin, Donaldson, Olds, and Fleming 2008) and industrial engineering (Walden and Foor 2008).

The engineering work force

Oxford (2008) reports on an individual interview with Dervilla Mitchell, an engineer from the United Kingdom, who recounts her experience as one of a small number of women enrolled in a university engineering program. The interview covered the various challenges Mitchell has faced in her professional career. Using this personal narrative and a brief literature review, Oxford concludes that the only way women will reach true parity is for culture and

society to change, to recognize that women are equally competent as men.

Much research is devoted to determining the reasons women choose to go into science, technology, engineering, and mathematics (STEM), but understanding men's motivations is also important. Zeldin, Britner, and Pajares (2008) conducted semi-structured interviews with a very small and non-generalizable set of 10 adult white men with at least a bachelor's degree in a STEM field. Consistent with dominant ideas about U.S. masculinity, most of the men indicated they chose their fields based on personal attainments, successes, and independent mastery. They also reported finding support for their work in the field, and did not experience the same academic, professional, or social challenges that women faced — often noting that women faced these difficulties. Likewise, they did not experience the pressures associated with trying to balance work and family issues, which are commonly expressed by women.

In a study of Australian engineers, Gill, Mills, Franzway, and Sharp (2008) show that whereas women moved into the field as a result of a high degree of science and mathematics skill, men were less likely to mention these skills as a reason for entering the field. The authors had interviewed 41 women and only 10 men: This particular article focused exclusively on the results of the women's interviews.

Women also indicated that their technical mastery resulted in special attention from a mathematics or science teacher, who recognized their talents and encouraged them to enter engineering. Parents in STEM fields encouraged their daughters to pursue engineering, once their daughters demonstrated skill in math and science. Despite positive classroom experiences and encouragement from parents, these women's experiences and responses to marginal status in the workplace (i.e., women engineers) reveal interesting differences. Some

of these 41 women engineers felt they needed to be "one of the boys" to get recognition from male colleagues and be effective, basically claiming that they were not like "other" women.

On the other hand, others — most often the younger women — chose to fall into a more feminine role while at the workplace like "daughter," "wife," or "mother." Such traditional female roles provided these women with a way to differ from the men with whom they worked, while still "fitting" an acceptable female niche for their male co-workers.

Patents are a way to determine women's impact on and contributions to engineering. Although the following study looked at patents within a science field, the findings could be important for engineers to consider. Whittington and Smith-Doerr (2008) analyzed reliable, high-quality archival data on career-histories of cellular and molecular biologists obtained from the National Institutes of Health along with patent data from the U.S. Patent and Trademark Office. They found little disparity in patent activity between women and men inventors at the early career stages. However, over time women obtained far fewer patents than men. When they considered the structure of the employer, Whittington and Smith-Doerr further found that in flat, highly connected network-based firms, women were more likely to be a part of a patenting team, while in more traditional hierarchical firms, women were less likely to be involved in patents. There are additional effects on patenting due to parenthood: Mothers tended to have fewer patents than non-mothers.

Mentoring

Mentoring has come to occupy a center-stage position in discussions about career success and advancement. College programs, especially those focused on women, emphasize establishing formal mentoring relationships because women often lack access to the informal networks in which males traditionally

find mentors. Males, in general, do not necessarily seek out mentors, but as a result of their participation in many informal and formal workplace networks, men are quite likely to locate people to guide them to career success. Mentoring programs typically make this process (1) more transparent, (2) more universal (i.e., mentors are made available to men and women), and (3) more deliberate via mentor trainings and other programmatic elements.

Eby, Allen, et al. (2008) use a modified meta-analytic approach to review findings from 166 articles and reports written on mentoring. These articles focused on youth mentoring (n= 40, 34 percent), academic mentoring (n= 53, 46 percent), and workplace mentoring (n= 23, 20 percent). The possible mentoring outcomes were coded into six categories: behavioral; attitudinal; health-related; relational; motivational; and career. They found that mentoring was correlated with many different protégé outcomes but that these were mostly mediated outcomes, meaning that they were contingent on more than one factor. In particular, protégé's attitudes played a big role in mediating outcomes, especially for youth.

Many studies document the strong, positive impact of academic mentoring, to some extent because mentoring is an intrinsic aspect of higher education. Since mentoring plays a key role in higher education, these mentors may have more resources and may be more prepared through training to deliver high-quality mentoring. Academic settings often feature clearer goals — such as degree attainment for students and tenure for faculty — accompanied by specific steps associated with attaining those goals, making them particularly amenable to a mentor's guidance.

The April 2008 issue of the *Journal of Vocational Behavior* focused on mentoring with a number of themes represented by the articles, including:

▲ “Naturally occurring” mentoring relationships

▲ Gender within formal mentoring
▲ Gender in face-to-face mentoring vs. electronic mentoring (e-mentoring)

▲ Influences of college mentoring on career development

▲ Perceived costs and benefits of mentoring

▲ Rating mentors' effectiveness

Some of the important findings from these articles:

▲ Girls' relationships tend to last for an extended period of time and are often longer than mentoring relationships for boys.

▲ E-mentoring benefited females more than males.

▲ Mentoring relationships can benefit mentors as much as they benefit protégés.

▲ There can be negative mentoring outcomes, such as when peer men-

toring creates a sense of competition rather than an overall feeling of support.

Because of the many positive outcomes from mentoring, it is a suggested tool in youth, academic, and workplace settings. Mentoring has been helpful in reducing turnover and fostering a sense of support in each of these three environments. If a mentoring network does not currently exist in your workplace, www.womenspeak.com suggests finding a mentoring program locally or taking the steps to create one. Other mentoring resources are available at: www.mentornet.org and www.ncwit.org (which offers a “kit” called “Mentor in a Box”). Informal mentoring is a core principle of the Society of Women

SWE in D.C.

By Katelyn Keegan

Last year, SWE increased its presence in Washington, D.C., and advocated for engineers around the country. Through sponsorship of Engineers Week, SWE continues to support the development of girls and young adults to explore the field of engineering through hands-on experiences and opportunities.

Most notably, SWE engaged members of Congress in discussions to increase their awareness about issues facing engineers today and the challenge of recruiting and retaining women in engineering. To this end, SWE worked with the House Diversity and Innovation Caucus, on which the Society currently leads the advisory committee. Through its work with the committee, SWE has served as a resource to congressional members and their staffs on all issues related to science, technology, engineering, and mathematics (STEM).

Seeing a need to build upon this new relationship with congressional staff, SWE held several briefings to provide information about the pipeline and encourage policymakers to consider broader implications and applications of Title IX. SWE also brought to Washington 200 scientists, engineers, researchers, and educators to speak with members of Congress and their staffs.

One of the important issues this past year was House Bill 3514, the Gender Bias Elimination Act of 2007, introduced by Rep. Eddie Bernice Johnson (D-Texas), to eliminate gender bias for women in STEM careers. For her work on this legislation and similar bills, Johnson received the SWE President's Award.

For those who couldn't attend the 3rd Annual Congressional Visit Day, SWE created an extensive online resource for members, Public Policy 101, to learn how they can advocate for issues of interest to them. In conjunction with this project, SWE set up an alert system to inform its members about important STEM and diversity bills and matters currently of interest to members of Congress.

• A sponsor of Engineers Week 2008 and charter member of the Engineers Week Diversity Council

• Connecting Educators to Engineering: SWE's Legacy Project
• Congressional briefings and roundtables, such as “The Leaky Science and Engineering Pipeline: How Can We Retain More Women in Academia and Industry?” and “STEM Education, Girls, and the Challenges That Follow: From the Classroom to STEM Careers”

• Leading the advisory committee of the U.S. House Diversity and Innovation Caucus

• Offered congressional testimony and produced position papers

• 3rd Annual Congressional Visit Day

Engineers, and takes place at all levels, from local gatherings to the national conference.

Getting ahead in the work force: news you can use from psychology experiments

Much of the research conducted by psychologists involves undergraduates who are required to participate in a certain number of experiments as part of their introductory psychology classes. These experiments are set up in tightly controlled environments in which the effects of carefully crafted stimuli are investigated. While these studies may have questionable reliability from a population standpoint, their careful controls provide important insights, often with strong validity. A number of interesting studies focused on power in the workplace, sexual harassment, and leadership.

The art of persuasion is an important skill in the business world. Cesario, Higgins, et al. (2008) show that persuasion includes more than convincing and influential words, but also reading and providing appropriate nonverbal cues. Their experiment involved showing videos to 90 students, which focused on two types of decision-makers as respondents to persuasion. Promotion-focused people prefer eager, advancement strategies, while prevention-focused people prefer vigilant, cautious strategies. The videos included identical verbal content with only the nonverbal cues (hand gestures) manipulated. The actor in the video used either eager and excited nonverbal cues, or vigilant and reserved ones. Participants who were promotion-focused rated the message in the video as more effective when an eager nonverbal delivery was used. For those who were prevention-focused, however, vigilant nonverbal cues were more effective.

Persuasion is a part of any negotiation. Galinsky, Maddux, Gilin, and White (2008) sought to determine the more effective viewpoint during negotiation: perspective taking (considering the world from another person's viewpoint) or em-

Women Engineering Deans

by Carolyn Brandi

Deirdre Meldrum, Ph.D.....	Arizona State University
Cheryl B. Schrader, Ph.D.	Boise State University
Esin Gulari, Ph.D.....	Clemson University
Gail Simmons, Ph.D.	College of Staten Island
Sandra Woods, Ph.D.	Colorado State University
Eleanor Baum, Ph.D.....	Cooper Union
Beverly K. Hartline, Ph.D.	Delaware State University
Susan M. Blanchard, Ph.D.	Florida Gulf Coast University
Stacy G. Birmingham, Ph.D.....	Grove City College
Elizabeth A. Eschenbach, Ph.D.....	Humboldt State University
Sharon A. Jones, Ph.D., P.E.	Lafayette College
Sarah A. Rajala, Ph.D.....	Mississippi State University
Lynne M. Lawson, Ph.D.....	Providence College
Leah H. Jamieson, Ph.D.....	Purdue University, West Lafayette
Sallie Keller-McNulty, Ph.D.....	Rice University
Dianne Dorland, Ph.D., P.E.	Rowan University
Belle Wei, Ph.D.....	San Jose State University
Elaine P. Scott, Ph.D.....	Seattle Pacific University
Linda E. Jones, Ph.D.	Smith College
Karen L. Whitehead, Ph.D.	South Dakota School of Mines & Technology
Pamela A. Eibeck, Ph.D., P.E.	Texas Tech University
Linda Abriola, Ph.D.	Tufts University
Cherrice Traver, Ph.D.	Union College
Linda C. Lucas, Ph.D.....	University of Alabama, Birmingham
Mary L. Good, Ph.D.....	University of Arkansas, Little Rock
Aicha A. Elshabini, Ph.D., P.E.	University of Idaho, Moscow
Kathleen A. Kramer, Ph.D.	University of San Diego
Jane S. Halonen, Ph.D.	University of West Florida
Pamela Leigh-Mack, Ph.D.....	Virginia State University
Candis S. Claiborn, Ph.D.....	Washington State University
Stacy S. Wilson, Ph.D., P.E.....	Western Kentucky University
Zulma Toro-Ramos, Ph.D.	Wichita State University
T. Kyle Vanderlick, Ph.D.....	Yale University

Source: American Society for Engineering Education, 2009, personal communication, Michael Gibbons. Note: All of the above occupied deans' positions at some time in 2008 and therefore are recorded by ASEE as being deans.

pathy (connecting emotionally with another individual). Approximately 365 full-time M.B.A. students who were enrolled in a negotiation course participated in experimental negotiations, taking on either the role of an empathetic negotiator or a perspective-taking negotiator. Perspective taking consistently resulted in greater negotiation success than empathy. Being aware of an opponent's in-

terests is more useful than having an emotional connection with the opponent when negotiating and making decisions (Galinsky, Maddux, et al. 2008).

More than 40 years following the Civil Rights Act of 1964, sexual harassment continues to remain a threat in schools and the workplace. According to the Equal Employment Opportunity Commission (2007), the number of

sexual harassment charges filed has decreased from 15,800 in 2000 to 12,000 in 2006. Psychology experiments in the area of sexual harassment at Midwestern institutions provide us with interesting findings:

▲ Younger people endorse more hostile sex attitudes toward women than do older people, and college-age participants were less sensitive to harassment (Ohse and Stockdale 2008).

▲ As the participants' acceptance of sexual harassment myths increased, the more they displayed traditional, sexist, and hostile attitudes toward women (Lonsway, Cortina, and Magley 2008).

▲ In a scenario-based study, housewives who were victims of sexual harassment were perceived as less negative, less competent, warmer, and less blameworthy than a nontraditional career woman. Furthermore, victims who responded to abuse with mild aggression were perceived to be significantly more blameworthy than those who remained passive (Capezza and Arriaga 2008).

Advancement in any workplace necessitates leadership development. Leaders are made, not born; therefore, it is important to provide equitable access to programming that improves leadership skills. However, the gendered dimension of this issue relates to how leadership is defined. For example, women may be less interested in becoming a manager, which often requires moving further from the technical work that initially drew them into engineering. Instead, women may be more interested in moving up the technical ladder.

Although the number of women in the work force rose by approximately 19 million from the early 1980s to 2000, women continue to make up just a small fraction of the executives and higher-order positions of leadership. The 2006 Fortune 500 firms had just 16.4 percent women among their corporate officers. (Carbonell and Castro 2008).

Walumbwa, Avolio, and Zhu (2008) surveyed employees at six bank branches in two bordering

Midwest states about their perceptions of management's leadership. Implementing a set of items used in similar studies, they found that transformational leadership positively relates to individuals' identities and performance within a work unit. There was also a strong correlation between performance and self-efficacy. The findings support the notion that having transformational leaders assists individuals who are interested in developing themselves.

Some more interesting findings from experimental research in psychology (small, local convenience samples):

▲ In a study at the University of Mannheim in Germany, female management students were more likely to feel that they were not suited to leadership when shown an advertisement that featured only a male. Both female and male management students were more likely to say that they were suitable for leadership positions when an advertisement featured a photo of both a man and a woman (Bosak and Sczesny 2008).

▲ 24 Midwestern undergraduate students expressed negative views of female-sex-typed leadership traits that included concern for others' feelings, getting input from others before making decisions, and valuing the friendship and trust of others (Johanson 2008).

▲ 50 English university students indicated that they preferred a female leader in a situation that featured within-group competition and a male leader when there was competition between groups (Van Vugt and Spisak 2008).

▲ When shown videotapes of interview situations in which candidates described feelings of anger or sadness, adult participants assessed the degree of status, power, and independence each candidate deserved in his or her future job. Professional women who expressed anger were consistently accorded lower status and wages, and were seen as less competent than angry men and unemotional women. However, when interviewees explained external reasons

for their anger, participants reported less negative responses. Fortunately for women, this demonstrates that a woman *can* express anger in the workplace without a drop in status *if* a situational explanation is offered (Brescoll and Uhlmann 2008).

International issues in engineering

The increasingly global market for talent and jobs has become an important issue for U.S. engineers. At many U.S. companies, engineers have worked in cross-nationally organized teams for years. Further, leaders around the world have come to realize that science and engineering are the foundations on which a country progresses, and that women are an important resource in this effort. Even in the Middle East, where women are sometimes strictly segregated from men, and have reduced public roles, leaders are working to increase the participation of women in science and engineering.

Qatar is an interesting example, according to Karlin (2008). Qatar, like many Middle Eastern countries with rich oil resources, depends to some degree on foreign engineers in the oil industry. To reduce dependency on foreign engineers, Qatar has focused on educating its own citizens to provide the needed workers in R&D. Part of this focus is directed specifically toward women. In 2001, Qatar University opened the doors of its engineering school to women, allowing them to enter specific disciplines as follows: 2001 computer and industrial engineering; 2004 chemical engineering; and 2008 electrical engineering. For the electrical engineering program, the goal is to have 30 women and 50 men. Qatar also sees this as part of an effort to stem "brain drain." Because engineers are in demand throughout the world, many men from Qatar who go to school in Europe do not come home. Women, however, tend to stay in Qatar for their education and employment.

Like Qatar, Nigeria also has substantial oil reserves and other natu-

ral resources that can be instrumental in its continued development. Aguele, Idialu, and Aluede (2008) review policies and educational initiatives to increase education in science, technology, and mathematics in Nigerian colleges and universities. Culturally, science is seen as men's province; therefore, women's enrollments have been low in science. In order to help women enter the mainstream of science and engineering education, the authors recommend providing women with financial aid for education and developing stronger employment opportunities for women with training in science and engineering.

A study of university students in Kenya explored the "digital divide" and impressions of information technology (IT) work among young students. Kvasny et al. (2008) interviewed 63 students (32 women and 31 men) in a class on social impacts of IT (i.e., a convenience sample). The students were between the ages of 20 and 22 and most were involved in an internship at a company. Students' responses echoed those of students in the United States: They would use IT skills in business and in technical jobs, ideally becoming an expert in the field. Women often indicated that they might face discrimination and that they were like pioneers in the field.

A study from Taiwan (Hong, Lin, and Veach 2008) reports results of a pre-test and post-test on the effects of a science intervention program among eighth grade "at risk" students. As divorce rates reach 30 percent, more Taiwanese children are growing up in single-parent households. The after-school intervention program conducted in 2004-2005 with 28 students (16 boys and 12 girls) sought to: (1) improve the interest in and performance in science among the girls; and (2) improve the students' self-esteem and social skills, while reducing sexist attitudes. The authors found that the program improved social skills of both girls and boys; that girls' interest and performance in science increased;

and for boys, feelings of self-worth increased while sexist attitudes by boys were decreased. This final finding is important because in many cases, programs are offered only to girls with the idea that girls need improvement. By including boys, however, the program described in this article was instrumental in impacting the peers with whom girls will have to deal at a later date should they enter science.

The persistence of differential treatment

Despite workplace advances, women continue to report discrimination based on gender. Citing national survey data, Settles et al. (2008) reported that nearly 48 percent of women believe that they have been discriminated against because of their sex, and 50 percent experienced sexual harassment. In the past year, a daylong conference was held at the American Enterprise Institute, organized by

antifeminist Christina Hoff Sommers, Ph.D., who also wrote an article that appeared in both *The American* and *USA Today*. The article and conference revisited the "women are deficient"-style explanations for their low levels of participation in academic science and engineering. And "consulting futurist" Coates proclaimed in an article this past year that:

Female engineers will not only be more numerous, but will more likely be members of two-income households. That is likely to push women into the aspect of engineering that will allow them ready access to home and housekeeping functions. (Coates 2008: 7).

While it may be comforting to think that sexism is a thing of the past, as these recent events indicate, women still face a different set of challenges in the workplace than do men. As discussed in this year's literature review, policymak-

Today's Youth: Confident or Egotistical??

By Carolyn Brandi

Today's youth, those born in the 1980s and 1990s, have been characterized as "more egotistical, entitled, and overconfident" compared with previous generations (Trzesniewski, Donnellan, et al. 2008). Growing up in a world where cell phones and the Internet put the world at their fingertips, the millennials, or Generation Y, are often thought to be self-indulgent, impatient, and presumptuous. Recent results from current research, however, dispute these stereotypes.

Twenge and Campbell (2008) performed a cross-temporal meta-analysis of the self-views of high school students between 1975 and 2006. Approximately 15,000 students across the United States were sampled each year, with a school participation rate of 66 to 80 percent. Compared with 37 percent of high school students in 1975, 56 percent of those in 2006 predicted they would be "very good" spouses one day. Significantly more high school students in 2006 were confident they would make "very good" parents (54 percent) and workers (65 percent), compared with students in 1975 (36 percent and 49 percent, respectively). Recent high school students also reported being more self-satisfied and earning higher grades than students in 1975 and 1976 (Twenge and Campbell 2008).

Another study by Trzesniewski, Donnellan, and Robins (2008) examined trends in self-enhancement and narcissism of college students from the late 1970s to 2007. More than 25,500 students from the University of California, Davis and Berkeley campuses, in 1996 and annually from 2002 to 2007, completed the Narcissistic Personality Inventory (NPI). The mean scores on the NPI from the 1990s and 2000s were compared with the means of the 1,018 participants who completed the NPI between 1979 and 1985 (Trzesniewski, Donnellan, et al. 2008). Self-enhancement was measured by comparing students' ratings of their intelligence to their SAT scores and college GPAs. Because college students' scores on the NPI did not increase from the 1980s to 2007, nor did their levels of self-enhancement, Trzesniewski, Donnellan, and Robins (2008) concluded that "today's youth seem to be no more narcissistic and self-aggrandizing than previous generations."

ers the world over are interested in increasing participation in engineering and recognize the need to focus attention on women's participation in the field. Global competition to increase productivity, advance technology, and solve the pressing problems associated with our shrinking world implies a need to tap the full talent pool.

Increasingly, researchers are shifting attention toward more structurally focused explanations for why there are fewer women in engineering and away from individuals' attributes. This means that rather than emphasizing that women lack the mathematics and science preparation — which, by the way, they do not — more research now focuses on what happens within the engineering school environment, how girls versus boys are recruited into the field, and eventually how employers can provide meaningful accommodations for people's complex lives.

Women account for just 10.8 percent of the U.S. engineering labor force. While women may be more highly represented in some disciplines like industrial and chemical engineering, they are woefully underrepresented in some of the largest subfields, namely mechanical and electrical engineering. Women have been quite successful in moving into a number of professional and scientific fields, many of which are just as technically demanding as engineering and which involve workplaces that are equally intense as engineering. Because of women's success in other professions, their persistent underrepresentation in engineering is often not well-known. As shown in the sidebar "SWE in D.C.," on page 152, SWE has taken a leadership role in educating policymakers about the issues surrounding women's participation in engineering. SWE has also worked hard to bring more experts to these policymakers to educate them about the research on women in engineering. Such educational efforts are crucial in calling attention to the important role women engineers play, and the need to better tap the female talent

pool to maintain the U.S. engineering edge in the competitive global economy.

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Women in Engineering:

A Review of the 2009 Literature

BY LISA M. FREHILL, PH.D., CAROLYN BRANDI, M. AMANDA LAIN, AND ANDREW FRAMPTON

As the engineering discipline expands and new technologies emerge, the need for a more diverse engineering work force is increasingly critical. Although women constitute 56 percent of all college undergraduates, they earn only 20 percent of undergraduate engineering degrees. (Commission on Professionals in Science and Technology [CPST] 2008 and Tsui 2009). Engineering also falls short on recruitment of underrepresented minorities with about 12 percent of bachelor's degrees in engineering awarded to African-Americans, Native Americans, and Hispanics in the 2007-2008 academic year. This is far below parity because members of these three groups account for 34 percent of all 18-24 year olds (CPST 2008). To remain a world leader in innovation, it is evident that the United States needs to tap into its rich female and underrepresented minority talent pools.

The literature exploring such topics was especially rich this year, with many articles and books that will be of interest to engineers, advocates of women in engineering, and researchers. As in past reviews, we highlight items grounded in strong methods. In traditional social science literature reviews, some of the descriptive terms that we use in this article (e.g., "careful," "useful," and "interesting") would be considered inappropriate. However, we use them here to provide SWE readers our expert assessment.

Furthermore, we point to some routine practices found in many

research articles, noting that while they are commonplace, they do not necessarily provide a strong foundation for research. For example, the use of convenience samples of self-selected respondents and low response rates (i.e., less than 65 percent) are two flaws that are endemic to some of the literature. Does this mean articles that feature one or both of these flaws should be disregarded? No, but it does mean that the research reported in those articles has some weaknesses and potential biases, and that the results should be viewed with some caution. Over time, as more researchers continue to work on similar research questions, a body of knowledge may develop within which the accumulated weak findings provide a stronger unified basis. It is also important that the researchers, themselves, acknowledge these weaknesses and not engage in over generalizing their results.

K-12 engineering education

Until recently, engineering education has rarely been discussed in the K-12 context. But declining interest in engineering and, especially, the persistent lackluster appeal of the field to young women (who now account for more than half of all students enrolled in colleges) suggests that it may be time for some new approaches. The Fall 2009 issue of the National Academy of Engineering publication, *The Bridge* (<http://www.nae.edu/TheBridge>), reports on a number of efforts underway to reach down the pipeline into K-12 to attract students to engineering.

After an initial framing by C.M. Vest, president of the National Academy of Engineering, the six articles in *The Bridge* issue cover a number of bases. The articles emphasize the need to overcome existing impressions that many K-12 teachers have of engineering — e.g., that only the super-smart kids can pursue the field (Cunningham 2009) — and learn effective strategies to teach age-appropriate material in their classes. The writers come at the issue from various points of view, providing a collection of interesting readings that address many facets of bringing engineering education into K-12 settings.

State educational standards are an initial hurdle that must be overcome to bring engineering into the K-12 environment. Engineering has not routinely been available in K-12, therefore, there are often no existing standards or a definition of how the discipline might "fit" into the existing curricular guidelines. Foster (2009) provides background on how the Commonwealth of Massachusetts developed and implemented standards and policies on STEM education after a 1993 Massachusetts Education Reform Law, so that now Massachusetts is a leader in implementing technology/engineering standards and curriculum for its K-12 students.

Cunningham's Engineering is Elemental (EiE, www.mos.org/eie) program at the Museum of Science in Boston illustrates how a private-sector organization was able to respond to the Commonwealth's challenges by developing high-quality, effective curriculum mate-

rials and professional development for K-12 teachers. Since 2003, the EiE program has learned many important lessons about developing these materials. For students, Cunningham reports that they found:

- Classroom testing of curriculum materials is critical.
- Children, even very young ones, are capable of complex engineering thinking, contrary to popular opinion of engineering as “difficult.” Indeed, engineering can be accessible to *all* students, even those whom many educators see as “struggling” or “disengaged.”
- Children react well to contextualized design.
- National evaluation results (not presented in the article) of the EiE curriculum indicate that the EiE activities do, indeed, improve students’ perceptions and understanding of engineering.

In their work with teachers, Cunningham’s team found that it was critical to overcome the teachers’ flawed impressions of engineering as a field appropriate only for their best and brightest or their own “fears” of engineering. By providing active and engaging workshops, the EiE team was able to model effective pedagogical approaches for teachers, who came to the subject *tabula rasa*: i.e., they lacked an existing paradigm for teaching engineering material. Finally, providing follow-up workshops for the teachers to revisit key concepts after having a chance to apply them in their own classroom was important.

To a large extent, the articles by Custer and Daugherty; Schunn; and Katehi, Pearson, and Feder merely amplify these points with reference to different settings in which curriculum design and teachers’ professional development has occurred. The piece by Jenniches and Didion expands upon these concepts in an important way to explain how such materials need to be developed to engage girls in engineering. Women are still underrepresented in engineering at all degree levels and in the engineering labor force

(CPST 2008). The key to maintaining the U.S. edge in the global innovation challenges that lie ahead will be engaging our full talent pool in the search for new ideas. Their piece describes the development of the Web site *EngineerGirl!* as a way to encourage young women to consider and then pursue engineering.

More common have been various outreach strategies implemented by colleges of engineering. One problem with such efforts is that engineers often lack good information about how best to relate to students of various ages and to do so in a truly gender-equitable way that goes beyond simplistic sex-based stereotypes. At the 2009 Society of Women Engineers conference in Long Beach, Calif., Catherine Didion (NAE) and Natalie Hebshie (of WGBH public television station in Boston) ran a workshop on how to talk to high school students about engineering. Grounded in marketing research, they reported that engineers often convey exactly the *wrong* messages, especially to girls, and that outreach visits may do more harm than good. Engineers who visit high schools on career days often convey the message that “engineering is hard, but it is worth it” or indicate that it is a great field if a student “loves” mathematics or science. Engineers also often fail to provide a good description of the actual work they do or the excitement associated with solving problems or working in teams. Within the world of teenage girls, the concept of “love” has a very emotionally laden meaning, making this message problematic. Emphasizing the difficulty of engineering rather than the actual work that engineers do is additionally problematic. By comparison, medical doctors go through difficult training, too, but when doctors speak to student groups, they emphasize the actual work and its importance rather than its difficulty. Similarly, it is important for engineers to convey that mathematics and science are *tools* used to solve

important problems.

The workshop provided materials designed to provide effective, market-tested outreach to secondary school students about engineering. These materials do not exclude boys — girls and boys are shown — but they do tap into messages about engineering that have been found to be effective in reaching young women. For example, engineers are shown doing work in various contexts. Rather than the Dilbert® cubicle-dweller, engineers are shown brainstorming with colleagues, developing products, and working outdoors. Also highlighted are projects that relate to “green” issues, as the current younger generation has shown a strong propensity toward engaging in work related to the environment. All materials are online at <http://www.engineergirl.org/> or can be obtained from the National Academy of Engineering, <http://www.nae.edu/>.

Cantrell and Taylor (2009) provide a descriptive report on an evening seminar series program for junior and senior high school students at the University of Reno, Nevada. These lessons echo those described by the *EngineerGirl!* materials (see sidebar on page 173). About 81 percent of the students had attended at least three of the eight seminars in the series and provided the basis for their data analysis to evaluate the program. The program’s eight seminars included speakers who discussed the merits of their field during a one-hour talk or, better, a hands-on activity. This was followed by a social hour in which students were able to connect more freely with the instructor, ask questions, etc., which proved to be quite important in engaging the students. Not surprisingly, students’ career interests changed almost weekly, often matching the career of the speaker. Even though their interests were unstable, it was important that students learned about science and engineering careers about which they had little prior

knowledge. Students are more likely to select fields about which they have some knowledge rather than ones about which they know nothing.

The importance of gender-neutral materials was a critical finding by Turja, Endepohls-Ulpe, and Chatoney (2009). Using experts on technology education from six nations — Austria, Estonia, Finland, France, Germany, and Scotland — Turja et al. reviewed the current status of curricula designed to teach very young children (mostly between the ages of 3-7) about technology. While they were interested in understanding how each nation assembles and implements curricula, the authors focused on the extent to which these curricula addressed gender. They found, in general, that early childhood educators needed more support to be conscious of including technology with additional support related to gender. Turja and her colleagues found that few of the curricula addressed the issue beyond general statements about equality or nondiscrimination and the like. Therefore, the authors provide some guidelines in this article about how early childhood technology education may be made more gender neutral, which could be instructive for postsecondary engineering educators as well.

Why does this matter? As early as 2 years old, young children are already embedded in their culture's gender schema, which is the way a society associates people, objects, ideas, feelings, emotions, etc. with gender. Su, Rounds, and Armstrong's (2009) meta analysis of sex differences in interests underscores this point, showing that vocational interests remain rather stable from ages 12-40, with interests that have vocational implications coalescing even earlier in children's lives. Many people assume that the propensity of boys to play with trucks and girls to play with dolls has to do with the mysterious operation of biology. In fact, children's behaviors have much more to do with the central lessons about gender, which they

Women Engineering Deans

by Carolyn K. Brandi

Doreen Edwards, Ph.D.	Alfred University
Deirdre Meldrum, Ph.D.	Arizona State University
Cheryl B. Schrader, Ph.D.	Boise State University
Esin Gulari, Ph.D.	Clemson University
Gail Simmons, Ph.D.	College of Staten Island, City University of N.Y.
Sandra Woods, Ph.D.	Colorado State University
Eleanor Baum, Ph.D.	Cooper Union
Melanie Hatch, Ph.D.	Gannon University
Stacy G. Birmingham, Ph.D.	Grove City College
Cherry Murray, Ph.D.	Harvard University
Elizabeth A. Eschenbach, Ph.D.	Humboldt State University
Natacha Depaola, Ph.D.	Illinois Institute of Technology
Sharon A. Jones, Ph.D., P.E.	Lafayette College
Sarah A Rajala, Ph.D.	Mississippi State University
Nada Marie Assaf-Anid, Ph.D.	New York Institute of Technology
Sandra J. DeLoatch, Ph.D.	Norfolk State University
Leah H. Jamieson, Ph.D.	Purdue University, West Lafayette
Sallie Ann Keller, Ph.D.	Rice University
Maria V. Kalevitch, Ph.D.	Robert Morris University
Dianne Dorland, Ph.D., P.E.	Rowan University
Deborah Huntley, Ph.D.	Saginaw Valley State University
Belle Wei, Ph.D.	San Jose State University
Elaine P. Scott, Ph.D.	Seattle Pacific University
Linda E. Jones, Ph.D.	Smith College
Lynne A. Molter	Swarthmore College
Laura J. Steinberg, Ph.D.	Syracuse University
Linda Abriola, Ph.D.	Tufts University
Cherrice Traver, Ph.D.	Union College
Linda C. Lucas, Ph.D.	University of Alabama at Birmingham
Mary L. Good, Ph.D.	University of Arkansas at Little Rock
Cammy R. Abernathy, Ph.D.	University of Florida
Kathleen A. Kramer, Ph.D.	University of San Diego
Jane S. Halonen, Ph.D.	University of West Florida
Pamela Leigh-Mack, Ph.D.	Virginia State University
Candis S. Claiborn, Ph.D.	Washington State University
Stacy S. Wilson, Ph.D., P.E.	Western Kentucky University
Zulma Toro-Ramos, Ph.D.	Wichita State University
T. Kyle Vanderlick, Ph.D.	Yale University

Source: CPST; data derived from American Society for Engineering Education

The number of female deans in engineering programs continues to increase. In 2007 and 2008, 33 deans in engineering programs at U.S. colleges and universities were female. In 2009, the number of female engineering deans increased to 38, and 11 schools hired female deans in their engineering programs: Alfred University, Gannon University, Harvard University, Illinois Institute of Technology, New York Institute of Technology, Norfolk State University, Robert Morris University, Saginaw Valley State University, Swarthmore College, Syracuse University, and the University of Florida.

start learning from the moment of birth, when hospitals color-code babies. Adults around children reinforce behaviors that conform to gender norms and punish — often boys more so than girls — behaviors that are counter to the child's expected gender. According to Turja et al., then, preschools can play an important role in countering the forces that tend to subtly disadvantage girls and advantage boys in technology. Girls' lower self-confidence in performing male-stereotyped tasks needs to be taken into account in developing these strategies. That is, girls "tend to attribute failure to their own lack of abilities and success to circumstances like luck" versus "boys attribute failure to external circumstances and success to their own abilities." (Turja et al. 2009: 363). In another piece, Dakers, Dow, and McNamee (2009) examine the need to deconstruct the masculinity of technology at the secondary level, echoing the themes from Turja et al.

Mathematics preparation

Mathematics readiness related to K-12 education is a common concern in engineering circles. Historically, women were less likely than men to be prepared to plunge head-first into the mathematics and science foundational classes typical of the first two years of engineering school, but that has changed. The largest gaps in readiness are found between whites and Asians versus blacks and Hispanics. According to a carefully constructed model and decomposition analysis by Long, Iatarola, and Conger (2009), even when black and Hispanic students have taken higher-level math courses, their "returns" to these courses — meaning, in this case, the likelihood that they will require remedial mathematics in college — are not as good as those for white students. This important study uses the Florida K-20 Education Data Warehouse, a rich source of comprehensive longitudinal data about Florida's public high school and college students.

2009 Outstanding Women in Engineering

By M. Amanda Lain

American Society for Engineering Education (ASEE) Awards

DuPont Minorities in Engineering Award
Brenda Hart, University of Louisville

Clement J. Freund Award
Brenda J. LeMaster, Ph.D., University of Cincinnati

Sharon Keillor Award for Women in Engineering Education
Alice C. Parker, Ph.D., University of Southern California

William Elgin Wickenden Award
Sheri D. Sheppard, Ph.D., Stanford University
Debbi Chachra, Ph.D., Franklin W. Olin College of Engineering

Best Paper - Pic I
Dianne Pawluk, Ph.D., Virginia Commonwealth University
Marcia Hoffman, Virginia Commonwealth University
Maria McClintock, Virginia Commonwealth University

Best Paper - Pic II/Best Overall Paper
Angela Bielefeldt, Ph.D., P.E., University of Colorado at Boulder

Best Paper - Pic III
Erin Cech, University of California, San Diego

Best Paper - Pic IV
Donna Llewellyn, Ph.D., Georgia Institute of Technology
Marion Usselman, Ph.D., Georgia Institute of Technology

Fellow Member Honorees
Marilyn Barger, Ph.D., P.E., Hillsborough Community College
Sheryl Sorby, Ph.D., Michigan Technology University; NSF

Section Awards

Gulf Southwest Section:
Best Paper Award (2nd Place)
Sharon Karackattu, Ph.D., University of North Texas

Outstanding Young Faculty Award
Mariah Hahn, Ph.D., Texas A&M University

North Midwest Section:
Outstanding Educator Award
Gul Afshan, Ph.D., Milwaukee School of Engineering

Southeast Section:
Thomas C. Evans Instructional Paper Award
Rebecca K. Toghiani, Ph.D., Mississippi State University
Adrienne R. Minerick, Ph.D., Mississippi State University
Keisha Walters, Ph.D., Mississippi State University

Professional and Technical Division Awards

Biomedical Engineering Division:
Best Paper Award
Mary Besterfield-Sacre, Ph.D., University of Pittsburgh
Angela Shartrand, Ph.D., National Collegiate Inventors and Innovators Alliance

Chemical Engineering Division:
Ray W. Fahien Award
Margot Vigeant, Ph.D., Bucknell University
Best Poster Award
Zenaida Gephardt, Ph.D., Rowan University

Continuing Professional Development Division: Joseph M. Biedenbach Distinguished Service Award
Linda Krute, Ph.D., North Carolina State University

CIEC- Best Session Award
Sally Coovert, Ph.D., University of South Florida

CIEC- Best Speaker Award
Marie-Pierre Huguet, Ph.D., Rensselaer Polytechnic Institute

CIEC- Best Workshop Award
Julayne Moser, Purdue University
Marie-Pierre Huguet, Ph.D., Rensselaer Polytechnic Institute

Certificate of Appreciation
Lynda Coulson, Rolls-Royce Corporation
Kim Scalzo, Rensselaer Polytechnic Institute
Linda Krute, Ph.D., North Carolina State Univ.

Design in Engineering Division:
Best Paper Award
Renee Rogge, Ph.D., Rose-Hulman Institute of Technology
Kay C. Dee, Ph.D., Rose-Hulman Institute of Technology

Educational Research & Methods Division:
Best Paper Award
Marissa Orr, Ph.D., Clemson University
Zahra Hazari, Ph.D., Clemson University

FIE - Helen Plants Award
Lisa Benson, Ph.D., Clemson University
Marisa Orr, Ph.D., Clemson University

FIE - Benjamin J. Dashner Best Paper Award
Marilyn Carlson, Ph.D., Arizona State University

Electrical and Computer Engineering Division: ECE Distinguished Educator Award
Sally Wood, Ph.D., National Science Foundation

Energy Conversion and Conservation Division: Best Paper Award
Elaine Scott, Ph.D., Seattle Pacific University

Engineering Management Division:
Best Paper Award
Natalie Charbaka, Ph.D., North Carolina State University

Environmental Engineering Division:
Best Paper Award
Angela Bielefeldt, Ph.D., P.E., University of Colorado at Boulder

First Year Programs Division:**Best Paper Award**

Rhonda Kowalchuk, Ph.D., Southern Illinois University Carbondale
Loen Graceson, Southern Illinois University Carbondale
Jale Tezcan, Ph.D., Southern Illinois University Carbondale
Kathy Pericak-Spector, Ph.D., Southern Illinois University Carbondale

Graduate Studies Division:**Best Paper Award**

Erin Crede, Virginia Tech
Maura Borrego, Ph.D., Virginia Tech

Industrial Engineering Division:**Best Paper Award**

Terri Lynch-Caris, Ph.D., P.E., Kettering University

International Division Awards**Best Paper Award:**

Kristine Lalley, D.Ed., University of Pittsburgh
Josephine Olson, Ph.D., University of Pittsburgh

Service Award:

Maria Larrondo Petrie, Ph.D., Florida Atlantic University

Liberal Education Division:**The Sterling Olmstead Award**

Sarah Pfatteicher, Ph.D., University of Wisconsin-Madison

Mechanical Engineering Division:

Dianne Pawluk, Ph.D., Virginia Commonwealth University
Marcia Hoffman, Virginia Commonwealth University
Maria McClintock, Virginia Commonwealth University

Mechanics Division: Best Paper Award

Anna Dollár, Ph.D., Miami University

Minorities in Engineering Division:**Best Paper Award**

Susan Walden, Ph.D., University of Oklahoma

New Engineering Educators Division:**Best Paper Award**

First Place: Donna Llewellyn, Ph.D., Marion Usselman, Ph.D., Georgia Institute of Technology
Second Place: Agnieszka Miguel, Ph.D., Seattle University
Third Place: Kathy Schmidt, Ph.D., University of Texas at Austin
Mia Markey, Ph.D., University of Texas at Austin

Women in Engineering Division:**Denise D. Denton Best Paper Award**

Catherine Amelink, Ph.D., Virginia Tech

The National Academy of Engineering**Bernard M. Gordon Prize**

Tina L. Seelig, Ph.D., Stanford Technology Ventures Program

Arthur M. Bueche Award

Sheila E. Widnall, Ph.D., Massachusetts Institute of Technology

New Female Members

Kristi S. Anseth, Ph.D., University of Colorado at Boulder
Deborah L. Estrin, Ph.D., University of California, Los Angeles
Claire L. Parkinson, Ph.D., NASA Goddard Space Flight Center
Monika Auweter-Kurtz, Ph.D., University of Hamburg

L'Oreal-UNESCO 2009 For Women in Science Award

Tebello Nyokong, Ph.D., Rhodes University, South Africa
Akiko Kobayashi, Ph.D., Nihon University, Japan
Eugenia Kumacheva, Ph.D., University of Toronto
Athene M. Donald, Ph.D., University of Cambridge
Beatriz Barbuy, Ph.D., University of Sao Paulo, Brazil

Society of Women Engineers (SWE) Awards**Achievement Award**

Aslaug Haraldsdottir, Ph.D., The Boeing Company

Upward Mobility Award

Joanne M. Maguire, Lockheed Martin Space Systems Company

Resnik Challenger Award

Margot L. Wasz, Ph.D., The Aerospace Corporation

Distinguished Engineering Educator

Amanie Abdelmessih, Ph.D., Saint Martin's University

Emerging Leader Award

Jennifer Bly, Ph.D., Intel
Stefanie Chiras, Ph.D., IBM
Peggy Panagopoulos Flaherty, ITT Industries
Amy Benecke McLaren, P.E., Peoria County Highway Department
Lt. Cmdr. Michelle Lee Nakamura, U.S. Navy
Soh Khim Ong, Ph.D., National University of Singapore
Julie Rolffs, Caterpillar Inc.

Distinguished New Engineer Award

Diane LaFortune, Northrop Grumman
Reena Singhal Lee, Google Partner Solutions Organization
Mary E. Perkinson, Northrop Grumman Shipbuilding
Jessica Rannow, Cardinal Health
Patricia Walker, Jacquelyn's Photography

Outstanding SWE Counselor

Diana Madden, Schiller and Hersh Associates Inc.

SWE Faculty Advisor

Candace S. Sulzbach, P.E., Colorado School of Mines

Fellows

Toni L. Doolen, Ph.D., School of Mechanical, Industrial, and Manufacturing Engineering, Oregon State University
Marge Inden, Morgan Stanley Smith Barney
Sandra Postel, Boeing Commercial Airplanes
Michelle Tortolani, Northrop Grumman Electronics
Janet L. Williams, Sandia National Laboratories

Collegiate Member Award

Martha Addison, University of Alabama
Sarah Grano, University of Alabama
Chelsea Ryberg, Seattle University
Kristina Wang, University of Colorado at Boulder
Jessica Wood, University of Illinois at Urbana-Champaign

Women in Engineering ProActive Network (WEPAN) Awards**Women in Engineering Initiative Award**

IBM Austin – E.X.C.I.T.E. Camp

Women in Engineering Program Award

North Carolina State University

WEPAN Educator's Award

Mary Anderson-Rowland, Ph.D., Arizona State University

University Change Agent

Patricia Hyer, Ph.D., Virginia Tech
Debra Lasich, Colorado School of Mines

Betty Vetter Award for Research

Karen Tonso, Ph.D., Wayne State University

Women in Engineering Champion Award

Janel Barfield, IBM
Kathryn Tobey, Lockheed Martin

Distinguished Service Award

Paige Smith, Ph.D., University of Maryland

Intel Science Talent Search Award

Chelsea Jurman, Fifth Place, New York
Preya Shah, Eighth Place, New York
Gabriela Farfan, Tenth Place, Wisconsin

Anita Borg Institute for Women and Technology (ABI)**Social Impact Award**

Ekaterina Fedotova, Project Harmony, Inc.

Technical Leadership Award

Ruzena Bajcsy, Ph.D., University of California, Berkeley

Denice Denton Emerging Leader Award

Nadya Mason, Ph.D., University of Illinois at Urbana-Champaign

Change Agent Awards

Halima Ibrahim, Mu'assassatul Mar'aatus Saliha Women's Skill Acquisition Centre
Anne Ikiara, Nairobi Trust
Oreoluwa Somolu, Women's Technology Empowerment Centre

Data are included about pre-high school and high school courses taken and a plethora of other education-relevant variables (e.g., whether the student was eligible for free or reduced-price lunches, had limited English proficiency, or were special needs). This makes it a relatively rare and unique dataset with which to carefully explore the key research question of this study, namely: What are the factors that affect the likelihood a student would need college mathematics remediation? Here are some key findings:

- High school mathematics courses do not explain the small disadvantage for women with respect to remediation because there is an interaction effect between gender and race/ethnicity. In other words, it is because of race/ethnicity issues and the fact that non-white women are more likely to go to college than non-white men, that women need more remediation *despite* having taken similar numbers of classes.
- The lower returns for low-income black and Asian students associated with mathematics courses implies that the lesser quality of those courses negatively impacts these students.

The highest course taken explains:

- 28-35 percent of the gap in Hispanic and black students' readiness relative to whites
- More than 75 percent of the advantage of Asians relative to whites
- While the study is restricted to analysis in one state, the unique dataset, the high level of that state's K-12 population diversity (CPST 2009), the strong cross-institutional collaboration in public higher education in the state, and the availability of a critical set of control variables make this an important piece of research.

An earlier micro-level study of mathematics and gender by Goodchild and Grevholm (2009) provides some food for thought about the nature of gender differences in mathematics performance. The authors' results are

exploratory because the students whose tests were analyzed represented virtually all the students enrolled at seven Norwegian schools that had agreed to participate in a larger project on Learning Communities in Math (i.e., the schools might, therefore, be different from the ones that chose not to participate). They found no performance differences between boys and girls in grades 4, 7, or 9, and the grade 11 significant sex difference was quite small. However, the authors then delved into the constituent elements of the grade 11 difference (124 boys and 110 girls) by conducting a meticulous analysis of the specific exam questions on which there were sex differences. Their results led to some interesting suggestions, which need to be researched in other settings:

- Some evidence to support girls' lower level of risk-taking behavior in terms of answering questions for which they were not sure of the solution.
- Students with more procedural learning grounded in rote learning were more prone to errors on some of the tasks they studied — girls tended to be more rules-based.

Goodchild and Grevholm's micro-level analysis is based within a larger study related to mathematics curriculum. Their findings — that the actual design of tests and curriculum materials produced gender effects — provides us with insight into the subtle and nuanced ways that gender bias is embedded within tests and how tests and materials can be better designed to be gender-neutral.

A carefully constructed piece of research by Ceci, Williams, and Barnett (2009) examines the role of socio-cultural and biological considerations in women's under-representation in mathematics-intensive STEM fields. The article is useful for engineers and advocates of women in engineering because it reviews the substantial body of literature on gender differences in mathematics performance along

with the arguments associated with various research approaches to understanding these gender gaps. In particular, they provide background on analyses at the tails of the distribution rather than looking at overall group means. As Hyde (2005) documents, intra-group differences are often larger than intergroup differences, with males, especially, tending to display a larger variability in performance than females. If the folks in the upper tails of the mathematics performance distribution are likely to be the next generation of scientists and engineers in mathematics-intensive fields, then group means analysis is unlikely to yield much fruit in understanding how to improve women's access to STEM. One of Ceci et al.'s more interesting findings was that the women in this high-performing group were more likely than the men to have both high mathematics and high verbal competence, implying that there may be more choices available to women than men who have such competencies. A second important finding, unrelated to K-12 but germane to the overall discussion, was that women with children are, indeed, penalized in promotion rates in some math-intensive fields.

Finally, a significant piece of cross-national research by Nosek et al. (2009) looked at how gender-science stereotypes were related to national-level differences in achievement in science and mathematics. The study makes use of two large-scale (and separate) data collections. First, the key independent variable was derived from the body of data that has accumulated from the Harvard-led implicit associations test (IAT) (<http://implicit.harvard.edu/>), which provides a measure of the extent to which respondents see science as masculine. Second, the key dependent variables were taken from results for the Trends in International Mathematics and Science Study (TIMSS), which provides data on mathematics and science performance of students

— separately by gender — in a number of countries. For the purpose of this article, there were 34 nations for which there were sufficient data from the IAT and the TIMSS to permit comparisons. The researchers found that as national-level bias toward science as masculine increased, so too did the gender gap in scores on the TIMSS for 8th grade girls and boys, with boys advantaged relative to girls within the same nation. The key policy implications of this study are that:

“Education campaigns attempting to bolster women’s participation and performance must overcome the pervasive implicit stereotypes that are already embodied in individuals’ minds. ... Changing implicit stereotypes is not just a matter of influencing intentions; it also requires consideration of the social realities that shape minds without intention.”
(Nosek et al. 2009: 10596-10597).

EDUCATIONAL PIPELINE: peers and institutional effects on persistence in undergraduate engineering education

Self-efficacy and women’s success in engineering school.

Self-efficacy was a consistent theme among articles on the educational pipeline this year. Self-efficacy is the belief that one is capable of attaining specific goals as a result of one’s performance (Bandura 1997). Self-efficacy is domain-specific, meaning that an individual might have a high level of self-efficacy in one area and a low level in another area. Over the past several years, the concept of self-efficacy has become a more powerful — and studied — predictor of educational outcomes, such as persistence to a degree, supplanting earlier studies that focused on self-esteem. Self-esteem is related to self-worth, which has only a tenuous theoretical connection to achieving a goal, such as a degree, in contrast to the stronger theoretical construct, of self-efficacy. For women engineers, there are some interesting connections between the two constructs. For

example, some women engineers may set high standards for themselves such that they could exhibit a high level of self-efficacy in the engineering domain, yet feel unable to live up to their high ideals and consequently suffer a blow to their self-esteem. Interestingly, men often experience the opposite and a high self-esteem may make them overly confident of engineering abilities that are not borne out in reality. It is also important to point out that self-efficacy is not merely “confidence,” as self-efficacy concerns the belief in the direct connection between the actions one takes and outcomes.

Self-efficacy is becoming increasingly important in discussions regarding women’s participation in technology fields, both for enrollment and decisions to stay the course. Damour (2009) suggested that “girls do not tinker,” noting that boys are encouraged to take things apart and learn the mechanics, while girls are often encouraged to use toys for accomplishing tasks (2009). As a result, boys are able to develop their cognitive and reasoning skills in a way that girls do not. This lack of investigation and experimentation puts girls at a disadvantage from an early age, which translates to feelings of reluctance, incompetence, and discomfort when pressed with figuring things out.

Schreuders, Mannon, and Rutherford (2009) discussed a similar finding from an online survey of 969 engineering students across 21 U.S. universities. The survey covered personal and academic background and motivations, interests, and comfort in engineering practice across 30 different activities. For the most part, there were few gender differences in background, but interests and comfort level on various activities did vary by gender. Similar to Damour (2009), Schreuders et al. found that women were less comfortable with computers, tools, and machines than were men, and were less interested in design, build, and analyze activities than men. Women

are greatly interested in the ways that engineering methods can be deployed to improve conditions for people and in socially conscious items. Schreuders et al. conclude that engineering faculty need to be more cognizant of the forces drawing women to the field and, therefore, should include more diverse examples of engineering work in their courses, especially matching women’s interests and motivations for pursuing the field. Such strategies could provide a basis for women to develop a stronger sense of self-efficacy in engineering.

Pedagogical implications were also associated with a study that involved 2,099 students enrolled in a calculus-based introductory mechanics course. An analysis of student evaluation, preparation, and attitude data found that women took fewer high school physics courses than their male counterparts; men outperformed women on the math sections of the SAT and ACT; and that women had lower normalized learning gains than men, all of which exacerbated the gender gap, with men more prepared for physics concepts and calculations than women (Kost, Pollock, and Finkelstein 2009).

Using a pre- and post-test to measure students’ conceptual knowledge of physics at the beginning and end of the semester, Kost et al. found that while both men and women shifted toward less expert-like beliefs about physics over the course of the class, women had more negative shifts than men, indicating a steady decline in women’s sense of confidence and ability surrounding physics (2009). This latter finding suggests that issues of gender equity in physics pedagogy may need greater conscious attention by physics faculty in order to provide both men and women with the requisite physics skill set they will need to successfully complete engineering coursework.

A sense of inclusion is also critical for women to complete their engineering education, according

to a study involving 196 female engineering students at five engineering schools across the U.S. Women completed an online assessment on self-efficacy, feelings of inclusion, and outcomes expectations, in addition to classroom and non-classroom experiences, academic preparation activities, and persistence plans. Women overall, perceived “a lack of inclusion in environments in which they study engineering,” including negative social cues from fellow students and faculty (Marra et al. 2009: 34). However, women’s reported intention to persist in engineering was positively related to factors such as career expectations, engineering self-efficacy, feelings of inclusion, coping self-efficacy, and math expectations. When self-efficacy increased, so did women’s intention and likelihood of completing engineering education. The authors concluded that, “a strong sense of self-efficacy, especially for women students who are underrepresented

in engineering classrooms, can help them persist and enable them to become practicing engineers” (Marra et al. 2009: 35).

Clearly, self-efficacy is related to positive outcomes in studying and pursuing careers in nontraditional fields. As such, a study from Spelman College — a historically black women’s university in Atlanta — explored how the characteristics, policies, and practices at that college promoted degree attainment for African-American women in STEM fields (Perna et al. 2009). The study involved five focus groups, three with students and two with faculty. Spelman’s reputation for advancing black women in STEM is an important reason students attend the institution. The institution’s characteristics and practices, namely, cooperative peer culture, faculty encouragement, academic supports, and availability of research opportunities, enabled students to meet their STEM educational and occupational aspirations. Consistent

with an array of findings in recent years, Perna et al. conclude that culturally relevant pedagogy is “particularly effective for promoting classroom participation among women and Blacks,” which, in turn, can improve students’ self-efficacy in engineering.

In summary, women’s self-efficacy, and their subsequent enrollment and retention in engineering, can be advanced by:

- Facilitating positive peer and faculty relationships and academic supports (Perna et al. 2009)
- Encouraging construction with tools and cognitive skill from an early age (Damour 2009 and Turja et al. 2009)
- Developing gender-specific curricula and recruitment strategies (Schreuders et al. 2009)
- Clearly describing the workplace, helping individuals identify with characteristics that appeal to them, and correcting misconceptions to match women with their occupational personality (Ash et al. 2009)

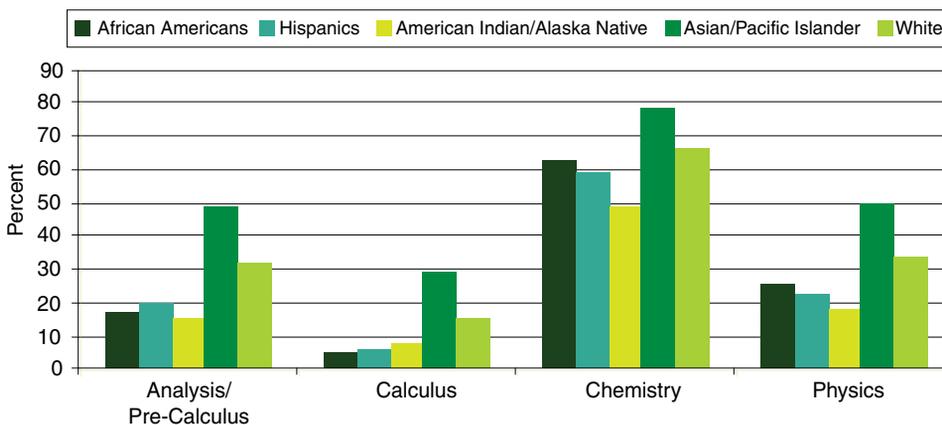
Differences by Gender and Race/Ethnicity in High School Math and Science Course Taking

By Lisa M. Frehill, Ph.D.

The graphs show the vast differences across demographic groups in mathematics and science course taking. These data are from the National Center for Education Statistics’ High School Transcript Studies, which uses transcript data to study the patterns of course taking among high school graduates. Nearly half of Asian/Pacific Islanders had taken analysis/pre-calculus. At the other end of the spectrum, the more rural American Indian/Alaska Native high school graduates were least likely to have taken this

same course and were also least likely of all racial/ethnic groups to have taken chemistry and physics. Proportionately few students from the three major underrepresented minorities — African-Americans (6 percent), American Indian/Alaska Natives (8 percent), and Hispanics (6 percent) — had taken calculus, severely hamstringing members of these groups who may be interested in pursuing studies in the physical sciences and engineering, fields in which calculus is a critical building block of a lengthy cumulative curriculum. Females (70 percent) were much more likely than males (62 percent) to have taken chemistry, but males were slightly more likely to have taken physics than females. It is noteworthy that, otherwise, there were few mean-

Percent of HS Graduates Taking Selected Math and Science Classes by Race/Ethnicity, 2005



Source: CPST analysis of data derived from National Center for Education Statistics *Digest of Education Statistics, 2007*.

- Providing women with role models and support to promote feelings of inclusion (Marra et al. 2009)

Gendered construction of engineering. Research relating to perceptions about whether women belong in male-dominated fields continues to be conducted. Despite women's advancements over the past 15 years, we still saw numerous articles pertaining to traditional values and women's acceptance into a typically male career. Traditional roles provide a sense of security and stability; the problem, however, is that when traditional roles are deviated from, the offender is often met with hostility and resistance, pushing him or her out of the field and back into his or her traditional role. But research by Williams (1995) shows there are asymmetric effects whereby men who take positions in female-dominated fields (like nursing) are advantaged while women who are in male-

ingful gender gaps in high school courses taken in the sciences and mathematics.

What accounts for differences in high school course taking? An interesting simulation presented by McFarland and Rodan (2009) illustrates how different factors influence mathematics course taking. Typically, these factors are: students' motivations; graduation requirements; course availability; and teachers' recommendations/past performance. They use data from two schools, "Magnet High" and "Rural High," to run the simulation. Simulation rules were developed for their model based on the actual graduation requirements of each school. For example, students needed to take only two years of mathematics at Rural High and could take relatively less-challenging courses versus the panoply of challenging options available to students at Magnet High, which required four years of mathematics to graduate. At Rural High, too, a failed math class could be retaken, whereas at Magnet High, failing a math class would get you bounced. Students were generally "tracked" into and subsequently through mathematics at Rural High, while the motivated and talented students at Magnet High made choices within a high-level constrained set. For the students at Magnet High, the pathway in mathematics was influenced by a vacancy model: Students were more limited by the number of "slots" available in classes that they could take because they were relatively homogeneous on motivation and were all required to take mathematics every year. Few of the Rural High students took higher-level mathematics due to their option not to, their heterogeneity with respect to post-high school plans, and the previous tracking into a specific set of mathematics classes.

dominated fields (like engineering) are disadvantaged by the gender hierarchy of the larger society.

Literature that examines the ways in which engineering is constructed and maintained as a masculine field has proliferated in recent years. Exemplar pieces include those from Faulkner (2000 and 2007), Frehill (2004), Miller (2004), and Oldenzil (1999). In contrast to some of the literature that takes, as given, the concept of traditional roles, this literature questions how these roles developed and, more importantly, how engineering became and continues to embody masculinity.

Race and sex form the basis of many students' perceptions of engineers and scientists. Hoh (2009)

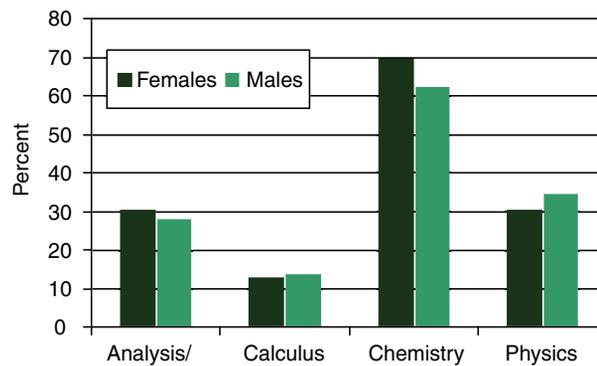
shows that many students at all levels "see" a Caucasian man when they imagine an engineer. The potential influence of teachers in the formation of this perception may be important. When asked to "draw an engineer," an overwhelming majority of high school biology teachers (45 male and 35 female; ages 25-40) drew a Caucasian man (Hoh 2009).

Perceptions can have many roots, including personal experience, peers, parents, media, culture, organizations, society, and so on. Lynch and Nowosenetz (2009) conducted four focus groups at a South African university — two single-sex and two mixed-sex groups — with six participants each and a flexible interview guide who started with a vignette

about the career paths of a male and female engineer. Both male and female participants held traditional gender-role values with respect to division of labor and differential of power. Further, male and female participants alike indicated they felt that STEM were masculine-natured

fields, more appropriate for men. Further, both male and female participants held that women must choose between a career and children but believed that married women should remain in the home. Additionally, male participants felt that gender equality was a women's issue — one they had no responsibility in fixing, and that gender equity was at the expense of male power with women encroaching on men's position in society. Further, male participants believed that men should have the power and control as a matter of

Percent of HS Graduates Taking Selected Math and Science Classes by Sex, 2005



Source: CPST analysis of data derived from National Center for Education Statistics *Digest of Education Statistics, 2007*.

patriarchal entitlement (Lynch and Nowosenetz 2009).

Another study at a U.S. urban Research I university explored perceptions and biases of 522 undergraduate students in an introductory engineering or general education English class. Students were provided with six small transcripts of dialogues from teamwork highlighting a complaint about the team, the project, or themselves (Wolfe and Powell 2009). The male engineering students were found to be biased against female-typical speech acts, generally those that admitted weakness or were self-criticism, regardless of the sex of the speaker (Wolfe and Powell 2009). Wolfe and Powell conclude that women should curb their tendency to criticize themselves and admit weakness. Such behavior does not challenge the status quo; rather it allows gendered patterns and beliefs to remain intact. Wolfe and Powell's research, though, also suggests that men in engineering may need to learn to be open to alternative points of view and that perhaps men need to become a bit more self-critical.

Logel, Walton, Spencer, Iserman, von Hippel, and Bell (2009) conducted an interesting set of experiments that show how interacting with sexist men can be problematic for women in engineering. In particular, when women in strongly male-dominated areas such as engineering deal with anti-female bias, they experience stereotype threat. This, in turn, impacts their performance in negative ways. To counter this, "organizations need to take steps to reduce the effect of social identity threat by reducing the level of prejudice in the environment" (Logel et al. 2009: 1101). Individual-level interventions can also help, which has been the case with other manifestations of stereotype threat. Women engineering students need to be provided with ways to reaffirm their self-integrity or to "reconstrue negative belonging experiences."

In recent years, literature on the

gendered construction of engineering has proliferated and is a fruitful area of research because it turns our attention to how social structures shape outcomes, such as the gender composition of occupations like engineering. A piece by Foor and Walden (2009) reflects this literature by examining the ways in which industrial engineering is maintained as a marginal "imaginary" engineering and provides a way for women in the field to "claim a nontransgressive feminine gender identity," while allowing men to reject hegemonic masculinity. The authors use rich qualitative data collected over four years' time at the University of Oklahoma, where there is a high enrollment of women in industrial engineering (58 percent). The faculty also has proportionately more women than most engineering programs — 40 percent — but neither statistic was the outcome of specific action to recruit more women. They discuss three important intertwined narratives about engineering that make it possible for industrial engineering to be carved out as appropriate for women. The narratives emphasize the distance of industrial engineering from technology, its presumably less-rigorous curriculum, and IE as "business engineering." These narratives result in the field's being devalued and delegitimized in the hierarchy of engineering fields.

An article by Powell, Bagilhole, and Dainty (2009) is another report of qualitative research that women in engineering will find of interest. They interviewed young women ($n = 26$) prior to and after they experienced their industrial placements ("co-op" or "internship" would be the U.S. experience). In addition to the interviews, they effectively used focus groups to further explore the women's experiences and how they made sense of these experiences during their industrial placement. To provide a basis for comparison, they also completed pre-interviews with 26 comparable women who did not undertake

industrial placements. While this latter set of interviews cannot provide a basis for comparison of the changes in which the authors were interested, it does provide a way for the researchers to show the extent to which the women who chose industrial placements were similar or different from those who did not. In a word, it permits them to determine whether their findings would be threatened by a selection bias.

Their findings will resonate with women engineers who have worked in similar settings. As with the Foor and Walden (2009) article, this article is an important piece of research because it subjects to careful research the behaviors that seem obvious, and then probes more deeply to reveal the gender issues that lurk far below the surface. Powell et al. describe a number of coping behaviors: acting like one of the boys; accepting gender discrimination — and rejecting gender as an explanation for poor treatment; achieving a reputation as an engineer; focusing on the advantages vs. the disadvantages of engineering work; and rejecting femininity, adopting an anti-woman approach. The women experienced conflict associated with the hyper-masculine construction of engineering, their desire to be good engineers, and the fact of their biology. Carving out a feminine identity within this context was fraught with peril because the coping strategies and ways women engineers addressed gender led to practices that perpetuated women's subordination. For example, by setting themselves apart from other women (anti-woman approach) and accepting gender discrimination, they could act like one of the boys and fit in as they established a professional reputation and identity as an engineer. But to do so, they had to accept that women were, indeed, inferior, which is a core component of patriarchy.

A final piece that appeared in this category is intriguing in its

exploration of the epistemology of ignorance. The old adage “knowledge is power” applies here. But Franzway, Sharp, Mills, and Gill, (2009) lead us to also see how that ignorance is more than sheer bliss, as it also represents power. Using multiple modes of inquiry (online surveys, organizational documents, observations, and interviews) this study looked at the policies, structures, and practices of three large multisite engineering organizations in Australia. The three organizations had experienced recent restructuring, were in need of more professional engineers [note: professional is the term used in Australia to refer to engineers who have college degrees] and had implemented gender equity programs. Franzway et al. (2009) found three important cross-cutting themes, the first being that, “gender equity has become an accepted demand” (Franzway et al. 2009: 95). Second, even with the dedication of resources, the efforts associated with gender equity have met with limited success and are “met with the sexual politics of resistance, hostility, or indifference by both women and men engineers.” (Franzway et al. 2009: 95). Finally, as with the women engineers studied by Powell et al., the denial of gender discrimination was quite common. The authors conclude “that the lack of progress for women resulting from programs for gender equity in engineering stems from a politics of ignorance and a refusal to know and challenge the role of sexual politics in workplace cultures.” (Franzway et al. 2009: 102)

Institutional strategies for increasing women’s participation in engineering. What role do institutions play in women’s recruitment, retention, and advancement in engineering? A number of this year’s articles provide insights following the chronology, if you will, from recruiting and enrolling, to the institutional experience, to graduating and training doctoral students to become future faculty. Gender disparities in engineer-

Significant Conferences in 2009

By M. Amanda Lain

Toronto, Canada

National Conference on Women in Engineering, 2009

The NCWIE Conference, “Designing the World to Come,” took place Nov. 27-29, 2009, in Toronto. The conference featured workshops, guest speakers, roundtable discussions, and activities focused on women’s involvement in the science and engineering professions, with the goal of learning, discussing, and challenging the social norms in society in order to create a more promising future. For more information, please visit <http://www.ncwie.skule.ca/>.

Long Beach, Calif.

Society of Women Engineers Conference, 2009

The Society of Women Engineers held its annual conference in Long Beach, Calif., Oct. 15-17, 2009. In addition to a Career Fair with more than 200 exhibitors, the conference offered a keynote address by Darlene Solomon, Ph.D., chief technology officer of Agilent Technologies. In addition, attendees could choose from more than 120 professional development workshops and seminars regarding leadership and communication skills, innovative technology, diversity, and careers across government and academia. Please visit <http://we09.swe.org/> for more information.

Austin, Texas

WEPAN/NAMEPA Conference, 2009

The Women in Engineering ProActive Network (WEPAN) and the National Association of Multicultural Engineering Program Advocates (NAMEPA) joined forces to present the 2009 National Conference in Austin, Texas, June 17-19, 2009. More than 200 professionals convened to discuss recurring and emerging issues, with the goal of creating changes that enhance the success of women of all races and ethnicities in science, technology, engineering, and math. The conference theme, “Center Stage: Effective Strategies for Recruitment and Talent Development,” highlighted topics pertaining to developing engineering talent at all ages, communicating engineering opportunities to women, building partnerships to support women in engineering and sciences, diversifying program staff, and impacting policy, legislation, and media. For more information, please visit <http://www.wepan.org/>.

Seattle, Wash.

The Women in Science and Engineering (WISE) Annual Conference, 2009

The WISE annual conference offers educational and professional development for women interested in engineering and science careers. More than 200 attendees from high school, college, faculty, administrators, and professional women attended the Feb. 7, 2009, conference in Seattle to discover new opportunities, identify personal strengths, and increase their confidence to embark on new academic and professional ventures. Please visit <http://www.washington.edu/> for more information.

Dallas, Texas

Women of Color in Technology STEM Conference, 2009

The national Women of Color in Technology STEM Conference was held Oct. 29-31, 2009, in Dallas. The conference focused on career opportunities in technology, promoting STEM across the K-12 level, and recruiting middle school, high school, and college students to STEM. Finally, the conference recognized the contributions of women of color in STEM. For more information, please visit http://www.ccmag.com/woc/about_conf.php.

ing bachelor’s degree production are often blamed on inadequate retention, but recent findings suggest recruitment and enrollment

are actually the greater problem: “retention is clearly not the root cause of the underrepresentation of women nationally. Recruitment

is.” (Cosentino de Cohen and Deterding, 2009: 222). Indeed, Cosentino de Cohen and Deterding reviewed the American Society for Engineering Education, Engineering Workforce Commission, and Engineering Trends databases, and the Institutional Postsecondary Education Data System (IPEDS) to show that, of the approximately 400,000 undergraduates in 22 engineering fields, there was “no evidence of lower rates of retention among women than men enrolled in engineering undergraduate programs” (2009: 219). Additionally, the largest engineering fields in terms of absolute numbers — computer, mechanical, and electrical — had the most severe female underrepresentation with women accounting for 12 percent of enrolled students and 14 percent of degrees, lower than the overall rates of engineering enrollment (20 percent) and bachelor’s degree attainment (22 percent). Finally, they found that high female retention was not associated with female faculty or low faculty/student ratios, and, in fact, these institutional variables are not good predictors of institutional effectiveness. In light of their results, the authors recommended targeted recruitment to increase female representation, including at middle schools, high schools, and community colleges, as well as to permeate classrooms with engineering concepts that students are unlikely to have seen prior to college (Cosentino de Cohen and Deterding 2009).

Lord et al. (2009) report findings similar to Cosentino de Cohen and Deterding (2009), via an analysis of longitudinal data from the Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD). The analysis of these institutional data on about 79,000 engineering students across nine universities in the U.S. southeast demonstrated that “the low representation of women in the later years of engineering programs is primarily a reflection of their rep-

resentation at matriculation” (Lord et al. 2009: 167). Indeed, by examining GPAs and persistence in engineering across race/ethnicity and gender, Lord et al. (2009) found that MIDFIELD women of all races performed as well as men in early science courses and often had higher STEM GPAs than their male counterparts. Additionally, the difference between female and male persistence in engineering was consistently low for all racial groups except Native Americans, and women persisted in engineering to the eighth semester at the same rate as men.

Fox et al. (2009) report qualitative analysis of 2004 interview

tion of women among bachelor’s degree recipients (1984-2001).

Fox et al. (2009) found that the most successful programs focused on institutional structures (“institutional/structural-centered”), while the least successful focused on women as individuals (“individual/student-centered”). In other words, when addressing issues, the most successful programs addressed the characteristics and features of the institution, while the least successful programs focused on “helping women students cope” (Fox et al. 2009). Unlike the “student-centered” programs, which tended to support the status quo of the insti-

Summary of most successful and least successful programs for undergraduate women in engineering

FOCAL AREA	PROGRAM	
	MOST SUCCESSFUL	LEAST SUCCESSFUL
Solution to problems	Early start (“bridge”) programs; residence hall clusters; broad mentoring	Peer tutoring/mentoring; early start (“bridge”) programs
New initiatives	Student research programs; hands-on research experience	Expand mentoring; expand early start programs
Characteristics of directors	Person and organizationally oriented; collaborative, resourceful, network-oriented	Person-oriented: approachable, nurturing, mentoring, warm, encouraging, interactive
Director’s leadership characteristics needed	Science/engineering degree important: <i>in relationship to college/institutions/faculty</i>	Science/engineering degree important: <i>for understanding students</i>
Aspirations/directions	Expand range of scope: Form partnerships with faculty, undertake proposals and external funding	Increase magnitude of present emphasis: More students, more retention, more bridge programs, more scholarships

Source: *Research in Higher Education* (2009) 50: 333-353.

data from directors of 10 programs for undergraduate women in science and engineering, each chosen for maximum contrast between “most successful” and “least successful” outcomes in terms of the proportion of degrees awarded to women at the relevant university. The 10 programs were selected from a total of 49 in the United States based on the propor-

tion by attempting to fit women students into the existing structure, the “structural-centered” programs took a more active stance by strategically working toward changes in the organization necessary to increase recruitment and retention of women.

As seen in the table above, directors of the most successful programs had a stronger link to the

administration and were more likely to report to a dean or someone at the administration level. Also, while directors in the least successful programs had an average of only 2.4 years in their positions, those in the most successful programs had an average of 7.2 years as director.

Marszalek, Linnemeyer, and Haque (2009) studied retention by looking at archival records of 235 women in engineering who participated in a mentoring program compared to 2,191 who had not been in the program. Marszalek et al. (2009) found that students with lower GPAs and those with fewer graded credit hours were more likely to drop out. Retention rates were higher among mentoring program participants than other female engineering students, and the odds of dropping out of engineering were significantly less for mentoring program participants. As a result of their findings, Marszalek et al. recommended that engineering educators foster women's interest in engineering and improve retention by showing the relevance of engineering to women's lives.

The overall importance of mentoring is documented in an article by Erickson, McDonald, and Elder (2009). They found informal mentoring can be especially critical to young people (high school-age teens) who have the fewest resources. Informal mentors were identified via students' answers to the following:

"Some young people know adults, other than their parents, who make an important positive difference in their lives. Some do not. Has an adult, other than your parents or stepparents, made an important positive difference in your life at any time since you were 14 years old?" (Erickson et al. 2009: 350)

The data were taken from the nationally representative National Longitudinal Study of Adolescent Health and the Adolescent Health and Academic Achievement study, which means that the results are generalizable across the United

States. This is important because, to date, most studies that examine the outcomes of mentoring are limited to small samples at a handful of colleges or universities or to participants in a specific program. The findings in this article are significant because they provide strong evidence that mentoring relationships have much potential to mitigate social inequality because advantaged youths already have access to resources and mentors, while disadvantaged youths have fewer options. Therefore, the availability of a mentor can provide compensatory resources to disadvantaged youths.

A national-level study by Cole and Espinoza (2009) used the 1999 Survey of Incoming Freshmen (SIF) and the 2003 follow-up data on these same respondents collected by the Higher Education Research Institute. Focusing exclusively on the small number of minority men (n=122) and women (n=107) in natural science and engineering majors who had completed the survey in 1999, Cole and Espinoza document the importance of completing separate analyses by gender within the category of race/ethnicity. In particular, they found that while the opportunity to tutor another student had a positive impact on outcomes for minority women, the same was not true for minority men. Both minority men and women were positively impacted by faculty support and encouragement (which was a highly reliable scale constituted with 12 items), net of high school grades.

Demetry et al. (2009) evaluated the effectiveness of a two-week camp for middle-school girls. The researchers contacted 176 students who had attended the camp, as well as students who had applied to the camp but were not selected to attend, and who were near the point of college entry. They found that the girls who attended the camp had enhanced interest in and knowledge of engineering,

enhanced motivation toward education, and enhanced engineering self-efficacy and confidence after participating in the program. Additionally, it was found that exposure to engineering later in middle school and high school increased both the camp and non-camp girls' participation in and understanding of engineering. Finally, the researchers found that continued exposure to STEM-related programming and role models was associated with stronger long-term outcomes, namely recruitment and retention into engineering (Demetry et al. 2009).

Tsui (2009) used interviews and focus groups to examine the recruitment of women into mechanical engineering, a strongly male-dominated field (see sidebar on pp. 174-175). Data were collected across six mechanical engineering programs in U.S. universities that enroll and graduate a relatively high proportion of women: Cornell University; Michigan State University; Southern University; Tuskegee University; University of California, Los Angeles; and University of New Mexico. Tsui found that all six sites offered pre-college summer programs for underrepresented students (females and underrepresented minorities) and had some form of K-12 outreach program. The fundamental problem, according to Tsui, was incoming college freshmen's lack of knowledge of engineering and the need to have more female-focused recruitment efforts.

Alongside the importance of recruiting females is the need to attract minorities to engineering. Only 12 percent of new engineering bachelor's degree recipients in the 2007-08 academic year were from underrepresented minority groups (African-Americans, Hispanics, and Native Americans). An interesting study in New York by the Community Action Board offers insight into the dynamics of recruiting. The study examined the effectiveness of various strategies in recruiting and enrolling adults with pre-diabetes into a di-

abetes prevention intervention (Horowitz et al. 2009). From April through July 2007, 555 people in East Harlem were approached through one of five recruitment strategies: clinicians; public events; special recruitment events; local organizations; or through a partner-led approach, in which community partners managed recruitment efforts at their sites. Horowitz et al. (2009) found that the partner-led approach was highly successful, with 68 percent of enrollees recruited, and 34 percent of those approached through this strategy enrolled, compared with a 0-17 percent enrollment rate of the other four strategies (Horowitz et al. 2009). Although this study focused on recruitment related to a health issue, the lessons are applicable to any program that seeks to reach an urban, minority audience: i.e., there is value in using partner-led recruitment (Horowitz et al., 2009).

Professional development for faculty/engineering pedagogy.

McKenna, Yalvac, and Light (2009) examined the extent to which faculty involvement in an Engineering Research Center (ERC) consisting of four participating universities impacted teaching styles in keeping with the How People Learn (HPL) framework. Survey data were collected from 24 ERC participants and a convenience sample of 30 engineering faculty who had not participated in the ERC. The ERC faculty and the 30 non-ERC faculty were rather similar in their approach to teaching prior to faculty involvement at the ERC. Using the 16-item *Approaches to Teaching Inventory* (ATI), McKenna et al. found that only those faculty who had “extensive engagement” with the ERC had teaching styles consistent with the HPL framework. This means that even engineering faculty who “attended several formal meetings, seminars, and workshops, and worked with learning scientists in the *design, implementation, and pre-assessment* of course materials” (i.e., someone

SWE in D.C.

By M. Amanda Lain

Over the past year, the Society of Women Engineers has steadily increased its presence in Washington, D.C., advocating for women and engineers across the country and around the world. SWE is becoming increasingly involved in government and public policy as a way to participate in discussions pertaining to science, technology, engineering, and math (STEM) education and Title IX. While women have advanced in many STEM fields, especially in the life sciences and medicine, women’s participation in engineering continues to lag far behind that of men. By being a vocal advocate of women in engineering, SWE can take steps to ensure that in larger debates about STEM, women’s underrepresentation in engineering does not get lost in the shuffle.

In 2009, SWE again joined with more than 100 professional societies, corporations, and government agencies to sponsor Engineers Week. Through this annual event, SWE inspires girls and women to explore the profession while providing encouragement and support to become part of the engineering work force.

With a different audience in mind, in April 2009, SWE co-sponsored the 14th annual Science, Engineering, and Technology Congressional Visits Day to raise visibility and support for STEM through meetings with congressional decision makers. As the only STEM event focused on diversity, SWE emphasized the importance of attaining a diverse and inclusive STEM work force. SWE participants attended training and visited the offices of U.S. representatives and senators.

SWE has become a resource for STEM issues in Washington and has laid the foundation to present issues critical to women engineers to the people who can bring about change from the top. The Society has successfully organized congressional briefings on Capitol Hill over the past year, and has continued to build relationships with key members of Congress. Additionally, SWE representatives met with members of President Obama’s administration to discuss the importance of diversity in STEM. Finally, SWE worked with the House Diversity and Innovation Caucus to discuss the challenges of recruiting and retaining women in engineering.

Highlights from 2009 include:

- Sponsored Engineers Week 2009, and remains an active participant in the Engineers Week Diversity Council, where SWE launched SASS-E Girlz (skills, attitude, science, smarts for engineering) to further educate girls about careers in engineering
- Co-sponsored Science, Engineering, and Technology Congressional Visits Day
- Held congressional briefing and roundtable participation, such as “The Dearth of Women in Academic Science and Engineering: Proactive Strategies for Improvement” and “STEM Education: How Gender Bias Hurts Girls, Boys, and U.S. Competitiveness”
- Leads the advisory committee of the U.S. House Diversity and Innovation Caucus
- Leads the STEM task force for the National Coalition for Women and Girls in Education, which released its gender-equity recommendations for President Obama’s administration
- Launched the Society’s 60th anniversary celebration year at the SWE national conference in Long Beach, Calif. Held in October, the theme of the conference was “Women Advancing the World of Technology.” The celebration of the 60th anniversary continues until the upcoming conference in November 2010 in Orlando.

with “moderate engagement”) were *not* any more likely to teach differently than those who had not participated in the ERC at all. To have an effect, beyond this involvement, the ERC engineering

educators also had to “have worked closely with learning scientists and *systematically assessed* their designed interventions, *re-iterated* their teaching methods, *presented* study findings at

conferences or *published* in education-focused academic journals and *consulted* with other faculty in their design efforts.” (McKenna et al. 2009: 22, italics in original). In short, engineering faculty need to invest substantial time and energy into the process of improving their pedagogy to implement strategies consistent with the HPL framework. As with many studies of engineering educators, the 12 women were too few to allow a comparison between men and women.

That pedagogical impact takes much time, reassurance, and continued effort and support was a key finding in Haviland and Rodriguez-Kiino (2009). Using qualitative research methods, these authors were particularly interested in the extent to which faculty members would adopt culturally responsive pedagogy at a small women’s college in the Southwest. Although the actual connection of program to results is not evidenced in this study, the article is one that engineering educators would be well-advised to read. Many studies we have discussed thus far point to the pressing need for changes in engineering pedagogy to make the field more responsive to the interests and needs of women and minorities.

The customary source that engineering educators concerned with pedagogy read is the *Journal of Engineering Education*, which offers limited insights into issues related to gender and race/ethnicity. Most studies reported in that journal rely on convenience samples of engineering students, which means that most samples lack the gender and racial/ethnic diversity necessary to explore these dimensions in the first place. Hence, it is imperative for engineering educators who care about diversity to look elsewhere to educate themselves about what it means to incorporate a true attention to gender and race/ethnic diversity into their pedagogy. The Haviland and Rodriguez-Kiino article is a good resource for these faculty because of the rich qualitative details and reflections from

program participants included in the article.

Finally, programs at institutions can provide assistance to students throughout the college experience as well as prepare students for success as STEM faculty. Indeed, several programs discussed by

Some Tips from EngineerGirl!

By Simil L. Raghavan, Ph.D.,
National Academy of Engineering

When talking to kids about engineering:

- DO** mention the importance of creativity, communication, teamwork, and interpersonal skills.
- DON'T** overemphasize the need for strong math and science skills.
- DO** explain that engineers solve problems that improve people’s lives.
- DON'T** talk about engineers as separate from the rest of society.
- DO** use real-world examples of engineering related to everyday objects and activities.
- DON'T** talk about abstract problems that don’t relate to ordinary people.
- DO** mention the benefits of an engineering career such as making a difference, interesting work, many job opportunities, and a good salary.
- DON'T** imply that money is the only reason to choose an engineering career.
- DO** explain that engineers work in teams with lots of people from different backgrounds.
- DON'T** give the impression that engineers work alone in an office with only a computer.

EngineerGirl! is a Web site maintained by the National Academy of Engineering to promote an interest in engineering to young girls and women.
<http://www.engineergirl.org/>

Austin et al. (2009) highlight the importance of improving undergraduate learning so as to prepare STEM doctoral students for filling faculty ranks. By reviewing Center for the Integration of Research, Teaching, and Learning (CIRTL) programs at the University of Wisconsin-Madison and Michigan State University, the authors found that learning communities are effective at improving preparation for teaching, enhancing student learning, and promoting institutional change (Austin et al. 2009). Furthermore, workshops targeted four professional skills that are key to successful graduate and professional careers: planning throughout the graduate program to identify and achieve career goals; developing resilience and tenacity to thrive through personal and professional stages; practicing active engagement in making important life decisions and in acquiring the skills necessary to attain career goals; and attaining and maintaining high standards of professionalism in research, teaching, and service (Austin et al. 2009).

These programs were found to: “promote graduate student retention and completion, enhance professional development opportunities in graduate school, give students a competitive edge securing professional positions, and supplement departmental advising activities” (Austin et al. 2009: 90), thereby creating STEM graduate students and post-doctoral researchers who are more effective faculty, researchers, and professionals.

As evidenced above, institutions can have a profound effect on STEM, from enrollment into programs to training and preparing future STEM professionals. In an effort to improve female underrepresentation in STEM, the research we have reviewed highlights: the importance of recruiting women from an early age into technology fields (Cosentino de Cohen and Deterding 2009); fostering women’s decision to enter STEM and building positive relationships

Engineering Colleges and Universities: Degrees and Faculty Data

By Lisa M. Frehill, Ph.D., and M. Amanda Lain

There have been few changes over the past nine years in the representation of women among degree earners in engineering, according to data collected by the American Society for Engineering Education (ASEE). Each year ASEE collects data on enrollments, degree attainments, and faculty representation, along with relevant demographic information from 339 U.S. and 10 Canadian colleges of engineering. These data, therefore, differ somewhat from the data collected nationally in the United States as part of the Integrated Postsecondary Edu-

cation Data System (IPEDS), reporting that is required for all U.S. institutions receiving any federal funding. However, the data represent the situation and output of the largest producers of engineering in both the United States and Canada.

Chart 1 shows that women's representation among engineering degree recipients declined at the bachelor's level, remained the same at the master's level, and increased at the doctoral level between 1999 and 2007. Overall, however, women's representation remains relatively low in contrast to many other fields in which women have achieved parity with men.

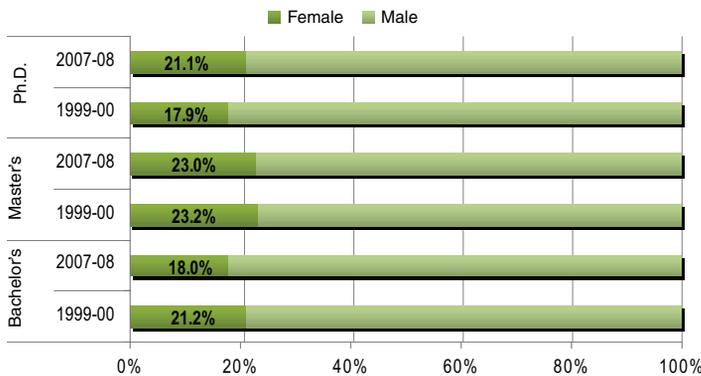
Women's representation among engineering degree recipients varies across racial/ethnic categories (Chart 1B). Caucasian (white) women have the lowest representation within any group with just over 15 percent. African-American women, on the other hand, accounted for a higher percentage (28 percent) of bachelor's degrees awarded in engineering to African-Americans. Hispanic women accounted for 23 percent and Asian-American women for 22 percent of degrees awarded to members of those groups. These data illustrate that engineering diversity is highly contingent on understanding the intersection of race/ethnicity and gender, and implementing policies and programs that will address issues associated with both identities.

Chart 2 shows that women's representation within engineering disciplines varies dramatically. Women are fundamentally at parity in environmental engineering with over 40 percent of bachelor's degrees in this field being awarded to women. Other fields in which women tend to have higher representations are biomedical, biological and agricultural, chemical, and industrial/manufacturing engineering. It should be noted, though, that these fields are often quite small in terms of the overall production of degrees in engineering. The fields that tend to have the highest number of degrees each year — notably mechanical and electrical engineering — are far from reaching gender parity. At this end of the spectrum, women accounted for just over 10 percent of all bachelor's degrees awarded in the 2007-08 academic year.

Indeed, Chart 3, showing the number of engineering faculty at the 349 colleges and universities surveyed by ASEE, provides insight into the relative sizes of engineering disciplines. Electrical engineering has the most faculty, 5,694, while mining engineering has just 79. Mining programs have been hard hit by large, structural changes: Mining is becoming less a critical part of the U.S. economy. Environmental engineering, the discipline with the highest proportionate representation of women at the bachelor's degree level, had just 296 tenured and tenure track faculty members in 2007-08.

1

Engineering Degree Attainment by Gender, 1999-00 and 2007-08

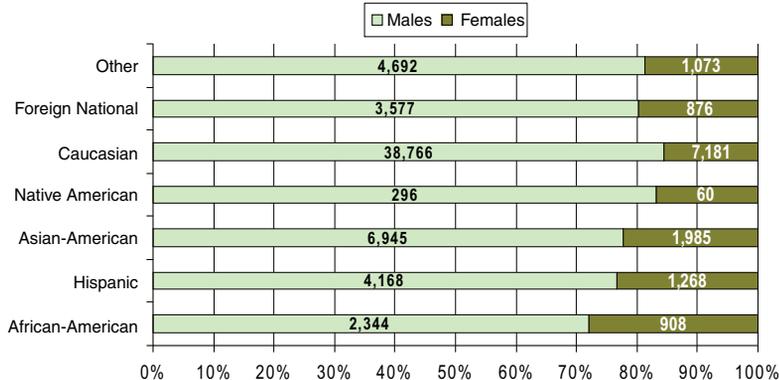


1B

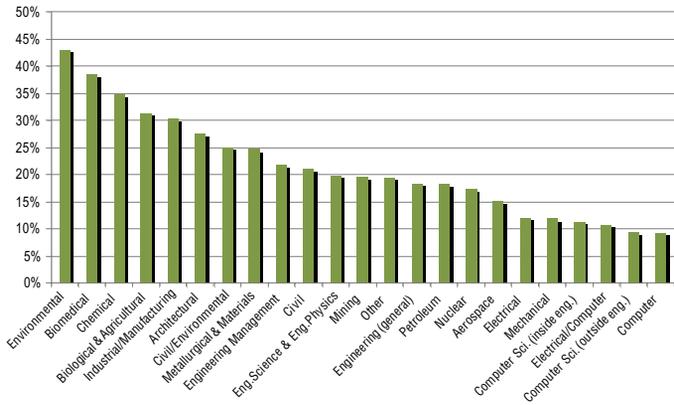
1B) Bachelor's Degrees in Engineering by Gender within Race/Ethnicity, 2007-08

	MALE	FEMALE	TOTAL	PERCENT FEMALE
African-American	2,344	908	3,252	27.9%
Hispanic	4,168	1,268	5,436	23.3%
Asian-American	6,945	1,985	8,930	22.2%
Native American	296	60	356	16.9%
Caucasian	38,766	7,181	45,947	15.6%
Foreign National	3,577	876	4,453	19.7%
Other	4,692	1,073	5,765	18.6%
Total	60,788	13,351	74,139	18.0%

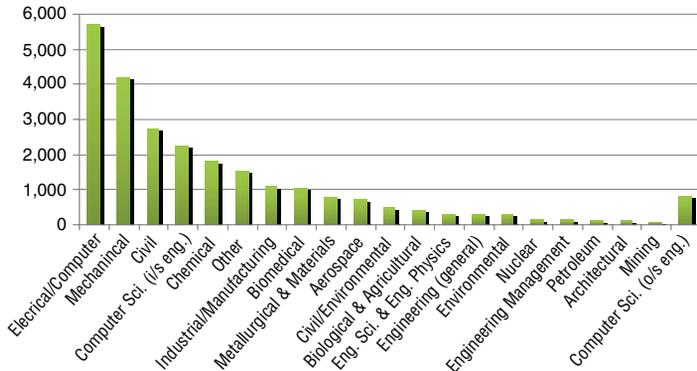
Bachelor's Degrees by Gender within Race/Ethnic Categories, 2007-08



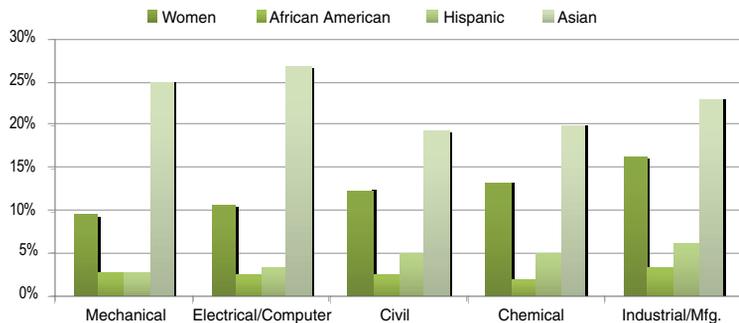
2 Percentage of Bachelor's Degrees Awarded to Women by Discipline, 2007-2008



3 Number of Tenured/Tenure-Track Faculty by Discipline, 2007-08 Academic Year (n = 24,207)



4 Percentage of Minorities and Women Tenured/Tenure-Track Faculty in Selected Disciplines



5 Percentage of Women Tenured/Tenure-Track Faculty by Discipline

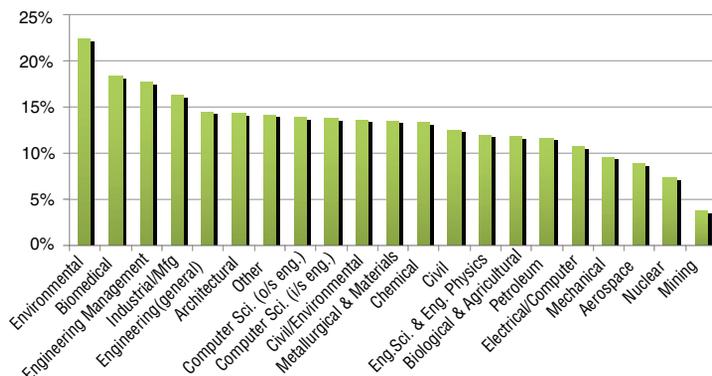
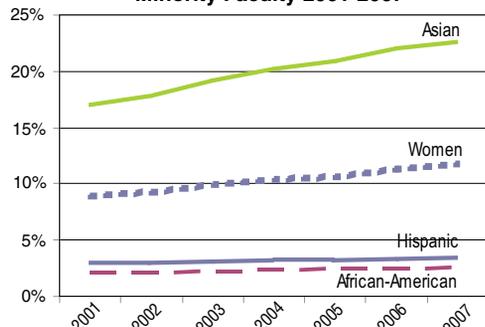


Chart 4 shows the representation of women and members of three key minority groups among faculty in the five largest engineering disciplines. Asians account for one-in-four or more electrical/computer and mechanical engineering faculty, with relatively high levels in the other three fields. Asians account for about 4 percent of the U.S. labor force; hence, these reveal a strong overrepresentation in the engineering professoriate. Women's representation among faculty in these disciplines is highest in industrial/manufacturing engineering (16 percent) and lowest in mechanical engineering (slightly less than 10 percent). Representation of African-Americans and Hispanics among faculty is quite low regardless of the discipline. Overall, industrial/manufacturing engineering is more diverse than the other engineering disciplines, with higher representations of African-Americans and Hispanics in addition to the larger representation of women. Chart 5 addresses the data on tenured/tenure track female faculty by all engineering disciplines, rather than the five largest, but does not break the data into minority groups.

Finally, Chart 6 shows the trend in women and minority representation on engineering faculty over time. Over the brief period shown, the greatest increases have been seen for women and Asian faculty, with each group posting 33 percent growth in proportionate representation among engineering faculty over the period. Change has been far slower for African-Americans and Hispanics: Representation from these groups on engineering faculty in the U.S. and Canada barely budged from 2001 - 2007.

ASEE's "Engineering by the Numbers" is compiled each year by Michael T. Gibbons, director of data research at ASEE. The data we show here are only the tip of the iceberg. The annual ASEE publication can be downloaded at no cost from www.asee.org/colleges in the section "Engineering Colleges and Profiles."

6 Percentage of Women and Minority Faculty 2001-2007



to retain their participation (Perna et al. 2009); exploring race and gender when discussing matriculation and retention (Lord et al. 2009); structuring guidance to ensure that engineers use their skills and abilities in the service of engineering-related careers (Lichtenstein et al. 2009); and training STEM students in a way that advances experiences and outcomes (Austin et al. 2009).

The engineering work force

Retaining female scientists and engineers is one key to maintaining a globally competitive work force. The total number of women earning engineering degrees has stagnated in the 21st century, hovering around 12,000 – 13,000 or so degrees a year (CPST 2009). However, while women constitute 41 percent of all science, engineering, and technology professionals at lower-level positions, more than 50 percent eventually leave, with the most women leaving these careers around the 10-year mark (Robinson 2009). So how can we continue to increase the number of women earning engineering degrees, and then better retain these women in the science, engineering, and technology work force?

Anticipatory socialization. Faculty are a critical bridge from school to the workplace, according to a study by Lichtenstein et al. (2009). In this narrow study, Lichtenstein et al. (2009) surveyed 74 engineering students, and interviewed 28 of them, over the course of four years regarding their undergraduate experience, how their interest in engineering evolved, and their post-baccalaureate intentions. Slightly more than half of the 74 students (39) were from a suburban private university, while the rest (35) were from a public technical institution. The private university offered a wide range of alternatives to engineering degrees while the public institution focused almost exclusively on technical degrees, with few options for nontechnical degrees (Lichtenstein et al. 2009). While 42 percent of students

stated they planned to pursue an engineering career upon graduation, 44 percent were unsure, and 14 percent stated they definitely would not be pursuing engineering. Students from the public technical institution were more likely to pursue engineering careers. Lichtenstein et al. concluded that many students' decisions concerning post-graduate plans likely take place "without the knowledge or influence of engineering faculty, who could conceivably provide valuable insights and guidance" (2009: 232). These findings indicate a need for advisors to encourage engineers to pursue careers in engineering, while also providing students with exposure to a range of jobs that could attract them to engineering careers.

A rather brief article by Male, Bush, and Murray (2009) concludes that engineering educators need to be mindful of their tendency to marginalize the female-typed competencies that are included in engineering education. Echoing findings of Fox et al. (2009), Male et al. (2009) emphasize the role of structures and engineering culture in women's underrepresentation in the field. Their study looked at how two different convenience samples of experienced male engineers in Australia rated the importance of 64 different competencies in engineering. Both groups had been out of school 5-20 years. In the first group, engineers rated the importance of competencies in their own jobs (245 men). The second group was made up of engineering managers or team leaders (246 men) who rated competencies for engineers entering the field.

Again, as with most convenience samples of engineers, there were too few women to permit comparisons by sex. A separate group of seven people were used to rate the gender-typing associated with the 64 competencies, with the focus of this study on the 29 typed as "female." In short, Male et al. found that key female-typed competencies that related

to ethics, diversity, and communication were devalued by the managers despite being seen as important in engineering work, and that managers engaged in gender-typing of engineering work.

Exemplars/models. Much can be learned from the stories and advice of successful women in engineering. Two excellent new books, both edited by Margaret E. Layne, P.E. (2009) provide myriad examples of successful women in engineering. The volume titled *Pioneers and Trailblazers* introduces the visionary women who opened doors for women into engineering. The selections provide a nice historical perspective on the struggles women have faced in realizing their dreams of becoming working engineers. The second volume, titled *Professional Life*, provides a more contemporary set of readings on women's participation in engineering. These readings are full of great career advice. Both volumes are available from ASCE Press (American Society of Civil Engineers) online at <http://pubs.asce.org>.

According to Andrew Lamb, CEO of Engineers Without Borders UK (EWB-UK), a student-led organization aimed at promoting sustainable development through engineering, gender often plays an important consideration when allocating engineers to EWB-UK projects. While the organization is estimated to be composed of 60 percent men and 40 percent women, women coordinate all six aspects of the EWB-UK program and have had a huge impact on increasing the amount of funding the charity receives (Rowley 2009). It is evident that females can thrive in engineering, but career possibilities, such as those like EWB, must be promoted to girls at an early age.

The Spring 2009 issue of *Energy Workforce* featured its Second Annual Women in Engineering Forum. The forum featured four female executives in the industry who were able to share their expe-

riences and thoughts on female advancement in the energy industry.

In order to advance one's career, Kristine J. Nichols, director of engineering at Nicor Gas, advises women to "objectively evaluate your past experiences, the value you currently add to your organization, and what experiences or skill sets you need to work on in order to be the best candidate for another opportunity" (*Power Engineering* Spring 2009:12). According to Betty Shanahan, CAE, F.SWE, executive director and CEO of the Society of Women Engineers, the key to female advancement in the energy industry is a commitment from top management. Once top management demonstrate their commitment to diversity, an "inclusive corporate culture [is created] where all employees can contribute" (*Power Engineering* 2009: 11).

Chemical & Engineering News annually surveys major, publicly traded U.S. chemical-producing companies. This year, 42 firms were studied via annual reports, proxy statements, and 10-K filings with the Securities and Exchange Commission. While some progress was made in the number of women in the boardroom, no overall changes occurred among the number of women serving in management (Tullo 2009). The average number of females serving as director of each company increased from 1.2 in 2008 to 1.3 in 2009, but only 0.9 female executive officers, on average, worked for each company in 2009, unchanged from 2008. Similarly, the proportion of 397 board positions held by women increased from 12.7 percent in 2008 to 13.9 percent in 2009, while only 8.6 percent of 428 executive officers surveyed were female in both 2008 and 2009. The chemical industry reached a milestone in 2009 when Ellen J. Kullman was made the CEO of DuPont and Lynn L. Elsenhans was appointed CEO of Sunoco (Tullo 2009).

Work experiences. There are various ways female engineers are

being trained for a more satisfying experience in the engineering work force. Ingram, Bruning, and Mikawoz (2009) administered an online survey to engineers from four Canadian companies to determine whether prior experience with the company improved their mentorship experiences. From the 344 male and the 70 female engineers who responded, the researchers were able to conclude that engineer-mentor relationships were more critical to females' job satisfaction than to males'. Additionally, female engineers who had undergraduate experience with a company were more satisfied with their growth opportunities than their male counterparts.

The Center for Work-Life Policy (CWLP) joined forces in 2004 with 35 global corporations to form CWLP's *Hidden Brain Drain Task Force*, which has conducted a number of studies on sustaining female and minority talent. One study, co-sponsored by Alcoa Inc., surveyed 2,300 male and female Alcoa employees with science or engineering degrees, supplemented by focus groups with women in engineering and technical fields (Robinson 2009). Accordingly, a number of factors contribute to the departure of women from science and engineering careers:

- *Dismissive and hostile workplace toward females in science and engineering*
- *Hours and expectations not supportive of working mothers*
- *Sense of isolation experienced when one is the only female at a certain level or on a team*
- *Frustration due to unclear channels to information and/or career advancement*

The study also described 14 programs that have begun to demonstrate success in retaining and advancing women. For example, Alcoa's Women in Operations Virtual Extended Network (WOVEN) allows female professionals to meet and support one another virtually. Another program by Alcoa, the manufacturing manager development program, addresses issues

related to career advancement and isolation by preparing junior candidates for line-management careers (Robinson 2009). According to Judi Nocito, assistant general counsel and co-leader of the Alcoa Women's Network, "this program offers women ... clear career plans so they can anticipate where they are going and can stay 'in the loop' from a networking standpoint" (Robinson 2009:96).

Research by Giles, Ski, and Vr-doljak (2009) examined the research career pathways for Australian science and engineering graduates. An electronic survey was completed by 1,206 postgraduates who had completed a research-based master's or Ph.D. in "natural and physical sciences," "engineering and related technologies," or "agricultural, environmental, and related studies" (i.e., SET) across the country. A smaller number of this group (n=123) responded to an invitation to answer additional questions as part of an e-mail case study. This latter group consisted of volunteers, posing a significant threat associated with response bias. That is, people who are eager to answer quite a few more survey questions are often different from those who do not volunteer to do so. The nature of the selection bias is that those who volunteer do so because the survey provides an outlet for "venting." That is, then, non-volunteers are perhaps more satisfied, so the volunteers represent a more extreme and negative viewpoint. The researchers concluded that Australian post-grads experienced high pressure and low job security in their research careers, forcing one-third of the respondents to move overseas for employment, with women feeling additional pressure from gender discrimination in traditionally male-dominated fields.

Conclusion

This year's literature provided a number of sources that shift our attention away from seemingly stale approaches to understanding women's persistent underrepre-

sentation in engineering and toward approaches that hold greater promise to address this important issue in a more comprehensive manner. Some would argue that women choose not to enter engineering; therefore, why is this a problem? In fact, engineers design our world. If we hope to see a world that reflects the rich diversity of human experiences, wants, and needs, then it is necessary that those who do the critical work of designing that world must represent that diversity. Should women be satisfied as mere consumers of the technology that is designed by others? Or should women assert an active role in designing those technologies?

The social construction of engineering work, as well as the research that has shifted our attention to *how* engineering is structured in colleges and in workplaces, pushes us to be attentive to the role of social forces in shaping the choices that are presented to individuals. Such social forces imply that limits, constraints, and information are not the same for all people at all times. Past research all too often has consisted of inventories of individual characteristics of engineers, showing whether men and women differ or are similar. Programmatic solutions that were derived from this literature have shown little progress in more than a quarter century.

Clearly it is time for new approaches and new ways of understanding *how* engineering, as a field designed by a particular group in a particular moment of time, needs to undergo change in order to enable broader participation. At stake is the future of our nation in the global innovation competition and the future of our world in the race to develop solutions to pressing global problems. Such solutions require full participation of our diverse human resources.

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Women in Engineering: 2010 Literature Review

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Research on women in engineering continued apace in 2010. For this literature review, we identified more than 120 resources, many of which were substantial contributions to the literature. Researchers made continued use of existing data sets (e.g., those collected by the National Science Foundation), but in the research published in 2010 there were also an impressive number of projects based on newly collected data. The good news, then, is that we are learning more about women in engineering; the bad news is that we continue to hear about ongoing obstacles to gender equality in the profession.

As in previous years, specific themes figure prominently in the research literature on women in engineering. Indeed, one of the more interesting aspects of working on this project is the opportunity to review previous years' literature reviews. One is struck by the fact that, while the research always tends to cluster around certain issues, some of these change from year to year. There is consistent, ongoing interest in certain themes, especially the recruitment and training of young women for the profession. However, attention to other topics, such as work/life balance, retention, globalization and its effects, workplace concerns, etc., has waxed and waned in ways that are sometimes difficult to account for.

The research reported in 2010 revealed a central focus on education. In fact, the majority of the articles we reviewed were concerned with some aspect of education. Within this broad area, much of the research

concentrated on students. There were numerous studies that attempted to identify factors that either encouraged or discouraged young women from pursuing an engineering degree. Others examined the role of various kinds of educational institutions such as community colleges, historically black colleges and universities, (HBCUs), etc. in training women engineers; while still others considered the matter of persistence — why do women students stay in or leave the engineering “pipeline”? Even the literature on women who had completed their training revealed an ongoing interest related to education, as there were many examples of research on women engineers and scientists in academics and on the continued shortage of female engineering professors, particularly at the senior level. Programs such as the National Science Foundation's (NSF) ADVANCE and the national discussion on the quality of scientific and technical education in the United States have undoubtedly helped to stimulate this research focus.

It is worth noting, however, the paradoxical character of this focus in the literature. While the research on education and academic women continues to produce important knowledge about factors influencing the supply of new female engineers, that same literature also has noted that labor supply may not be the biggest problem. A number of the studies we reviewed (as well as earlier research on similar questions) reported, in various ways, that the number of women being trained in engineering and scientific fields was

not being matched by an increase in the numbers of women in engineering and scientific careers. One would expect, then, that future research would expand the amount of attention being devoted to areas such as the nature of engineering labor markets, retention, and career satisfaction.

Also surprising was the relatively limited amount of research on engineering employment *outside* the academy. While there were some studies of engineers working in industry and government, these were outnumbered by studies of engineering education and university women. We were struck by how little research focused on such topics as work/family balance, employment security, pay equity, and career structures, which, in the past, had been at the center of the discussion. Does this mean that these issues have been resolved or that there is nothing new to learn about them? In view of the growing sense that retention, and not just recruitment, of women engineers is a crucial issue, we suspect that this is not the case.

Finally, it is worth noting the tendency in the literature to talk about science, technology, engineering, and math (STEM) employment generally — thereby lumping engineering together with other cognate fields. We encountered many studies that contained useful information about female engineers but were really focused on STEM employment as a whole. Perhaps this reflects the national debate about STEM education generally, and about the need to increase the numbers of American students and professionals

in these fields. But, it co-exists uneasily with the awareness that not all STEM fields are the same — the experiences of women in the life sciences and of women in engineering differ. Indeed, even engineering fields vary, with women more heavily represented in biomedical engineering than in mechanical engineering, for example. These distinctions certainly warrant additional research attention in the future.

In the literature review that follows, we have summarized the most important research articles on women in engineering published in 2010. We searched for articles by examining more than 70 journals that typically publish articles on gender and engineering in disciplines such as psychology, sociology, management, education, gender studies, and science and technology studies, as well as engineering; and by conducting keyword searches in a range of discipline-specific search engines to find articles in journals not specifically focused on engineering and gender. Reflecting the clustering of research interest, we have organized the review topically. As in previous years, the research we read was of varying quality and substance. We have tried to focus attention on the most rigorous pieces of research, and on research that underwent peer review before publication. We also point to any methodological limitations of the research we discuss.

Recruiting young women to engineering majors

As in previous years, researchers devoted quite a bit of attention to the factors that affect young women's decisions about an area of study, and specifically whether or not to study engineering. Dickson's (2010) large, careful study of more than 100,000 students in the University of Texas system confirmed that academic preparation is a very important factor affecting initial choice of major. However, the study also confirmed that gender is even more

significant — white women remain far less likely to choose engineering as a major than white men. Race, while less important, was also negatively correlated with a choice of engineering as a major, with African-Americans and Hispanics less likely to choose engineering. In this study,

women, generally, were also found to be more likely to switch out of engineering — which was confirmed by various other studies discussed below.

Since high school girls' preparation for engineering careers (e.g., math education) has improved markedly,

Women Engineering Deans

by Peggy Layne, P.E., F.SWE

Doreen Edwards, Ph.D.	Alfred University
Deirdre Meldrum, Ph.D.	Arizona State University
Cheryl B. Schrader, Ph.D.	Boise State University
Jane Matty, Ph.D.	Central Michigan University
Esin Gulari, Ph.D.	Clemson University
Gail Simmons, Ph.D.	College of Staten Island, City University of N.Y.
Sandra Woods, Ph.D.	Colorado State University
Susan M. Blanchard, Ph.D.	Florida Gulf Coast University
Melanie Hatch, Ph.D.	Gannon University
Stacy G. Birmingham, Ph.D.	Grove City College
Cherry Murray, Ph.D.	Harvard University
Elizabeth A. Eschenbach, Ph.D.	Humboldt State University
Natacha Depaola, Ph.D.	Illinois Institute of Technology
Sharon A. Jones, Ph.D., P.E.	Lafayette College
Sarah A. Rajala, Ph.D.	Mississippi State University
Nada Marie Anid, Ph.D.	New York Institute of Technology
Sandra J. DeLoatch, Ph.D.	Norfolk State University
E. Diane Rekow, Ph.D.	Polytechnic Institute of New York University
Leah H. Jamieson, Ph.D.	Purdue University, West Lafayette
Maria V. Kalevitch, Ph.D.	Robert Morris University
Deborah Huntley, Ph.D.	Saginaw Valley State University
Belle Wei, Ph.D.	San Jose State University
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Borjana Mikic, Ph.D.	Smith College
Lynne A. Molter, Ph.D.	Swarthmore College
Laura J. Steinberg, Ph.D.	Syracuse University
Linda Abriola, Ph.D.	Tufts University
Cherrice Traver, Ph.D.	Union College
Linda C. Lucas, Ph.D.	University of Alabama, Birmingham
Mary L. Good, Ph.D.	University of Arkansas, Little Rock
Cammy R. Abernathy, Ph.D.	University of Florida
Kathleen A. Kramer, Ph.D.	University of San Diego
Jane S. Halonen, Ph.D.	University of West Florida
D. Joanne Wilson, Ph.D.	University of Wisconsin, Platteville
Pamela Leigh-Mack, Ph.D.	Virginia State University
Candis S. Claiborn, Ph.D.	Washington State University
Julie R. Ellis, Ph.D.	Western Kentucky University
Zulma Toro-Ramos, Ph.D.	Wichita State University
T. Kyle Vanderlick, Ph.D.	Yale University

researchers have turned their attention to other factors that might encourage or discourage girls from entering engineering programs. Several studies emphasized the important role played by parents in encouraging and supporting students' interest in engineering. Aschbacher, Li, and Roth (2010) reported on a mixed-methods study of 33 California high school students who were interviewed twice and surveyed three times over the course of three years, noting that students' commitment to a STEM career dropped during high school and that a lack of advocates at home was part of the problem. Hoffman et al.'s (2010) exploratory study of engineers and their daughters also pointed to the fact that "parents can shape their daughters' perceptions of engineering in powerful ways" (p. 237). The study is limited, however, by the fact that it only considers four families with a similar socioeconomic background. Fouad et al. (2010) found that parents' influence was strongest on middle-school students.

Two studies suggested that the "match" between students and the characteristics of people working in a given field may affect students' willingness to enter it. Cheryan and Plaut's (2010) study of a convenience sample of college students found that women were less interested in computer science than men and that this was related to the fact that they perceived themselves as not being like the computer scientists; the reverse was true for interest in majoring in English. Since studies of persistence in engineering (e.g., Alpay et al. 2010) found that women are less likely to see a good "fit" between themselves and engineering careers, this study hints at a possible barrier to women's entry to the profession.

A second study of a sample of undergraduates, by Rosenberg-Kima et al. (2010), involved changing the race and gender of computer-animated agents in a video about engineering and found that respondents' likelihood of endorsing

gender stereotypes was affected by the gender of the "agent." The authors point to the fact that the lack of role models is often cited as a deterrent to women and minority group members entering engineering. Research on persistence in engineering also finds that similarities between students and teachers have an effect on whether students continue their course of study, but the effect is complicated, as described in the next section.

Related literature argues that women "avoid" STEM careers because they perceive these fields as unsuited to their goals, values, and/or interests. A typical example is Diekman et al.'s (2010) psychological study of a convenience sample of just over 300 undergraduate students. They argue that women's low numbers in STEM careers must be specifically related to the perceived characteristics of STEM careers, since other difficult-to-enter careers such as medicine or law have higher percentages of women. The study finds that women are more oriented than men to "communal" goals, such as helping others or serving humanity; that STEM careers are perceived as less consistent with these goals; and that, as a result, women's interest in those careers is lowered by their commitment to communal goals even when they are strongly prepared academically for STEM programs. Oehlberg, Shelby, and Agogino (2010) report on an effort to make a first-year mechanical engineering course more accessible to women and minorities by focusing on "sustainable human-centered design." While the study is not generalizable (being focused on a very specific course), it does provide suggestive evidence that projects with social relevance are particularly appealing to female students considering engineering.

The fact that young women continue to be reluctant to enter engineering programs implies the need for positive efforts to

recruit them. Several articles we reviewed took up this issue, although inconclusively. Sinkele and Mupinga's (2010) "literature review" (how the literature was selected is not made clear, however) supports the hypothesis that "all-girl workshops, to some extent, do increase the number of females pursuing an engineering degree" (p. 41). In contrast, Molina-Gaudo et al.'s (2010) study of Spanish high school students found that a one-day outreach workshop had little effect on the intent to study engineering. They call for an earlier intervention, but their data don't provide much empirical support for this conclusion. Townley (2010) responds to an earlier article by Bouville, arguing that outreach programs are both needed and effective; where Bouville concluded that such programs were coercive, Townley argues that they merely help young women make informed choices.

Persistence

Scholars have now recognized that increasing the numbers of women engineers is not simply a matter of increasing the numbers of students entering engineering majors, but also of taking steps to ensure that women persist in engineering majors. It is frequently argued that women are more likely than men to leave engineering in favor of a different major; many of the studies we reviewed were attempts to understand why this is so and what might be done to encourage women to stay. Much of what these studies found is relatively familiar, but worth reviewing.

High "mortality" rates among engineering students of both sexes are a major concern in the profession. Kokkelenberg and Sinha's (2010) study of Binghamton University undergraduates between 1997 and 2007 found that 50 percent switched out of engineering. Preparation was the key to persistence for both genders. Eris et al.'s (2010) study of 160 undergraduates at four institutions extends previous research in this

area by developing and evaluating a series of “constructs” hypothesized to be associated with persistence in engineering. Their sample is somewhat unrepresentative, since attrition was relatively low (only 25 percent) and they oversampled women. The constructs included influence of parents, influence of mentors, confidence in various skills, perceived importance of various skills, curriculum overload, and a range of others. Most of the constructs were found *not* to be related to persistence or nonpersistence in engineering, but lack of confidence in math and science skills did matter.

While neither of these studies found differences between men and women, others find that women are less likely to persist and/or drop out for somewhat different reasons. The most frequently mentioned factor in the literature was the question of confidence. Two (2010) studies of first-year students (Jones et al.; Meyers et al.) reported that women score lower on measures of self-efficacy and express lower confidence in their skills. This, rather than gender itself, is held responsible for lower rates of persistence among these students. Alpay et al.’s (2010) study of European graduate students found that women had less confidence in their skills, particularly in “group work and communication within the research area” (p. 143).

Perhaps related to this, women’s lower persistence was found to be associated with experiencing a smaller degree of “fit” with engineering. This made them less likely to expect to go on to work in engineering careers. Concannon and Barrow (2010) studied 493 undergraduate engineers at a Midwestern university, finding that the best predictor of persistence was career-outcome expectations. Unfortunately, their methodology is not adequately described, so our ability to extrapolate and generalize the findings is minimal. Amelink and

Creamer’s (2010) rich exploratory study used material from the *Student Persisting in Engineering Survey* to examine 1,629 undergraduates over a five-year period; they conclude that satisfaction with the major does not vary by gender, but that men are significantly more likely to expect to be working in engineering 10 years hence than are women. Matusovich et al. (2010) and Alpay et al. (2010) both found that women are more likely to question their “fit” with engineering work, which may help to explain why growth in the numbers of women in engineering programs has not translated immediately into larger numbers of employed female engineers.

At least two other interesting persistence-related issues were raised in the literature. Two studies examined the effect of student grades on persistence, but came to different conclusions about gender differences in this area. Concannon and Barrow’s study (described earlier) found that women are more likely to persist if they expect to get A or B grades, while men are more likely to persist if they expect to complete their courses (suggesting that women hold themselves to a higher standard). However, Griffith’s (2010) analysis of data from two national samples was inconclusive on this point. The samples were from the “National Longitudinal Study of Freshmen (NLSF)” that followed students entering 28 selective colleges and universities in 1999, and the “National Education Longitudinal Study of 1988 (NELS),” which followed a cohort of eighth-graders in 1988 as they progressed through high school and completed college. The NLSF data suggested that women were actually *less* sensitive to lower grades than men, but the NELS data did not support this conclusion. Evidently, this is an area in which further research is needed.

A final theme in the literature on persistence concerned the effect of “departmental demography.” Does it

matter whether faculty and students in the program are predominantly white and male? Interestingly, despite the argument that a lack of role models helps to deter women from entering engineering, both Griffith’s (2010) and Price’s (2010) studies of a large cohort of Ohio freshmen concluded that a high number of female faculty members is actually associated with lower persistence in STEM fields. Indeed, Price found that this was true, specifically, for female students. In contrast, a study by Amelink and Creamer (2010) found that having interactions with female role models was a positive factor for female engineering students. One might ask whether this difference is because Amelink and Creamer studied engineers, not STEM majors in general, suggesting the shortcomings of lumping all STEM disciplines together. Having faculty who are members of minority groups is associated with higher persistence among minority group undergraduates. Griffith’s study showed that persistence among female and minority group respondents to the NLSF was higher in schools where there were higher percentages of minority group and female students.

The research on departmental demographics may shed light on other research findings about the importance of good social relationships to women’s persistence in STEM. Amelink and Creamer (2010) found that having good relationships with peers was particularly important for female students. This, in turn, may be consistent with Morganson, Jones, and Major’s (2010) psychological analysis of the role of coping strategies among 1,061 undergraduates at two East Coast universities, one of which was a historically black college or university (HBCU). They found that female students cope differently than male students: Where men try to change

or ignore stressors, women are more likely to cope by seeking support from other students (“social support coping”). On this basis, they speculate that the “chilly climate” other researchers have identified in STEM fields may inhibit female coping strategies and make it more likely that they will leave the field.

These complex, and somewhat contradictory, findings on the effect of diversity on community and persistence, as well as Wao, Lee, and Borman’s (2010) suggestive finding that students in Florida engineering programs experienced, but had difficulty articulating, incidents of racism and sexism, point to the need for further research on the effects on *students*, not just faculty, of factors such as departmental diversity and climate. The very high rates at which students in general, and female students in particular, leave engineering programs indicate that learning more about these issues is of great potential importance.

Institutional Types — Community Colleges

In July 2009, President Obama announced an initiative to enable community colleges to boost graduation rates, improve facilities, and develop new technology. The initiative was aimed, in some degree, at Rust Belt states where opportunities for workers without significant education are atrophying. One consequence of the president’s focus on community colleges was to redirect scholarly interest toward expanding the role of this type of academic institution.

While not, strictly speaking, a response to the Obama administration’s policies, the special issue on community colleges published by the *Journal of Women and Minorities in Science and Engineering* (2010) is an example of this renewed interest in two-year institutions. It discusses the potential of community colleges as a source for students to enter STEM disciplines,

focusing particularly on what role they might play in providing access and opportunity for women and ethnic minorities to pursue STEM education.

Hardy and Katsinas (2010) reviewed National Center for Education Statistics (NCES) Integrated Postsecondary Education Data System (IPEDS) data for the period 1985 to 2005, focusing on public institutions granting associate’s degrees. They find an increase in the numbers of women receiving STEM degrees, yet at 22.6 percent, women remain a minority of those receiving such degrees from two-year institutions. Women’s still-small number of STEM associate’s degrees contrasts with the fact that they receive a significant majority of associate’s degrees overall, at 63.4 percent. Moreover, the authors note that in 2005, the number of associate’s degrees awarded to both men and women in engineering, engineering technology, and science was actually *lower* than in 1985, despite a rebound in the early 21st century.

Hagedorn and DuBray (2010) reported on a transcript analysis of students in the Los Angeles Community College District that examined 5,011 students enrolled in 241 classes. Although the study did not focus primarily on gender, almost 60 percent of the respondents were women. It found that only a small fraction of students interested in STEM careers actually transferred to a four-year institution. The primary barrier to success in STEM programs in the LA district was found to be inadequate math preparation, not race or gender.

Starobin and Laanan (2010) analyzed the NSF Survey of Doctorate Recipients and found that women, minority group members, and Ph.D.s who are first-generation college students are more likely to stay in their home state than are others. They argue that this points to the importance of community colleges for these groups’ access to STEM degrees, but their data do not allow them to

support this claim, because the NSF data do not contain information about community college degrees.

Hoffman, Starobin, Laanan, and Rivera (2010) concluded the special issue of the *Journal of Women and Minorities in Science and Engineering* with a set of policy recommendations emphasizing the need for better advising of potential STEM students, better coordination between two- and four-year institutions, and encouragement and validation of women and minority students in these fields. Overall, the articles in this special issue point to the conclusion that community colleges are important to female and minority students, but their impact on the numbers of women and minority group members in STEM disciplines is, at this point, somewhat limited.

Women Engineers in Academia

A large portion of the research literature on women in engineering in 2010 focused on women in academic careers. Within this literature, a number of the studies were either funded by NSF-ADVANCE or were responding to or commenting on aspects of an ADVANCE program. Most of the research focused on one of two “stages” in the academic career: the recruiting process and first job; and, retention and promotion of experienced women faculty.

Recruiting. McNeely and Vlaicu (2010) reviewed recent trends in initial hires of STEM faculty, using data from the Integrated Postsecondary Education Data System and data on degree attainment gathered by the NSF. They note that while women now earn almost 40 percent of advanced degrees in STEM fields, the numbers of women faculty do not match this rate. Their analysis of hiring patterns shows considerable variability by field and institution. Ironically, they find proportionally larger pools of applicants in fields where there are fewer female Ph.D.s (physics, engineering) than in supposedly female-friendly fields such as biology.

In addition, schools with relatively few female STEM faculty were more likely to show recent gains than schools with relatively more female STEM faculty. The authors speculate that there may be a plateau effect at work — efforts to recruit female faculty are more likely when women faculty are scarce; when women are somewhat more common, complacency sets in. Chesler, Barabino, Bhatia, and Richards-Kortum's (2010) analysis of declines in the numbers of women in the female-friendly field of biomedical engineering should probably be put in this context.

It also makes sense, in light of McNeely and Vlaicu's findings, that several articles scrutinized the search process itself, identifying it, not the supply of candidates, as the problem. Hemami and van der Meulen's (2010) amusing commentary piece effectively debunks a number of the common myths used to explain away the failure to hire more women faculty: "There are no women scholars in our field"; "She'll never come here, her husband is in ... fill in the blank"; "We need quality, not diverse faculty members"; etc. Tyson and Borman (2010) echo one of Hemami and van der Meulen's comments as their analysis of interviews with 10 tenured female faculty in the Florida system — part of a larger NSF-funded project — reports that male faculty tend to see recruiting women as a problem for female faculty to resolve.

Practical advice about how to overcome such problems is offered by Bilimoria and Buch (2010). They report on two NSF-ADVANCE-funded projects, one at Case Western Reserve University and the other at the University of North Carolina-Charlotte. This particular article is based on analysis of 193 STEM searches at the two schools during the time period of 2001-7 at CWRU, and 2003-8 at UNC-Charlotte. They note research indicates that women applicants are more fairly reviewed when women

constitute at least 30 percent of applicant pools; the two ADVANCE programs had successfully raised the proportion of women in applicant pools above that mark. They did so by combating problems identified with traditional searches, such as:

- passivity (expecting that potential applicants will apply)
- time-limitedness (not engaging in ongoing recruiting efforts)
- non-inclusivity (only involving search committee members)
- non-diversity (allowing search committees to reflect existing departmental demography)
- inexpertise (not training faculty in search and hiring techniques)
- unconscious bias

Techniques used to overcome these shortcomings in the recruitment process included training search committee members; providing search committees with effective resources and tools for conducting inclusive searches; making efforts to align searches with institutional commitments to diversity; and encouraging faculty to recruit year-round, at conferences, meetings with colleagues, etc.

Another approach to increasing the number of female applicants is suggested by Bhatia and Amati's (2010) research. They provide assessment data from the first two years of the Women in Science and Engineering — Future Professionals Program (WiSE-FPP) at Syracuse University, a program designed to "prepare women graduate students in STEM for leadership roles in their respective fields" (p. 5). Participants reported that the most beneficial aspect of the program was the peer mentoring component/opportunities to interact "with other women graduate students who were going through the same types of experiences" (p. 7). The program helped them overcome isolation and build confidence that they could handle the "multiple roles of teacher, scholar, wife, and mother" (p.8). While their study is not able to follow

these graduate students into the labor market, it may be that the increased confidence these students develop will encourage them to seek academic positions they might otherwise have shied away from.

A direction for future research on recruitment is suggested by Leggon's (2010) comment on diversifying science and engineering faculty. She notes that there is a tendency in the literature on STEM faculty to ignore the intersection of race, ethnicity, and gender. Problems recruiting women are discussed in one place; problems recruiting minority faculty in another. However, the recruitment of minority female faculty is rarely discussed, although they are the least represented group on university faculties and are the most likely to be in marginal academic positions. She calls for more attention to particular subgroups of women in this light.

Retention and promotion.

The awareness that increasing the numbers of women faculty is not just a matter of recruiting women but also of nurturing them once hired underlies the numerous articles we read exploring the experiences of academic women beyond graduate school. Retention of female faculty continues to be a major issue.

Tyson and Borman (2010) conducted interviews with 10 tenured female faculty in Florida, finding that it was the characteristics of departments, not the behaviors of female faculty, that were crucial to retention. Specifically, they report that the women they interviewed were frustrated with their isolation; they often had to seek female collaborators and/or colleagues outside their home departments and institutions. These faculty didn't believe gender alone accounted for their isolation, but Tyson and Borman note that collegiality seemed more important to female faculty, making this a significant issue to be addressed.

Fox (2010) conducted a mailed survey of more than 1,100 STEM faculty, of which just under half

were women, in an effort to explore “organizational” issues that affect female faculty’s participation, performance, and advancement. Her study focused on four social-organizational features of academic work: frequency of speaking with faculty in one’s home unit about research; ratings of aspects of one’s position and department; characteristics of departmental climate; and levels of interference between work and family. She found that female faculty were more likely to report infrequent, meaning less than weekly, conversations about research; reported a lower sense of inclusion; less access to equipment; and a smaller amount of recognition from colleagues. Female faculty were more likely to describe their departments as stressful, and less likely to call them informal, exciting, or creative. Finally, women were more likely than men to report reciprocal interference between work and family. Fox suggests that this points to the need for institutional policies designed to counter these negative experiences.

The issue of the isolation of women faculty also is raised by Feeney and Bernal’s (2010) analysis of women’s presence in STEM networks. They used data from a national survey of scientists (NETWISE) in six fields, of which one is electrical engineering, to examine whether women are present in the collegial networks of male and female scientists, and whether men and women consult with female colleagues in the same ways. Not surprisingly, they find that men are more likely to report that they have no women in their network. This was the case for about 50 percent of male electrical engineers, for example, as opposed to 30 percent of female electrical engineers. They also note that while women are more likely to consult other women about a wide range of professional and personal issues, by a significant margin the most common reason for doing so is work/family

2010 Outstanding Women in Engineering

by Molly R. Hall

American Society for Engineering Education (ASEE) Awards

Sharon A. Keillor Award for Women in Engineering Education

Kauser Jahan, Ph.D., Rowan University

James H. McGraw Award

Marilyn Dyrud, Ph.D., Oregon Institute of Technology

Meriam/Wiley Distinguished Author Award

Johnna S. Temenoff, Ph.D., Georgia Tech/Emory University

Fellow Member Honorees

Lia Brillhart, Triton College

Joan Gosink, Ph.D., Colorado School of Mines

Lueny Morell, P.E., Hewlett Packard Laboratories

Teri Reed-Rhoads, Ph.D., Purdue University

Jennifer Sinclair Curtis, Ph.D., University of Florida

Bevlee Watford, Ph.D., P.E., Virginia Tech

William Elgin Wickenden Award

Demei Shen, Ph.D., University of Missouri-Columbia

Rose M. Marra, Ph.D., University of Missouri

Jenny Lo, Ph.D., Virginia Tech

ASEE Section Awards

Midwest Section:

Outstanding Teaching Award

Julia Keen, P.E., Kansas State University

Middle Atlantic Section:

Outstanding Campus Representative Award

Sharon A. Jones, Ph.D., P.E., Lafayette College

Best Paper Award

Hong Li, Ph.D., New York City College of Technology of CUNY

Jenn Rossmann, Ph.D., Lafayette College

Karina Skvirsky, Lafayette College

Pacific Southwest Section:

Outstanding Community College Educator Award

Kate Disney, Mission College

Southeast Section:

Best Paper Award

Judy Schneider, Ph.D., Mississippi State University

Keisha Walters, Ph.D., Mississippi State University

New Faculty Research Award (1st Place)

Holly Stretz, Ph.D., Tennessee Technological University

New Teacher Award

Tanya Kunberger, Ph.D., Florida Gulf Coast University

Thomas C. Evans Instructional Paper Award

Julie Trenor, Ph.D., Clemson University
St. Lawrence Section:

Outstanding Educator Award

Joan V. Dannenhoffer, P.E., Morrisville State College

ASEE Professional and Technical Division Awards

Biomedical Engineering Division:

Best Paper Award

Alyssa Taylor, University of Virginia

Katelyn Mason, University of Virginia

Shayn Peirce, Ph.D., University of Virginia

College/Industry Partnerships Division:

CIEC Best Session Award

Letha Hammon, DuPont Corporation

Terri Morse, The Boeing Company

Continuing Professional Development Division:

CIEC Best Workshop Award

Marie-Pierre Huguet, Ph.D., Rensselaer

Polytechnic Institute

Deb Manzo, Ph.D., North Carolina

State University

Certificate of Appreciation

Lynda Coulson, Rolls-Royce Corporation

Certificate of Merit

Kim Scalzo, State University of New York

Cooperative and Experiential Education Div:

Lou Takacs Award

Candee Chambers, American Electric Power

Best Workshop

Gayle Elliott, University of Cincinnati

Kara Leonard, Rochester Institute of

Technology

Michelle McGee, Rochester Institute of Technology

Best Session

Suzanne Norris, University of Alabama-Huntsville

Debe Williams, University of Illinois

Educational Research and Methods Division:

Benjamin Dasher Award

Glenda Stump, Arizona State University

Jenefer Husman, Ph.D., Arizona State

University

Wen-Ting Chung, Arizona State University

Best Paper Award

Lisa Lattuca, Ph.D., Pennsylvania State University-Main Campus

Energy Conversion and Conservation Division:

Best Paper Award (2nd Place)

Eileen Cashman, Ph.D., Humboldt State University

Engineering Design Graphics Division:

Chair's Award

Marie Planchard, SolidWorks Corporation
Jennifer McDonald, Daniel Webster College
Alexandra Sobin, Daniel Webster College

Engineering Economy Division:

Eugene L. Grant Award

Alisha D. Youngblood, Ph.D., Southeast Missouri State University

Engineering Libraries Division:

Best Poster Award

Karen Andrews, University of California-Davis

Jean McKenzie, University of California-Berkeley

Lisa Ngo, University of California-Berkeley
Emily Stambaugh, California Digital Library

Best Publication Award

Meghan Lafferty, University of Minnesota

Engineering Management Division:

Bernard R. Sarchet Award

Susan Murray, Ph.D., P.E., Missouri University of Science and Technology

Best Paper Award

Suzanna Long, Ph.D., Missouri University of Science and Technology

Jane Fraser, Ph.D., Colorado State University at Pueblo

Best Presentation Award

Susan Murray, Ph.D., P.E., Missouri University of Science and Technology

Engineering Technology Division:

Best Session Award

Marilyn Dyrud, Ph.D., Oregon Institute of Technology

Joy L. Colwell, J.D., Purdue University-Calumet

Best Conference Presenter

Marilyn Dyrud, Ph.D., Oregon Institute of Technology

Environmental Engineering Division:

Best Paper Award

Kristen Sanford Bernhardt, Ph.D., Lafayette College

Sharon Jones, Ph.D., P.E., Lafayette College
Jacqueline Isaacs, Ph.D., Northeastern University

Early Career Grant

Nicole Berge, Ph.D., University of South Carolina

International Division:

Global Engineering and Technology Award

Linda Phillips, University of South Florida

Best Paper Award

Beena Sukumaran, Ph.D., Rowan University

K-12 Division:

Best Paper Award

Christine Schnittka, Ph.D., University of Kentucky

Carol Brandt, Ph.D., Virginia Tech

Liberal Education Division:

The Sterling Olmstead Award

Julia Williams, Ph.D., Rose-Hulman Institute of Technology

Mechanical Engineering Division:

Best Paper Award

Carolyn Conner Seepersad, Ph.D., University of Texas at Austin

Katja Holtta-Otto, Ph.D., University of Massachusetts-Dartmouth

Best Paper Award (Honorable Mention)

Debra Mascaro, Ph.D., University of Utah

Stacy Bamberg, Sc.D., University of Utah

Alice Kendrick, Ph.D., Southern Methodist University

Women in Engineering Division:

Denice D. Denton Best Paper Award

Rachelle Reisberg, Ph.D., Northeastern University

Margaret Bailey, Ph.D., P.E., Rochester Institute of Technology

Carol Burger, Ph.D., Virginia Tech

Women in Engineering ProActive Network (WEPAN) Awards**WEPAN Distinguished Service Award**

Martha Cyr, Ph.D., Worcester Polytechnic Institute

WEPAN Educator's Award

Sarah Rajala, Ph.D., Mississippi State University

WEPAN Founders Award

Cathleen Barton, Intel

WEPAN Betty Vetter Award for Research

Elizabeth Creamer, Ed.D., Virginia Tech

Peggy Meszaros, Ph.D., Virginia Tech

WEPAN University Change Agent Award

Helen Buettner, Ph.D., Rutgers University

WEPAN WIE Champion Award

Sandra Witman, DuPont

The National Academy of Engineering**Arthur M. Bueche Award**

Anita Jones, Ph.D., University of Virginia

New Female Members

Lisa Alvarez-Cohen, Ph.D., University of California-Berkeley

Cynthia Barnhart, Ph.D., Massachusetts Institute of Technology

Rebecca M. Bergman, Ph.D., Medtronic Inc.

Maryellen Giger, Ph.D., University of Chicago Medical Center

Irene Greif, Ph.D., IBM Thomas J. Watson Research Center

Laura Haas, Ph.D., IBM Almaden Research Center

Society of Women Engineers (SWE) Awards**Achievement Award**

Chieko Asakawa, Ph.D., IBM Research

Upward Mobility Award

Gayle Roberts, P.E., Stanley Consultants

Resnik Challenger Medal

Elizabeth Sholes, Ball Aerospace and Technologies Corp.

Entrepreneur Award

Sandra C. Scanlon, P.E., LEED® AP, Scanlon Szynskie Group Inc.

Work/Life Balance Award

Debbie Edwards Veihdeffer, Northrop Grumman Corporation

Emerging Leader Award

Helen M. Phillips, Northrop Grumman Corporation

Karla Tankersley, The Kroger Company

Tamaira Ross, The Boeing Company

Claire Jung, Ph.D., Texas Instruments

Anisha Ladha, Intel Corporation

Jill Sciarappo, Intel Corporation

Michele Van Dyke-Lewis, Ph.D., Lockheed Martin

Distinguished New Engineer Award

Missy M. Brost, The Boeing Company
Kerrie Greenfelder, P.E., CDM

Tina Haley, The Walt Disney Company

Erin McGinnis, The Boeing Company

Kelly Griswold Schable, The Boeing Company

Fellows

Alma Kuppinger Forman, P.E., Retired
Jane Knoche, P.E., Federal Aviation Administration

Wendy Schauer Landwehr, Northrop Grumman Corporation

continued on page 190

2010 Outstanding Women in Engineering

continued from page 189

April Renee Lauper, D.B.A., P.E., KBR
Terri Fraser Morse, The Boeing
Company
Mary D. Petryszyn, Raytheon
Company
Linda Reed, Northrop Grumman
Corporation

Distinguished Service Award

Yvonne Brill, Consultant
Marjorie Inden, Morgan Stanley
Smith Barney, LLC
Marilee Wheaton, The Aerospace
Corporation

Outstanding Faculty Advisor Award

Louise Stark, Ph.D., University of
the Pacific

Outstanding Counselor Award

Karen J. Horton, P.E., University
of Maine

Outstanding Collegiate

Member Award

Theresa LaFollette, Ph.D., Carnegie
Mellon University
Michelle Oswald, University of
Delaware
Anne Silverman, Ph.D., University of
Texas at Austin
Katherine Gage, California Polytechnic
State University, San Luis Obispo
Lesley Telford, California Polytechnic
State University, San Luis Obispo
Katie Tepper, University of Missouri
Jenny Tsao, University of Illinois at
Urbana-Champaign
Amanda Wachtel, University of
Alabama

The Anita Borg Institute for Women and Technology Awards

Innovation Award

Kathleen R. McKeown, Ph.D.,
Columbia University

Social Impact Award

Lila Ibrahim, Intel Corporation

Leadership Award

Kristina M. Johnson, Ph.D., Under
Secretary for Energy

Intel Science Talent Search Awards

Erika DeBenedictis, first place,
New Mexico
Lynnelle Ye, fourth place, California
Katherine Rudolph, eighth place,
Illinois
Linda Zhou, tenth place, New Jersey

National Society of Black Engineers (NSBE) Awards Lifetime Achievement in Academia Minority Engineering Program Director of the Year

Amy L. Freeman, Ph.D., The
Pennsylvania State University

Dr. Janice A. Lumpkin Educator of the Year

Mary W. Stroud, Xavier University

Graduate Student of the Year Mike Shinn Distinguished Member of the Year (Female)

Sophoria N. Westmoreland, University
of Maryland, College Park

Pre-College Initiative Program of the Year

Beverly Johnson, Polytechnic
Institute of New York University

Pre-College Initiative Student of the Year (Female)

Sydney S. Steward, North Carolina

Pre-College Initiative Director of the Year

Margaret C. Tarver, Georgia

Alumni Extension Member of the Year

Ivy White, Central Ohio Alumni
Chapter, Honda Manufacturing of
America

Alumni Extension Technologist of the Year

Jamie Haynes, Region V Member-At-
Large, The Boeing Company

Society of Hispanic Professional Engineers (SHPE) Awards

Hispanic in Technology, Government Award

Enid Marie Sanchez-Bubb, Naval Air
Systems Command

Honorary Member Award

Erica Reynosa, Lockheed Martin
Corporation

American Indian Science and Engineering Society (AISES) Awards

Technical Excellence Award

Karen McDaniel, Sandia National
Laboratories

Most Promising Engineer/Scientist Award

Karletta Chief, Ph.D., Desert Research
Institute

concerns. This may be evidence that female faculty are finding the kind of collegial support they desire; on the other hand, as Feeney and Bernal suggest, it may also point to a degree of separation between male and female faculty that isn't so positive.

One aspect of the conflict between work and family roles is well-described in an article by Schiebinger and Gilmartin (2010) published in *Academe* and summarized by Laster (2010) in *The Chronicle of Higher Education*. Research conducted by the Michelle R. Clayman Institute for Gender Research at Stanford University — the Managing Academic Careers Survey of 1,222 tenured and tenure-track faculty in the natural sciences — showed that female scientists undertake more household tasks than their male counterparts. Where the female scientists did 54 percent of the core tasks in their households, such as cooking, cleaning, laundry, etc., their male counterparts did only 28 percent of those tasks. In other words, female faculty continue to get less help from their partners than male faculty, increasing the burden for female faculty to balance work and family responsibilities.

Mack et al. (2010) argue that feelings of empowerment are important to the development and retention of female faculty. They distinguish between structural empowerment, the sharing of power with those in authority, and individual empowerment, which derives from the intrinsic rewards of work, and question whether gender affects how empowerment develops. Their analysis of 650 online questionnaires returned by faculty at HBCUs, a type of institution known to be unusually successful in nurturing female STEM faculty, found no significant gender differences in feelings of empowerment. However, they did find that factors predicting various forms of empowerment *did* vary by gender. Their results are too complex to summarize here, but they point to policy interventions that might

encourage the development of feelings of empowerment among female faculty and, in turn, help to retain and promote them.

The underrepresentation of female STEM faculty in leadership positions was the focus of two articles we reviewed. Layne (2010) notes that only 69 women have served as deans of colleges of engineering in the United States (38 are doing so in 2010). She interviewed 21 female deans of engineering and reported their comments on how they juggled multiple responsibilities, their career paths into administration, and their leadership styles. Some reported that their gender did not affect their leadership style, but others gave evidence of favoring a more “transformational” style of leadership, focused on empowering subordinates, than their male counterparts.

O’Bannon et al. (2010) examined the Leadership Institute, an NSF-funded program to encourage female faculty in science and engineering to prepare for leadership roles. Three cohorts of 15-30 female faculty attended two two-day sessions where they followed a curriculum developed by the University of Missouri-Kansas City’s faculty in nonprofit leadership. Evaluation data indicated that the participants had enhanced leadership skills and were satisfied with the experience. Few of the non-administrators among the participants had moved into administrative roles at the end of the time period under review; however, many of them were performing “leadership” activities in their professional associations and academic departments, such as chairing committees, serving as associate chairs, etc.

Efforts to improve the recruitment, retention, and promotion of female faculty depend on institutional and social support for those efforts. Two articles we reviewed comment on important aspects of these supports. June (2010) notes that NSF-ADVANCE funding provides significant help to institutions seeking

to improve the status of female faculty in STEM fields. However, this funding is time limited, so the question arises of how to sustain the gains made after the grant expires. Her review of this question notes that doing so is often difficult and depends on administrative commitment, which may or may not be present, and on the ability of universities to find alternative sources of funding to sustain some of the activities initiated during the grant period.

Walters and McNeely (2010) discuss one of the legal tools available to those seeking to improve the diversity of STEM faculties — Title IX. They note that, while this is widely regarded as a law applicable only to athletics, it actually covers a wide range of areas, including employment issues such as hiring, compensation, family responsibilities, sexual harassment, and work environment. The use of Title IX to handle faculty diversity issues has been limited, in part by congressional reluctance, in part by practical problems such as individual fear of retaliation, the high cost of legal action, and by the reality that the government relies heavily on institutions themselves to ensure compliance. Nevertheless, they argue that the existence of Title IX represents a potentially powerful legal mechanism for ensuring gender equity in universities generally, and STEM faculties in particular.

Women engineers and the workplace

We found a relatively limited amount of new research on women engineers employed outside the academy. Although there is a substantial body of ongoing research on professional workplaces generally, focusing on issues such as the conflict between work and family roles, glass ceilings/glass escalators, pay equity and employment security, researchers examining these questions do not appear to be focusing on engineers specifically. This is disappointing, because engineering is one of the

largest professional occupations in the United States, one of the least gender-balanced, and, because occupation-specific research that does not assume all STEM occupations are alike is badly needed.

Career advancement and moving into senior-level positions was one major theme in the literature we did identify. Researchers adopted various approaches to this question. Wirth (2010) reported on interviews conducted with an unspecified number of women who served on the boards of engineering companies. Her approach was to ask her respondents for advice about traits they associated with their own success. Her list of five very general “traits” includes persuasive communication, leading with your heart, taking care of yourself, seeing the big picture, and knowing yourself. This list does not produce concrete career-building advice to younger women; moreover, since there is not a comparison group of women who did *not* achieve board-level positions, it is difficult to know whether these traits really differentiate successful women from those who are not.

Ramaswami et al. (2010) adopted a more sociological approach, examining the effect of mentors on career success for professional and managerial women, including those working in engineering companies. This is well-trodden ground, but the study attempts to specify the effect of particular kinds of mentors in particular settings. The authors analyzed a sample of 491 graduates of a relatively large, selective private university in the Midwest and found that female professionals and managers benefit particularly from having a senior male mentor when they are employed in “male-gendered” industries (they characterize engineering as one of these). This finding alerts us to the possibility that mentoring, networks, and other social relationships may have different consequences in sociologically different settings.

The other major employment-related theme addressed by researchers in 2010 was retention. Cha (2010) analyzed longitudinal data from the Survey of Income and Program Participation, which allowed her to follow the careers of a large sample of workers, including more than 8,000 professionals, over a

Engineering Degrees and Faculty Data

By Peggy Layne, P.E., F.SWE

The American Society for Engineering Education (ASEE) collects information about enrollment, degrees awarded, and faculty composition at 343 engineering schools in the United States and 10 in Canada. ASEE makes these data available annually on its website at <https://www.asee.org/papers-and-publications/publications/college-profiles>.

As shown in Chart 1, Engineering Degree Attainment by Gender, there has been little change in the proportion of engineering degrees awarded to women over the past 10 years. In the 2008-09 academic year, women earned a slightly lower percentage of the

engineering bachelor's degrees than they did in 1999-2000 (17.8 percent vs. 20.8 percent), but a slightly higher percentage of Ph.D. degrees (21.2 percent vs. 15.9 percent). To put these numbers in perspective, in 2007-08 women earned 57.3 percent of all bachelor's degrees awarded in the U.S. (National Center for Education Statistics, Fast Facts, <http://nces.ed.gov/FastFacts/>), but only 3 percent of bachelor's degrees earned by women are in engineering or computer science fields, while 15.2 percent of all bachelor's degrees earned by men are in engineering or computer science (Su 2010).

The proportion of bachelor's degrees awarded to women varies by race/ethnicity categories, as shown in Chart 2. Of African-Americans earning engineering degrees, 27.6 percent are women, while only 15.5 percent of Caucasians who earn bachelor's degrees in engineering are female.

Charts 3 and 4 show that the gender distribution varies widely across engineering disciplines.

CHART 1. Engineering Degree Attainment by Gender, 1999-2000 and 2008-2009

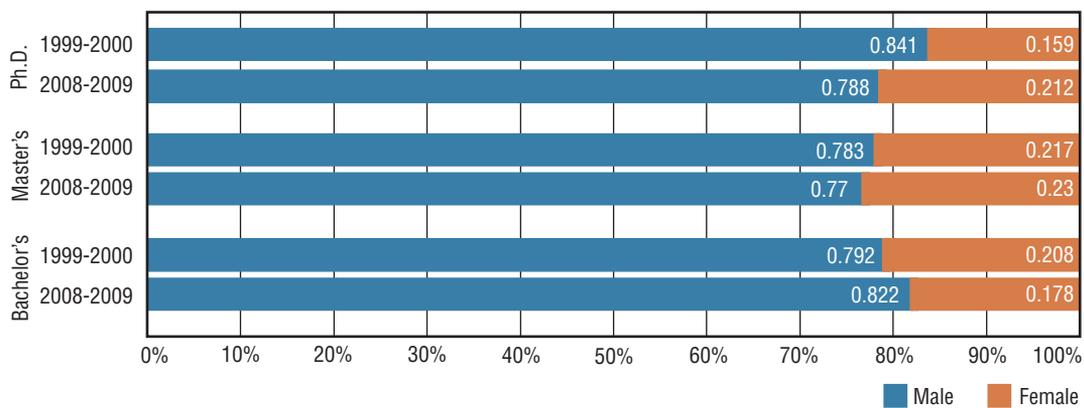


CHART 2. Engineering Bachelor's Degrees by Gender within Race/Ethnicity, 2008-09

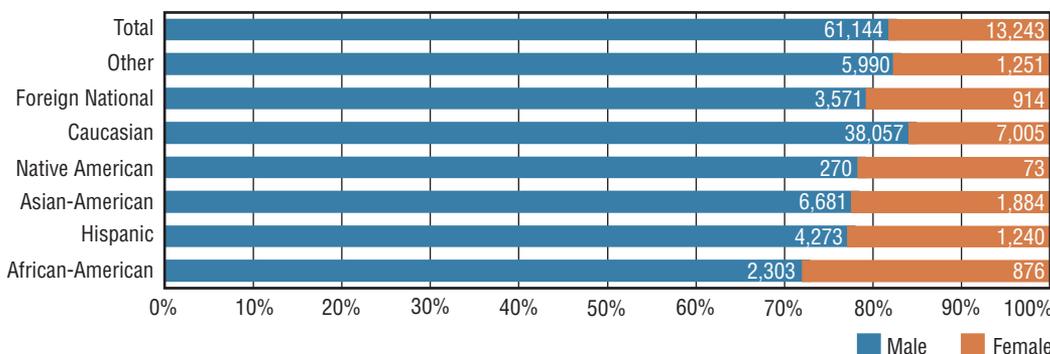
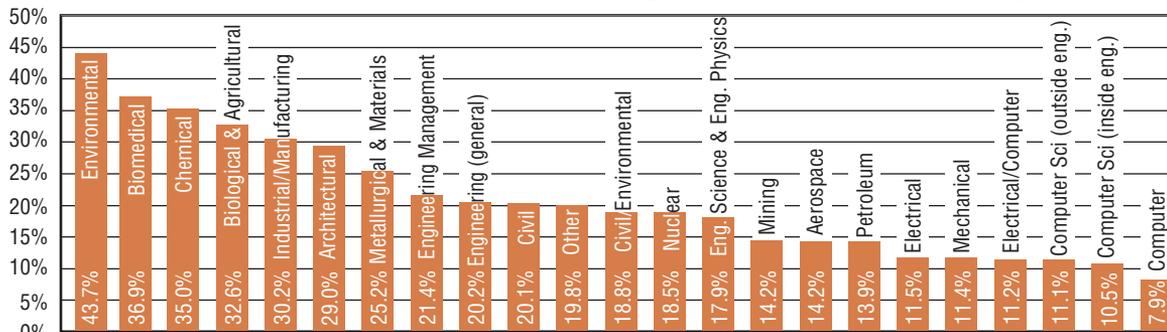


CHART 3. Percent of Bachelor's Degrees Awarded to Women by Discipline, 2008-09



The engineering disciplines with the highest percentage of women at the bachelor's degree level include environmental, biomedical, chemical, biological and agricultural, and industrial and manufacturing engineering, all with more than 30 percent of bachelor's degrees awarded to women. However, the largest engineering disciplines, in terms of the total number of degrees awarded, are mechanical, electrical, civil, and computer science. Among those four largest fields, civil engineering was 20.1 percent female in the

CHART 4. Engineering Bachelor's Degrees by Discipline, 2008-09

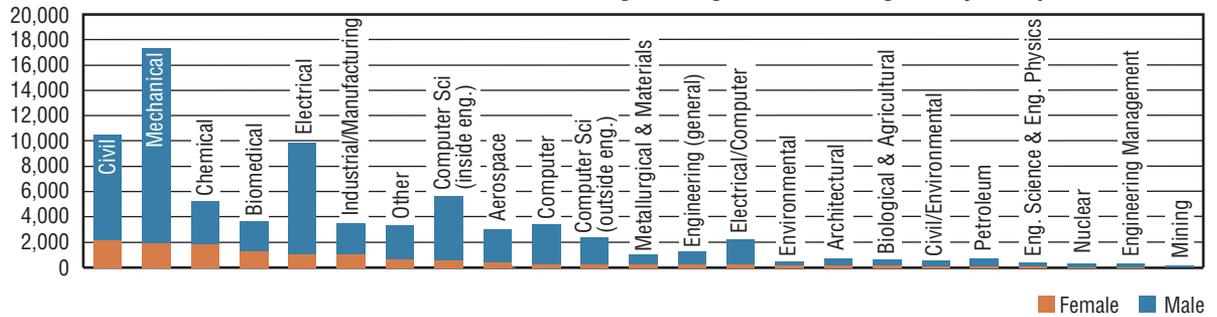
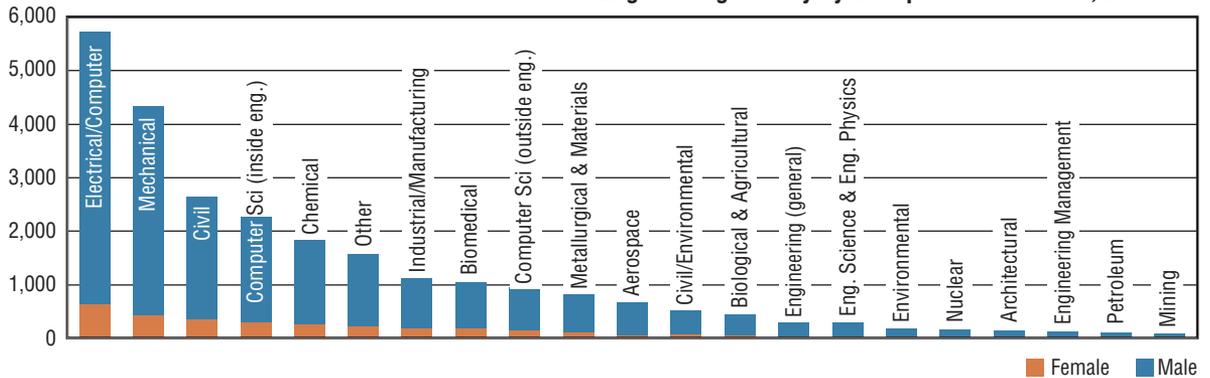


CHART 5. Engineering Faculty by Discipline and Gender, 2008-09

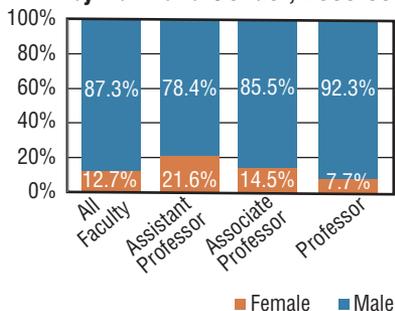


class of 2009, while the other four disciplines awarded less than 12 percent of their degrees to women. The engineering disciplines with the largest numbers of women earning bachelor's degrees in 2009 were civil, mechanical, chemical, biomedical, electrical, and industrial/manufacturing.

On the faculty side, Chart 5 shows that the largest numbers of women engineering faculty are in electrical/computer, mechanical, and civil engineering departments, while the highest percentage of women faculty can be found in environmental (22.1 percent) and biomedical (18.9 percent) engineering programs. Faculty members are usually hired at the rank of assistant professor, are promoted to the rank of associate professor after a probationary period of six or seven years, and may be promoted to the rank of professor based on their scholarly accomplishments over time. Since women

are relative newcomers to the faculty in engineering, it is not surprising that they are more likely to be found at the more junior ranks of assistant or associate professor, as seen in Chart 6. Women are currently 12.7 percent of all engineering faculty, but 21.6 percent of assistant professors (comparable to the percentage of engineering Ph.D.s awarded to women), 14.5 percent of associate professors, and only 7.7 percent of faculty at the most senior rank of professor.

CHART 6. Engineering Faculty by Rank and Gender, 2008-09

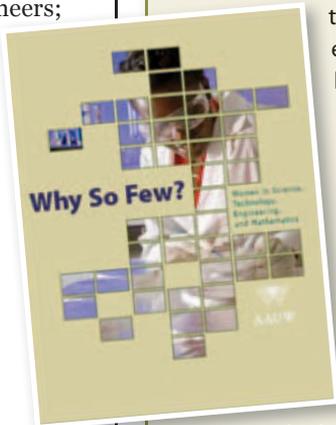


four-year period. Although her focus was not specifically on engineers, her results are potentially relevant to understanding why female engineers leave their positions. She found that women whose spouses work long hours are more likely to quit than those whose spouses do not work long hours; the reverse is not true for men with spouses who work long hours. Since professional women, such as engineers, are particularly likely to be married to men in professional and managerial careers, and who thus work long hours, this finding is at least suggestive.

On the other hand, Frehill (2010) summarized the results of an analysis of data collected for the Society of Women Engineers' Corporate Partnership Council, performed by the Commission on Professionals in Science and Technology. She calls into question the conventional wisdom

that women are particularly likely to leave engineering, arguing, instead, that the data indicate more generally that engineers of both genders change careers and that the most significant variations are discipline, not gender-related. Thus, civil engineers are more likely to persist, while exits from engineering are more common among chemical and mechanical engineers; the pattern for electrical engineers is complex. Frehill does acknowledge some gender differences — e.g., she notes that men are more likely to say they left to pursue better opportunities, while women are more likely to say they left for work/family reasons. The quantitative data she presents also do appear to suggest that, in some disciplines at least, such as in chemical engineering, women are more likely than men to leave. Nevertheless, her analysis is a useful caution that we need to place women's actions in the context of specific occupations and disciplines.

One final, interesting employment-related project is Tong's (2010) analysis of immigrant scientists and engineers. Using SESTAT data, Tong compared the earnings of immigrant engineers who were educated abroad with those who were educated in part or in whole in the United States. SESTAT is the NSF Scientists and Engineers Statistical Data System, an integrated data collection based upon three national surveys: the National Survey of College Graduates (NSCG), the National Survey of Recent College Graduates (NSRCG), and the Survey of Doctorate Recipients (SDR). Interestingly, Tong found that those whose college education took place abroad are paid less than those who were educated entirely in the U.S.; those who finished their education in the United States had incomes that rose faster than those who did all of their graduate work overseas. Tong notes an important gender-related complexity in the data, however. The



Summary of *Why So Few? Women in Science, Technology, Engineering, and Mathematics*

By Molly R. Hall

Commissioned by the National Science Foundation, the AAUW report *Why So Few? Women in Science, Technology, Engineering, and Mathematics* highlights eight recent research findings that help explain the current underrepresentation of women and girls in STEM fields. These findings range from what happens when

teachers and parents tell girls that intelligence expands with experience and learning (they do better on tests and are more likely to indicate a desire to study math in the future); to the understanding that girls hold themselves to a higher standard in subjects like math; to the subtle but powerful influence of implicit bias. Examined individually and as a whole, these findings clearly indicate ways in which cultural factors influence the number of women who both pursue and persist in science and engineering disciplines.

Why So Few? offers numerous practical recommendations for changing perceptions and biases that negatively impact girls' and women's participation in math and science. By counteracting these often implicit beliefs, teachers, family members, employers,

and others can help women and girls to reach their potential in STEM fields.

Recommendations include the following action items.

Recommendations for increasing girls' interest and achievement in STEM fields (pp. 90-92):

- Spread the word about girls' and women's achievements in math and science.
- Teach girls that intellectual skills, including spatial skills, are acquired, not innate, and can be improved with practice.
- Teach students about stereotype threat and promote a growth-mindset environment that emphasizes the perspective that intelligence is not fixed but can be developed.
- Encourage children to develop their spatial skills.
- Make performance standards and expectations clear.

Recommendations for creating more supportive university environments (pp. 92-95):

- Send an inclusive message about who makes a good science or engineering student.
- Emphasize real-life applications in early STEM courses.
- Conduct departmental reviews to assess the climate for female faculty.
- Ensure mentoring for all faculty.
- Support faculty work/life balance.

Recommendations for counteracting unconscious bias (pp. 95-96):

- Acknowledge that we all have implicit biases.
- Learn about your own implicit bias.
- Keep your biases in mind.
- Take steps to correct for your biases.
- Raise awareness about bias against women in STEM fields.
- Create clear criteria for success and transparency.

For specifics on the report's recommendations and research findings, or to download a copy of the report, visit www.aauw.org/learn/research/whysofew.cfm

income gap for immigrant women is smaller than for immigrant men, suggesting that gender may trump immigration status in these fields.

Finally, it should be noted that *Leadership and Management in Engineering* published a special issue on women in civil engineering in 2010 (See Layne 2010a for an overview). While several of the articles in the collection are not research articles and are meant more to encourage women in the field, and while the more research-based articles focus on academic women, the special issue is at least an acknowledgment that gender in the engineering workplace remains a topic worth discussing and that there are questions left to be analyzed and resolved. ■

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Peggy Layne, P.E., F.SWE, joined Virginia Tech in 2003 as director of the AdvanceVT program. Previously, she was director of the program on diversity in the engineering work force at the National Academy of Engineering. She is a registered professional engineer with degrees in environmental and water resources engineering from Vanderbilt University and the University of North Carolina School of Public Health, and worked for 17 years as an environmental engineering consultant. Layne spent a year as an AAAS Congressional Fellow sponsored by the American Society of Civil Engineers. A Fellow of the Society of Women Engineers, she served as SWE president in 1996-97, and is FY11 chair of the Society's government relations and public policy committee.

Molly R. Hall is a doctoral student in the Educational Research and Evaluation program at Virginia Tech. Prior to returning to graduate school, she worked in higher education for 10 years. She holds a master's degree in college student personnel from Miami University and a bachelor's degree in psychology and sociology from Indiana University. Her research interests include program evaluation and advancing women in academe.

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Women in Engineering: 2011 Literature Review

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Introduction

Research on women in engineering and on women in science, technology, engineering, and math, the STEM disciplines in general, was abundant in the past year. Our search of the journal literature revealed a large number of research projects on various aspects of the issues women face, including several major contributions involving large data sets and research projects of substantial ambition.

As in the past, the central questions animating much of this research were why there continue to be relatively small numbers of women in engineering; what is keeping women out of the profession; and what are the characteristics of programs and workplaces that retain women, or of the women who succeed in pursuing an engineering career. This focus should hardly surprise us, in view of the sobering reality that the numbers of women in engineering are not growing rapidly and that, as several of the studies we reviewed noted, it may even be that women's share of engineering degrees is decreasing, even as the overall numbers of students majoring in engineering stagnates or declines. The stalled progress these numbers represent points to the need, which researchers appear to be answering, for continued investigation into the obstacles to gender equality in engineering.

While the basic problem remains a familiar one (why so few women), we did note some different themes in the work we reviewed this year. First, there continues to be interest in not just what attracts or fails to attract women to engineering, but also to forces pushing them out, the “leaky pipeline.” However, the utility of this metaphor, which has dominated much recent analysis of the problem, is being questioned. Many scholars continue to explore why women leave engineering during their school years or after embarking on a career, acknowledging that women's share of engineering jobs is smaller than their share of places in engineering

programs. However, some now question whether the pipeline metaphor adequately describes the phenomena they observe.

Pawley and Hoegh (2011) report on discussions they had with a group of faculty members at Purdue in which the pipeline metaphor was critiqued. Respondents generally accepted the metaphor, but had difficulty applying it to their own careers. This exploratory project revealed that careers are not unidirectional or identical to one another as the pipeline metaphor implies, suggesting the utility of other metaphors such as “pathways” or “snowstorms” to describe engineers' experiences.

Not everyone enters the pipeline at the same point; Maltese and Tai (2011) noted that 80 percent of students in STEM majors entered the pipeline after beginning high school, while only 20 percent expressed early interest, in contrast to one prevailing stereotype of how STEM students develop. Layne's (2011) study of engineering deans demonstrated that their careers didn't always proceed in a linear fashion and that there were multiple paths leading to a given outcome.

In addition to these explicit critiques of the pipeline metaphor, there are numerous studies examining the differences among institutions and types of institutions training and/or employing engineers, many of which show that local practices have significant impacts on the numbers of women recruited and/or retained. Similarly, we encountered a number of studies emphasizing the point that viewing women as a uniform group was an error; women of color, nontraditional women students, and women with different sexual identities may have very distinct experiences within engineering careers. In short, researchers remain concerned about what attracts women to engineering, and why they leave, but seem increasingly inclined to think about these issues within a context

that acknowledges that there is no “correct” way into or out of an engineering career.

Another interesting aspect of this year’s work on women in engineering was the reappearance of feminism. Researchers were not concerned so much to discover whether feminist ideas were being embraced by contemporary female engineers but, instead, to explore whether feminist ideas were informing research on women in engineering. Underlying this inquiry may be a sense that understanding persistent gender inequalities in engineering and STEM generally requires different theoretical tools and a more fundamental rethinking of existing practices.

In the literature review that follows, we have summarized the most important research articles relevant to the situation of women in engineering in 2011. We searched for articles by examining major research databases and more than 70 journals that publish articles on gender and engineering and a wide range of disciplines. We have organized the review topically, to draw attention to the central issues animating research and to highlight debates and controversies in the literature. The result was a very large list of materials, too numerous for us to summarize in full here. As in the past, the research we reviewed was of varying quality and substance. We have tried, therefore, to focus on the most rigorous pieces of research, on peer-reviewed articles, and/or on articles that offer fresh insights and new approaches. We also point to any methodological limitations, and to innovative methodological approaches, in the research we discuss.

Women Engineering Deans

By Peggy Layne, P.E., F.SWE

Cammy Abernathy, Ph.D.	University of Florida
Tyseer Aboulnasr, Ph.D.	University of British Columbia
Linda Abriola, Ph.D.	Tufts University
Cristina Amon, Ph.D.	University of Toronto
Nada Marie Anid, Ph.D.	New York Institute of Technology
Stacy Birmingham, Ph.D.	Grove City College
Susan Blanchard, Ph.D.	Florida Gulf Coast University
Candis Claiborn, Ph.D.	Washington State University
Sandra DeLoatch, Ph.D.	Norfolk State University
Natacha Depaola, Ph.D.	Illinois Institute of Technology
Betsy Dulin, J.D., P.E.	Marshall University
Doreen Edwards, Ph.D.	Alfred University
Julie Ellis, Ph.D., P.E.	Western Kentucky University
Jacqueline El-Sayed, Ph.D.	Kettering University
Elizabeth Eschenbach, Ph.D.	Humboldt State University
Esin Gulari, Ph.D.	Clemson University
Jane Halonen, Ph.D.	University of West Florida
Beverly Hartline, Ph.D.	University of the District of Columbia
Melanie Hatch, Ph.D.	Gannon University
Deborah Huntley, Ph.D.	Saginaw Valley State University
Leah Jamieson, Ph.D.	Purdue University, West Lafayette
Sharon Jones, Ph.D., P.E.	University of Portland
Zella Kahn-Jetter, Ph.D., P.E.	Saint Martin’s University
Maria Kalevitch, Ph.D.	Robert Morris University
Kathleen Kramer, Ph.D.	University of San Diego
Debra Larson, Ph.D., P.E.	California Polytechnic State University, San Luis Obispo
Linda Lucas, Ph.D.	University of Alabama, Birmingham
Borjana Mikic, Ph.D.	Smith College
Amy Moll, Ph.D.	Boise State University
Lynne Molter, Sc.D.	Swarthmore College
Cherry Murray, Ph.D.	Harvard University
Sarah Rajala, Ph.D.	Mississippi State University
Elaine Scott, Ph.D.	Seattle Pacific University
Laura Steinberg, Ph.D.	Syracuse University
Zulma Toro-Ramos, Ph.D.	Wichita State University
T. Kyle Vanderlick, Ph.D.	Yale University
Belle Wei, Ph.D.	San Jose State University
Kimberly Woodhouse, Ph.D., P.Eng.	Queen’s University
Sandra Woods, Ph.D.	Colorado State University

Recruitment of students to engineering

Although researchers' attention is focused increasingly on the reasons women decide to leave engineering at various points in their careers, scholars continue to study the recruitment of women into the field. While the numbers of women who enter engineering are larger than the numbers who remain in the field, they still represent a minority. So even a pipeline that did not leak at all would still result in gender imbalances in the profession.

Since research on barriers to entry has been well established, much of the work published this year covered relatively familiar territory. Two studies of schoolchildren in the Midwestern U.S. (Capobianco et al. 2011; Karatas et al. 2011) noted that grade school children continue to perceive engineers as male as evidenced by their drawings of engineers as male, a discouraging finding in view of the Society of Women Engineers' (and others') efforts to reverse this perception. Cheryan et al.'s (2011) experimental social psychological study of a sample of psychology majors found that women's perception of their likely success in computer science was negatively affected by their encounters with stereotypical, i.e., male, computer scientists; however, they found that exposure to nonstereotypical, i.e., female, computer scientists did not have the opposite effect. Stout et al. (2011) conducted a pair of cross-sectional controlled experiments and a longitudinal study of a calculus class that yield conflicting results. They found that exposure to female STEM experts promoted stronger identification

with STEM, greater self-efficacy in STEM, and a stronger commitment to STEM careers, although negative stereotypes about their gender and STEM persisted. Given such contradictory findings, it is hard to say definitively whether the persistence of gender stereotypes in engineering is a key barrier to recruiting more women into the field.

Researchers continue to be interested in the role played by math in shaping students' orientation to STEM careers in general and engineering careers in particular. Women's math achievement no longer trails significantly behind men's as it once did, and the argument that math achievement is an obstacle to women's entering engineering careers has weakened. Newton et al.'s (2011) analysis of data from the National Educational Longitudinal Study of 1988 (which follows a cohort of students over a period of years) finds that women are as likely as men to enroll in college math courses, and that the timing of taking algebra, whether in the 8th or 9th grade, is *not* a predictor of students' choosing STEM majors. Riegle-Crumb et al.'s (2011) analysis of data from a sample of 8th grade students collected in 2003 suggests a possible reason why increased math achievement by women hasn't translated into increasing numbers of female engineering students: They found that *enjoyment* of math, not just achievement, was central to students' choice of majors. Therefore, recruiting more women to math-related careers requires attention to the kinds of experiences students have in math while still in school. However,

Meyers and Mertz's (2011) study of 163 first-year engineering students found that female students were more likely than male students to report being good at math and science as a reason for choosing an engineering career. It appears that there is a need for more research on how math achievement and enjoyment affect women's interest in engineering.

Several studies offered support for the idea that women, perhaps more than men, are attracted to engineering by nontechnical factors. Barone's (2011) analysis of a large sample of university students in several European countries concluded that the gendering of majors was not related to the traditional divide between the humanities and the sciences; rather, it was linked to the distinction between caring and technical work. Given prevailing gender preferences, a definition of engineering as technical, not care work, tends to perpetuate male domination of the field. Meyers and Mertz (2011) reported that women engineering students were much more likely than men to identify a desire to build a better world as a motivation for entering engineering. This was the second most cited reason for females, but the sixth for males.

A pair of articles by Bowman questioned the hope that new disciplinary directions in engineering may make the field more attractive to women. Bowman (2011a) analyzed American Society for Engineering Education (ASEE) data on materials engineering programs, speculating that the field should be attractive to women because it is interdisciplinary, has more women faculty, tends to have

small class sizes, and has to recruit aggressively. However, except at the graduate level, the numbers of women obtaining degrees in the field did not grow between 2001 and 2009. Even more interesting is his (2011b) analysis of ASEE data on 54 U.S.-based universities offering biomedical engineering programs. He noted that the expansion of programs in this area has been identified as a possible way to attract more women to engineering because it can be linked to care work and seems more “female friendly” as a result. However, while women received 36 percent of biomedical engineering degrees in these universities in 2009, women’s share of overall engineering degrees had actually declined in the period studied. He speculates that women in engineering have shifted from other engineering disciplines into biomedical and that, ironically, the shift may have hardened the perception that other fields are masculine in nature. His research points to the conclusion that the gender integration of engineering depends on changes in the discipline as a whole, not just on creating female-friendly havens within the field.

Retention in degree programs

Our review of the research on women in engineering found that the majority of studies are on women’s educational experiences. Clearly, considerable research attention is now focused on understanding why women drop out of engineering programs and/or why they stay, as well as on exploring changes that might help increase the retention of women who aspire to engineering degrees.

Maltese and Tai (2011)

argue that previous research on persistence has focused too much on the issue of students’ preparation and skills and overemphasized the degree to which students who leave do so because they were not adequately prepared. Using data on 4,700 participants in the National Longitudinal Study of 1988, of which just over half were women, they argue that educational experiences are an important predictor of persistence. In particular, students who say they are interested in a science career are more likely to complete a STEM degree, suggesting that educators should focus on developing student interest in the field and on making math and science more relevant to the daily lives of students. On the other hand, they acknowledge that preparation, e.g., factors such as number of math and science classes completed in high school, can be a factor in promoting or inhibiting persistence. This finding is echoed by Moses et al.’s (2011) analysis of 129 students in first-year engineering courses at East Carolina University, which showed that math readiness was a strong predictor of retention in engineering programs.

Neither of these studies found that gender was a significant factor affecting persistence probabilities. However, a number of other studies did, and they tended to focus on the effect of experiences rather than achievement. For example, Holland et al. (2011) found that women and minority students endorsed formal, university-focused “capitalization” activities (i.e., professional development activities) more than majority male students, and that participation in these activities

solidified their commitment to and identification with the field. Fabert et al. (2011) conducted a qualitative, longitudinal study of 24 graduate students, 10 of whom were in engineering, finding that they encountered disparaging comments, an unpleasantly competitive atmosphere, and generally were aware of feeling “different,” both because they were women and because they were nontraditional students in other ways.

These feelings of difference led Fabert et al.’s respondents to question their fit with the institution in which they were studying as well as their competence, a sentiment that was echoed in several other studies published in 2011. Rosenthal et al. (2011) studied 65 participants in a single-sex STEM program at an otherwise coeducational university, finding that perceived support from the program, as well as perceived identity compatibility and perceived support from close others, was associated with a greater sense of belonging in their major and the university. This study suggests that the experience of being among comparable others promoted a sense of belonging, although caution needs to be exercised since this study lacked a control group and did not examine students who dropped out of the program.

Cech et al. (2011) conducted an online survey of 288 students at four New England engineering schools with the objective of learning whether there were gender differences in respondents’ persistence to obtain a degree and their intentions to remain in engineering, employed, for the next

2011 Outstanding Women in Engineering

by Molly R. Hall

American Society for Engineering Education (ASEE) Awards

Sharon A. Keillor Award for Women in Engineering Education

Sheryl Sorby, Ph.D., Michigan Technological University

Frederick J. Berger Award

Carol A. Richardson, Rochester Institute of Technology

Clement J. Freund Award

Helen C. Oloroso, Northwestern University

Fellow Member Honorees

Mary E. Besterfield-Sacre, Ph.D., University of Pittsburgh
 Susan M. Blanchard, Ph.D., Florida Gulf Coast University
 Nancy L. Denton, P.E., Purdue University
 Leah H. Jamieson, Ph.D., Purdue University
 Linda Krute, Ph.D., North Carolina State University
 Carol A. Richardson, Rochester Institute of Technology
 Jacquelyn Sullivan, Ph.D., University of Colorado at Boulder

William Elgin Wickenden Award

Sheri D. Sheppard, Ph.D., P.E., Stanford University
 Jini Puma, Ph.D., University of Colorado, Denver

ASEE Section Awards

Middle Atlantic Section:

Best Section Paper Award, Spring Conference

Gay Lemons, Ph.D., Tufts University

Midwest Section:

Outstanding Paper Award, Second Place

YoonJung Cho, Ph.D., Oklahoma State University

North Midwest Section:

Outstanding Teaching Award

AnnMarie P. Thomas, Ph.D., University of St. Thomas

North Central Section:

Outstanding Teaching Award

Anna Dollár, Ph.D., Miami University

Southeast Section:

New Faculty Research Award

Qiong Zhang, Ph.D., University of South Florida

Thomas C. Evans Instructional Paper Award

Melissa A. Dagley, Ph.D., University of Central Florida

St. Lawrence Section:

Outstanding Teaching Award

Susan Daniel, Ph.D., Cornell University

ASEE Professional and Technical Division Awards

Chemical Engineering Division:

William H. Corcoran Award

Gifty Osei-Prempeh, Ph.D., University of Kentucky

Ray W. Fahien Award

Adrienne Minerick, Ph.D., Michigan Technological University

Joseph J. Martin Award

Lisa Bullard, Ph.D., North Carolina State University

Graduate Student Future Faculty Grant

Debra Gilbuena, Oregon State University

Civil Engineering Division:

Gerald R. Seeley Fellowship

Ellie H. Fini, Ph.D., North Carolina A&T State University

College/Industry Partnerships Division:

CIEC Best Session Award

Martina Y. Trucco, Hewlett-Packard
 Cath Polito, University of Texas at Austin

CIEC Best Presenter Award

Cynthia C. Fry, Baylor University

Continuing Professional Development Division:

CIEC Best Session Award

Kim A. Scalzo, State University of New York

Terrye Schaetzel, Georgia Institute of Technology

Anna-Maija Ahonen, Aalto University
 Kirsti Miettinen, Aalto University

CIEC Best Conference Presenter Award

Sue Bray, New Vistas

Certificate of Appreciation

Lea-Ann Morton, 2011 CIEC Program Chair

Cooperative and Experiential Education Division:

Lou Takacs Award

Laura Chessa, Johnson & Johnson/
 McNeil Consumer Care

Co-op Student of the Year Award

Roshni Barot, Northwestern University

Division of Experimentation and Laboratory Oriented Studies (DELOS):

Best Paper Award

Lisa Huettel, Ph.D., Duke University
 Debra J. Mascaró, Ph.D., University of Utah

Stacy J. Morris Bamberg, Sc.D., University of Utah

Educational Research and Methods Division:

Distinguished Service Award

Cynthia J. Finelli, Ph.D., University of Michigan

Best Paper Award

Margot Vigeant, Ph.D., Bucknell University

*Energy Conversion and Conservation Division:***Best Paper Award**

Margaret B. Bailey, Ph.D., P.E., Rochester
Institute of Technology

*Engineering Design Graphics Division:***Oppenheimer Award**

Nancy Study, Ph.D., Virginia State
University

Editor's Award

Holly Ault, Ph.D., Worcester Polytechnic
Institute

*Engineering Libraries Division:***Homer I. Bernhardt Distinguished****Service Award**

Dorothy Byers, Ph.D., Khalifa University,
Abu Dhabi

Best Publication Award

Cheryl McCallips, Pennsylvania State
University

Sylvia Nyana, Pennsylvania State
University

Bonnie Osif, Ed.D., Pennsylvania State
University

*Engineering Management Division:***Bernard R. Sarchet Award**

Lucy Morse, Ph.D., University of Central
Florida

Best Paper Award

Amy K. Zander, Ph.D., P.E., Clarkson
University

*Environmental Engineering Division:***Best Paper Award**

Stephanie Luster-Teasley, Ph.D.,
North Carolina A&T State University
Cindy Waters, Ph.D., North Carolina
A&T State University

*Industrial Engineering Division:***Best Paper Award**

Lizabeh T. Schlemmer, Ph.D.,
California Polytechnic State
University, San Luis Obispo

*Mechanical Engineering Division:***Best Paper Award**

Peggy Noel Van Meter, Ph.D.,
Pennsylvania State University

**Best Paper Award,
Honorable Mention**

Daisie D. Boettner, Ph.D., P.E., U.S.
Military Academy

*Systems Engineering Division:***Best Paper Award**

Cecelia M. Wigal, Ph.D., P.E.,
University of Tennessee,
Chattanooga

*Women in Engineering Division:***Denice D. Denton Best Paper Award**

Rose Marra, Ph.D., University of
Missouri, Columbia
Lois Trautvetter, Ph.D., Northwestern
University

Lisa Lattuca, Ph.D., Pennsylvania
State University

Katie Piacentini, Ph.D., University of
Missouri, Columbia

Apprentice Educator Grant

Stephanie Claussen, Stanford
University
Sara Atwood, Ph.D., Elizabethtown
College

**Women in Engineering
ProActive Network (WEPAN)
Awards****Distinguished Service Award**

Tricia Berry, University of Texas,
Austin

Educator's Award

Wendy C. Crone, Ph.D., University of
Wisconsin-Madison
Barbara Ruel, Rensselaer Polytechnic
Institute

continued on page 206

five years. They found that, counter to expectations, neither of these forms of persistence was linked to family plans for women, although they were for men! Nor did math self-assessment have an effect, although women's self-assessment was lower. Instead, what predicted persistence best was "professional role confidence," which they define as having two aspects: expertise confidence, defined as confidence in one's ability to wield the skills required, and career-fit confidence, which is confidence that one's career path is consonant with one's interests and values. Moreover, the women in the study were less likely to have high levels of professional role confidence, which helped explain why they had lower rates of persistence than their male counterparts.

As indicated earlier, some studies argued that gender is *not*, in fact, a major predictor of leaving engineering programs. Hosoi and Canetto (2011) analyzed data on all graduate students enrolled in engineering programs at Colorado State University from 1990 to 2005. They found that female students were no more likely to drop out of engineering doctoral programs than male students when factors associated with degree completion, such as final GPA and engineering field, were considered. As such, the key to increasing the numbers of women completing engineering doctorates is recruitment, not retention. Maltese and Tai (2011) use data on 4,700 participants in the National Longitudinal Study of 1988, just over half of whom were women, to examine factors that predict persistence in STEM. They found

2011 Outstanding Women in Engineering

continued from page 205

Founders Award

Jan Rinehart, Rice University

Betty Vetter Research Award

Michelle Hebl, Ph.D., Rice University

University Change Agent Award

Chris S. Anderson, Michigan Technological University

Women in Engineering Champion Award

Audrey Romonosky, IBM

The National Academy of Engineering

The Charles Stark Draper Prize

Frances H. Arnold, Ph.D., California Institute of Technology

New Female Members

Nadine N. Aubry, Ph.D., Carnegie Mellon University
 Susan T. Dumais, Ph.D., Microsoft Research
 Jacqueline Gail (Berg) Gish, Ph.D., Northrop Grumman Aerospace Systems
 Linda G. Griffith, Ph.D., Massachusetts Institute of Technology
 Daphne Koller, Ph.D., Stanford University
 Joanne M. Maguire, Lockheed Martin Space Systems Company
 Joan B. Rose, Ph.D., Michigan State University

Society of Women Engineers (SWE) Awards

Achievement Award

Cristina H. Amon, Sc.D., University of Toronto

The Suzanne Jenniches Upward Mobility Award

Tana L. Utley, Caterpillar Inc.

Resnik Challenger Medal

Kim de Groh, NASA Glenn Research Center

Distinguished Engineering Educator

Christine Hailey, Ph.D., P.E., Utah State University

Work/Life Balance Award

Kate Maxwell, Raytheon Company

Emerging Leader Award

Colleen M. Layman, P.E., Bechtel Power
 Jessica Rannow, jcpenny
 Alyse Stofer, Medtronic Inc.
 Januca Berry, Northrop Grumman Corporation
 Stephanie Shanley, P.E., Intel Corporation
 Erica J. Messinger, Agilent Technologies
 Melissa Soley, Booz Allen Hamilton Inc.

Distinguished New Engineer Award

Allison Goodman, Intel Corporation
 Dayna Johnson, P.E., Independent Consultant
 Lindsay Laskowski, Chevron
 Angela McMullen-Gunn, Hamilton Sundstrand
 Deborah Willems, Raytheon Company

Fellow Award

Bernice Brody, IBM
 Joan Graf, CenturyLink
 Nora Lin, Northrop Grumman Corporation
 Gail Mattson, P.E., PAI Corporation
 Mary Phelps, HEDGE Co
 Ronna Robertson, Roquette America Inc.
 Yvonne Simms, The Boeing Company

Outstanding Faculty Advisor Award

Mary Verstraete, Ph.D., The University of Akron

Outstanding SWE Counselor Award

Alexis Wallen, University of Pennsylvania

Outstanding Collegiate

Member Award

Kristina Hammarstrom, University of the Pacific
 Jill Hoover Hershman, University of Alabama
 Shantel Hunt, University of Hawaii
 Cassandra Janakos, University of California, Berkeley

Outstanding Graduate Collegiate Member Award

Prinda Wanakule, University of Texas at Austin

The Anita Borg Institute for Women and Technology Awards

Women of Vision Innovation Award

Mary Lou Jepsen, Ph.D., Pixel Qi

Women of Vision Social Impact Award

Karen Panetta, Ph.D., Tufts University

Women of Vision Leadership Award

Chieko Asakawa, Ph.D., IBM Research – Tokyo

Technical Leadership Award

Mary Lou Soffa, Ph.D., University of Virginia

Denice Denton Emerging Leader Award

Tiffani Williams, Ph.D., Texas A&M University

A. Richard Newton Educator Award

Lisa Pruitt, Ph.D., University of California, Berkeley

Intel Science Talent Search Awards

Michelle Hackman, *second place*,
New York
Madeleine Ball, *fourth place*, Texas
Selena Li, *fifth place*, California
Xiaoyu "Carrie" Cao, *eighth place*,
California
Jenny Liu, *ninth place*, Connecticut

National Society of Black Engineers (NSBE) Awards

Minority Engineering Program Director of the Year

Florence Boldridge, University of
Kansas

Pre-College Female Student of the Year

Rosheena Hairston, Virginia

Outstanding Woman in Technology

Joan Robinson-Berry, The Boeing
Company

Society of Hispanic Professional Engineers (SHPE) Awards

Jaime Oaxaca Award

Olivia A. Graeve, Ph.D., Alfred
University

Hispanics in Technology Award, Government

Debbie Martinez, NASA Langley
Research Center

Green Engineer Award

Laura Verduzco, Chevron
Corporation

that gender had no independent predictive effect on persistence in STEM disciplines.

Studies such as these are important reminders that men leave engineering, too, and that the problem of recruiting and retaining students in engineering and other STEM disciplines is not limited to women. Smith's (2011) thorough analysis of educational data from the U.K., representing hundreds of thousands of cases over several decades, shows clearly that universities struggle to recruit and retain both male and female students in disciplines such as engineering. Holloway et al. (2011) argue that understanding women's experience can actually help educators understand why men stay or leave engineering programs. Analyzing first-year cohorts at Purdue University from 2000 to 2009, they argue that women are "the canary in the mine," leading indicators of factors that affect retention rates. Women appear to be more susceptible to both positive and negative factors that affect retention, but the same factors predict whether men stay or leave the discipline.

Nevertheless, one can also point to potential problems with the conclusion that there are no gender differences at all in retention. Both Hosoi and Canetto and Maltese and Tai argue that gender is not an independent predictor of retention, *net* of other factors. But, it is quite possible that other factors are strongly correlated with gender, e.g., as Cech et al. argue, women may have lower rates of professional role confidence. As a result, women may leave engineering at higher rates than men because being female is strongly linked to the

factors that predict departure from the discipline for *both* men and women.

George-Jackson's (2011) analysis of data on full-time, first-time, first-year students at five Midwestern land-grant universities, all of whom completed their degrees within six years, also questions the view that women are more likely to leave STEM. Although she found that women did leave "high status" STEM fields, including engineering, more than men, they completed STEM degrees (broadly defined) at similar rates to men. The obvious response, here, is that it remained the case that women were more likely to leave engineering; the fact that they shifted to other STEM disciplines, some of which would not be defined as STEM by all observers, does little to alter the gender imbalances within engineering and similar disciplines.

Another interesting pattern revealed in the research we reviewed concerned not whether women left engineering, but how and when. Min et al. (2011) analyzed data on more than 100,000 engineering students in nine public Southern universities from 1987 to 2004. They employed a sophisticated methodology that allowed them to examine not just whether an event (departure from engineering) occurred, but when. Among their findings was the fact that women tended to leave engineering earlier than other groups. Since the early part of the engineering curriculum focuses on basic math and science courses, they suggest that increasing the amount of engineering content and the number of hands-on activities

in the first and second years might help retention in general, and the retention of women in particular.

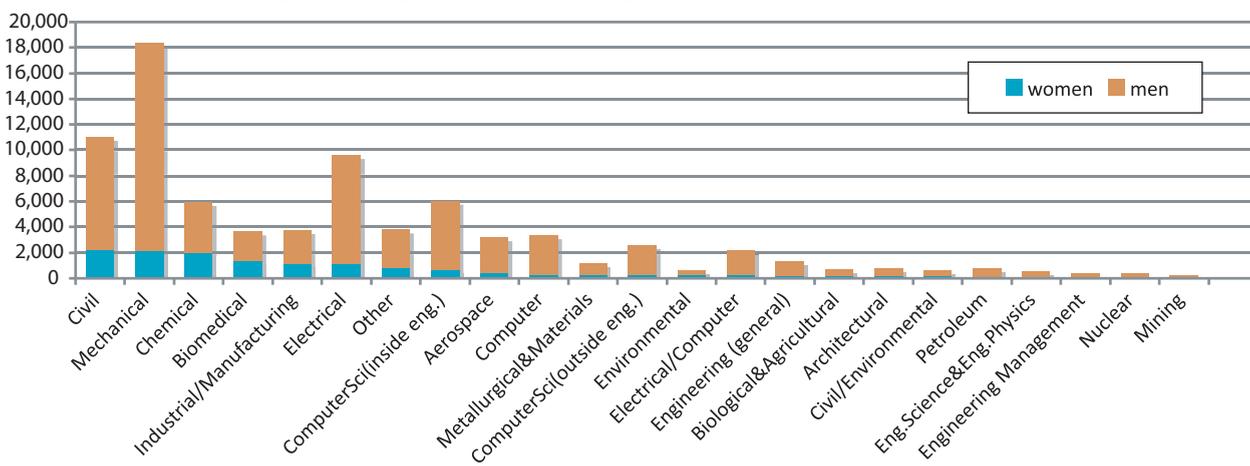
Ohland et al. note that some of the disagreement as to whether women persist in engineering at lower rates than men may have to do with how one measures persistence and with differences in the pattern of departure for men and women. Thus, persistence could be measured by the four-year graduation rate, the six-year graduation rate, by persistence after four years whether or not one

has graduated, etc. Analyzing data from the 1990s on engineering students at nine Southeastern universities, they found that women had lower four-year persistence rates, but that, among students who persisted for four years, women were *more* likely to graduate in six years than men. This, in turn, can be explained by differences between how men and women leave engineering programs. Women are more likely to leave early, and to leave voluntarily, perhaps because of the

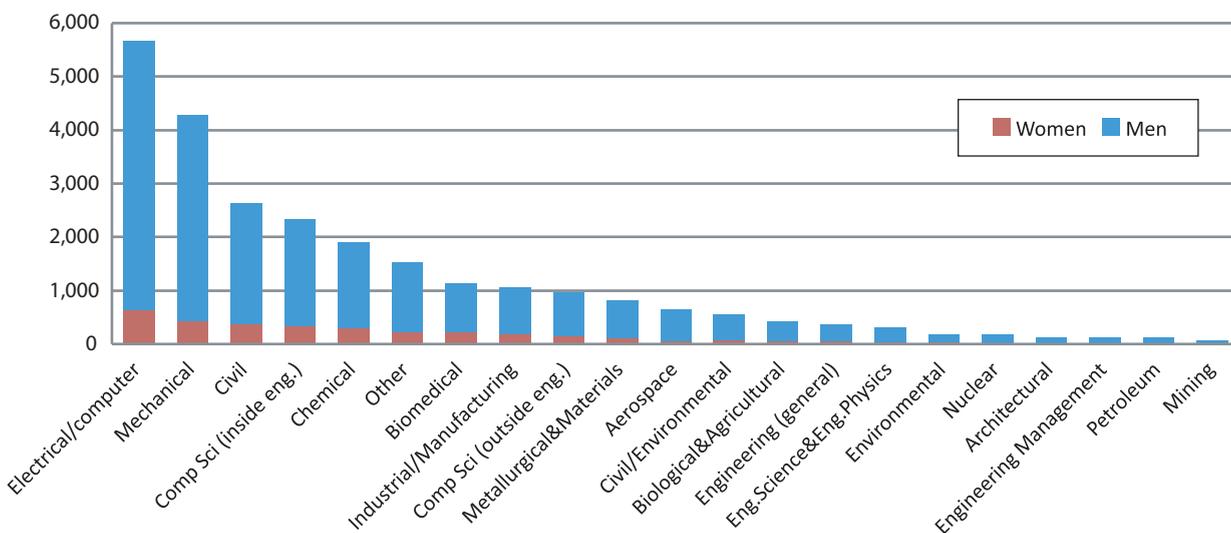
feeling, described earlier, of not belonging. Men, however, are more likely to be dismissed; Ohland et al. argue that men are more likely to believe that the problem is with someone else, so they persist even when they are doing poorly.

Several studies examined the ways in which the engineering curriculum affects the retention of female students. Amelink and Meszaros (2011) surveyed students at nine engineering schools and found

Engineering Bachelor's Degrees by Discipline and Gender, 2010



Engineering Faculty by Discipline and Gender, 2010

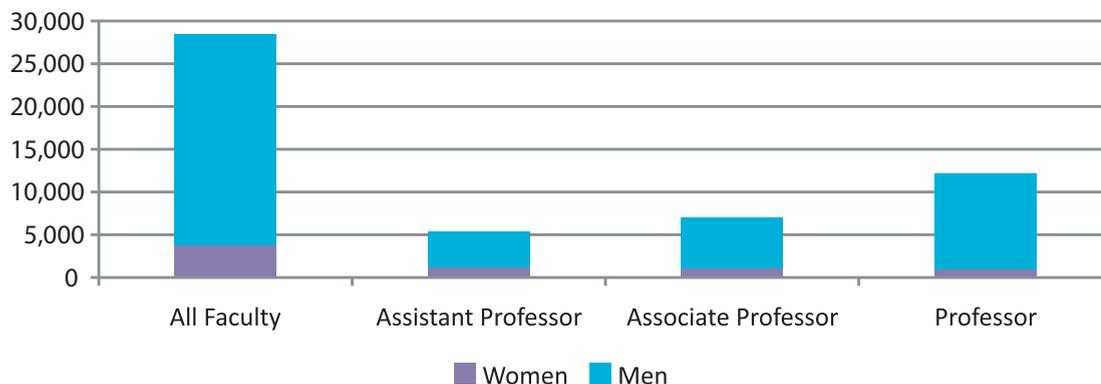
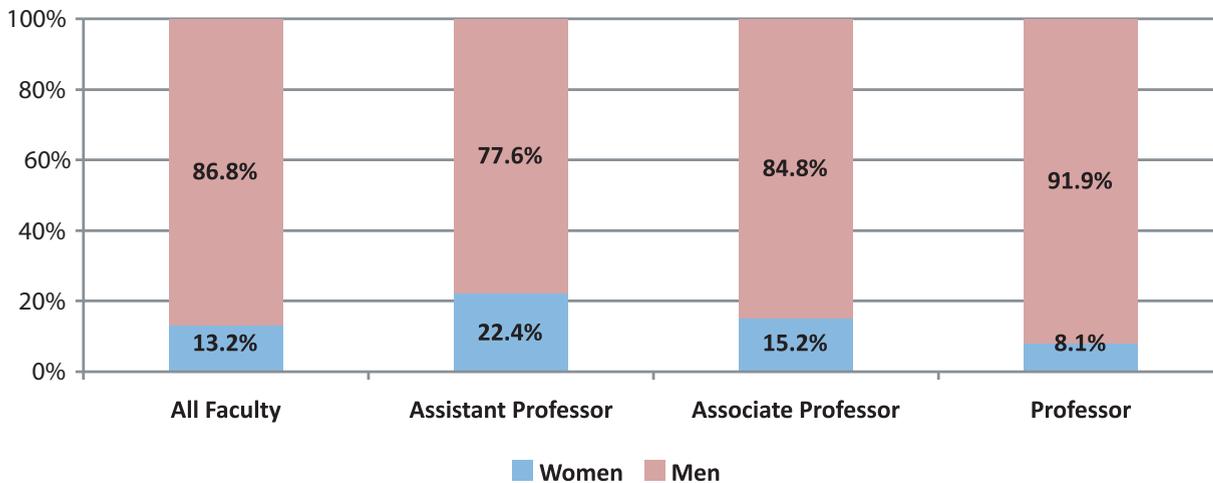


that different factors affected male and female students' intentions to remain in engineering. Female respondents were more likely to value study groups, internships, and engineering student organizations, and to experience grade competition and the length of coursework as discouraging factors. Unfortunately, this study must be approached with caution, in particular because the authors provide little information about the nature of the sample, response rates, etc. Nevertheless, it seems to support the view that female students, in particular, seek hands-on experience and real life experiences (Patterson

et al. 2011) in engineering programs. Sallee (2011) conducted ethnographic interviews and participant observation in a department of aerospace and mechanical engineering, showing that students were socialized to adopt masculine values, including those that privilege competition, hierarchy, and the objectification of women, which in turn created an unwelcoming climate for women. Another interesting article reported on an effort to design a model, reformed mechanical engineering curriculum. Bush-Vishniac et al. (2011) describe the DEEP project, in which representatives from eight collaborating institutions

participated in an effort to explore whether the complex string of prerequisites — a factor cited as a problem by Amelink and Meszaros' female respondents — was really a necessary part of the curriculum. Participants analyzed what mechanical engineers needed to know, identified appropriate relationships among the component parts of the required knowledge, then organized the material into clusters that fit together. The result was radically different from the conventional mechanical engineering curriculum; in place of long strings of sequenced courses were clusters of material

Engineering Faculty by Rank and Gender, 2010



whose order of presentation was less crucial. Participants also explored the possibility of incorporating material on technologies of greater interest to female students, e.g., green technologies as opposed to the more traditional focus on automobiles. The effort stopped short of implementation, and identified numerous obstacles to implementation. But, this exercise indicated that it is possible to design a more flexible engineering curriculum that might appeal more to female students.

Work experiences

What happens to women after they leave school is also an important element in understanding why engineering remains predominantly male. Many studies have indicated that women leave engineering, and STEM fields in general, after beginning their careers, finding the conditions of work inhospitable and unacceptable. Similarly, women in engineering, like women in other professional fields, encounter obstacles to upward mobility that limit their careers and may even encourage them to leave.

Servon and Visser (2011) conducted an online survey of almost 2,500 women in engineering and technology fields and, with a subset of participants, followed up with 28 focus groups to examine what were the barriers to women's career progress in science, engineering, and technology. They reported that women complain of a male corporate culture in which they are harassed, undervalued, and treated poorly; in which they feel isolated and lack mentors; and in which they face jobs that make extreme demands on their time. The ways in which women cope with these conditions may actually hinder their progress. For

example, some respond by seeking jobs in which the pressures are not as great, but which may in the end hurt their careers. Servon and Visser argue that masculine behaviors such as aggression characterize science, engineering, and technology workplaces, which they contend make them hostile to women. However, they don't present specific evidence that women's feelings of mistreatment and harassment directly relate to these behaviors. It is possible, therefore, that something other than these masculine behaviors are the source of the problem.

Researchers continue to examine whether work/family conflict is an important factor affecting women's progress in engineering and STEM careers. James' (2011) study of Irish employees in the IT sector included engineers, among other professionals, and found that they did experience work/life conflicts, not primarily from

long hours, but from long commutes, demands to be on-call, and periodic pushes to complete projects on a deadline. Employers made efforts to respond to these conflicts by providing flextime options, but this was not useful to most employees, who expressed a preference for reduced work options and the ability to work at home. James argues that some female employees leave because of these conflicts, and the lack of adequate policies responding to them. Employers should be concerned not just because of the costs of finding replacements, but because of lost expertise, lost tacit knowledge, and the lost benefits of diverse work groups if they replace women with male employees.

Two studies we reviewed explored barriers to entry into engineering jobs. Shantz, Wright, and Latham (2011) conducted a survey of 100 applicants to a British employer of engineers. They found that access to inside information was a crucial factor

Journal of the Society of Women Engineers 60th Anniversary Edition

Occupying a unique research niche, the *Journal of the Society of Women Engineers, 60th Anniversary Edition* was released in October 2011. This special peer-reviewed volume marks the organization's founding in 1950, and follows the footsteps of the Society's initial publication, the *Journal of the Society of Women Engineers*, published from 1951-1954, to be replaced by a national newsletter, and later, this magazine.

During the course of the Society's 60th anniversary, an interdisciplinary group of scholars combed SWE's extensive archival collection, housed at Wayne State University's Walter P. Reuther Library. Applying the training and methods of social science and history, they brought a critical eye to the materials, teasing out of them many of the stories and insights hidden between the lines, and suggesting that lessons taken from the archives hold much promise to resolve gender issues facing the profession today.

See <http://www.nxtbook.com/nxtbooks/swe/60thanniversary/>



determining whether applicants were successful in obtaining a position. Applicants who used recruitment agencies or had access to word-of-mouth information tended to be most successful because these were valuable sources of inside information, as opposed to Internet searches, for example. Women in their sample were less likely to use search methods that yielded inside information, so they conclude that differential access to information, linked to different search methods, may be a factor hindering women's access to jobs in engineering.

Ceci and Williams (2011) conducted an extensive review of the literature on why women are underrepresented in science. They argue, although with somewhat limited documentation, that the prevailing explanation focuses on discrimination in hiring and interviewing as well as in grant and journal reviewing. Their review of the empirical literature finds no evidence of this discrimination, however. Instead, they contend that women's preferences and choices are responsible — young women avoid math-intensive careers, largely because of family concerns, particularly a desire to work fewer hours, have part-time options, etc. In addition, they find that women have a preference for careers focusing on people, rather than things. Unfortunately, their argument fails to confront the sociological literature on the gendered nature of organizations, and does not address such matters as *why* do workplaces demand long hours; *why* is it assumed that employees have supportive spouses at home allowing them to devote long hours to work? They also note that conditions are different in fields that aren't math-based, but fail to propose a persuasive account of why this is the case.

Several of the studies we reviewed

were focused on the experiences of women in academic settings. Xu and Martin (2011) interviewed eight faculty members (four male, four female) and surveyed more than 9,000 STEM faculty members in the Southeastern United States about the role of networks in career development. They found that both male and female faculty were aware of the importance of these networks, but that women had more difficulty establishing them, a fact of which male faculty were not aware. In addition, female faculty were more likely than their male counterparts to use networks for social and emotional support and to have networks that were more diverse in gender terms.

Lariviere et al.'s (2011) study of Quebec university professors also found that women faculty had more geographically limited networks. More importantly, they found that, once they reached the age of 38, female researchers received less funding than men, and were less productive in terms of publications. And, senior women researchers were less likely than comparable men to direct research teams. Overall, they found that the careers of female researchers developed differently than those of their male counterparts in ways that are not completely understood. The study is inconclusive and lacks information about the nature of the sample; however, it suggests the need for future research on female scientists' and engineers' research productivity.

Female academic scientists and engineers also struggle with work/family conflict. Fox, Fonseca, and Bao (2011) surveyed a sample of women faculty in two STEM fields and a stratified random sample of men in computer science, engineering, and six science fields at nine highly ranked research universities. They found that both men and women report work/

family conflict, with women reporting higher rates. Rather surprisingly, however, being married significantly increases the probability of family-to-work conflict for men, but not for women. Senior rank decreased the likelihood of work-to-family conflict for women, but increased the likelihood of family-to-work conflict. Overall, the study paints a complex portrait of work/family conflict in academic science, but, encouragingly, finds evidence that administrative efforts to encourage departmental cultures and practices that minimize work/family conflict can be effective.

Goulden, Mason, and Frasch (2011) analyze a variety of data sets, including the Survey of Doctorate Recipients (SDR), containing information about the careers of academic scientists. They find evidence that women leave more frequently before achieving tenure, and argue that the SDR data show that marriage and childbirth account for the largest leaks. Although young scientists, both male and female, reported that negative student experiences were the most important factor discouraging them from continuing in research careers, career/life issues were second, especially for women. Academic research careers were not seen as family-friendly, in part because of the reality that researchers, especially young ones, receive limited benefits from family-friendly policies, e.g., students and post-docs often are not eligible for such benefits.

This year's literature included a major study that promises to shed additional light on why women leave engineering. Fouad and Singh (2011) report on the first wave of a study of more than 3,700 female engineers who are graduates of 30 universities cooperating with this National

Science Foundation-funded study. Their sample of women with undergraduate engineering degrees falls into four categories: women who never entered engineering; women who left more than five years ago; women who left less than five years ago; and women who are working as engineers.

Fouad and Singh find that the most frequently cited reasons among women who never entered engineering were that they were not interested in engineering; that they didn't like the culture of engineering; that they wanted to start a business; or that they never planned to enter engineering. Most were working in other fields, so they had not dropped out of the labor force to care for children. Women who left engineering more than five years ago similarly mentioned loss of interest in engineering and dislike of the workplace cultures as reasons for their departure, but many also cited work/family conflict, poor working conditions, and lack of opportunity for promotion. The majority of those who left were still working, some in well-rewarded, demanding positions; but around 25 percent had left the work force altogether and were caring for families. Fouad and Singh also report that women's desire to stay in engineering seemed to be enhanced by individuals and policies who were supportive, invested in their training, and took steps to minimize work/family conflict. Overwork and incivility increased work/family conflict and increased women's desire to leave. In general, an unsupportive work climate was found to have a negative effect on women's commitment to staying in the profession.

Fouad and Singh's study is ongoing and promises to provide important insights into women's decisions regarding engineering careers post-graduation. What it cannot do, however, is answer questions about whether women are *different* from men in this regard. Their respondents are exclusively women, so it is not possible to tell from their results whether men react differently to the conditions that push women out of the profession. And, while it is frequently asserted that women *are* more likely to leave engineering than men, a study we discussed in last year's review has raised questions about how accurate this assertion actually is. Frehill (2010) reported on a study showing that men and women, in at least some engineering disciplines, are *equally* likely to leave the profession, and that both men and women leave the profession in significant numbers. At the same time, in other disciplines, e.g., chemical engineering, women did appear to be leaving at higher rates, and there were differences in the reasons for men's and women's departures from the profession. Men who left were more likely to emphasize better opportunities and women were more likely to emphasize work/family reasons. Thus, there continues to be a need for comparative studies examining the question of whether leaving engineering differs between men and women.

Beyond the pipeline metaphor

In the mid-1970s, Malcom, Hall, and Brown (1976) published the now classic study "The Double Bind: The Price of Being a Minority Woman in Science,"

which documented the compound problems faced by women of color in STEM. This represented one of the first acknowledgements that diversity in engineering went beyond gender and that there was a need to reflect on the variety of experiences different types of people in the profession have. This theme continued to be central to research reported in the 2011 literature, and provides an underpinning from which to question the pipeline metaphor.

While identity has remained an issue (see sidebar, "The Intersections of Gender, Race, and Multiple Identities," on page 213), identity is not defined solely on the basis of gender or race. Although sexual orientation is not a well-researched aspect of diversity in engineering, at least one article we reviewed provided insight into this issue. Cech and Waidzunus (2011) conducted an exploratory study of 17 lesbian, gay, and bisexual (LGB) students enrolled in an engineering department at a major U.S. college. While this is a small sample study, its results suggest that LGB students face their own set of challenges in engineering programs. The study describes a culture of heteronormativity in engineering that forces LGB students to "pass" as heterosexual or to downplay characteristics associated with their LGB identities. To succeed, these students must compartmentalize their lives — a requirement that burdens them with additional academic and emotional work.

The fact that engineers have diverse, indeed multiple, identities is but one piece of evidence used to criticize the pipeline

The Intersections of Gender, Race, and Multiple Identities

More than 30 years ago, a report to the American Association for the Advancement of Science, "The Double Bind: The Price of Being a Minority Woman in Science" (Malcom et al. 1976), first raised the question of whether women of color face particular obstacles in entering and establishing careers in engineering and science. The passage of time has not eliminated the double bind, nor has there been a dramatic increase in research on or awareness of the problem, as revealed by several articles published this year, including a "Symposium: Unraveling the Double Bind," a special section that appeared in the Summer 2011 issue of the *Harvard Educational Review*. In that issue, an article co-authored by one of the original authors of "The Double Bind..." argued that in some respects, things have changed:

"The next-generation women, the Double Bind daughters, face different challenges from those faced by their mothers. Now it is less about rights versus wrongs, and more about support versus neglect; less about the behavior of individuals and a culture that was accepting of bias as 'the natural order of things,' and more about the responsibilities and action (or inaction) of institutions" (Malcom and Malcom 2011:163).

At the same time, the ignoring and underrepresentation of minority women in engineering and science generally remains an ongoing problem.

The fact that not all women's experiences are the same emerges clearly from a study by Litzler et al. (2011), who analyzed data from the 2008 Project to Assess Climate in Engineering survey, involving more than 38,000 students at 21 participating schools. Because of the large size of the data set, they had an unusual opportunity to look at differences across race and

ethnicity for women students. For example, black women reported being more willing to ask questions in class and meet with professors, while Native American women were the least comfortable with taking these actions. On the other hand, among minority women, black women were most likely to report having been singled out in class unfairly because of their race or ethnicity. Differences such as these indicate that race/ethnicity, as well as gender, need to be factored into analyses of the experiences of women in engineering.

Ong et al. (2011) review the 40-year literature on the post-secondary experiences of women of color in STEM and find evidence not just of difference, but also of inequality. They note that women of color are stereotyped as not being interested in STEM, something that functions as a myth used to explain away the continued small numbers of minority women in these fields. Programs aimed at helping women or at serving minority groups also are criticized for not serving the needs of minority women.

This last argument underlines the growing sense that there is a need to go beyond the notion that race and gender should be considered separately. Sociologists refer to the combined effects of multiple identities as "intersectionality," a concept that is evident in what is being said about minority women in engineering. Numerous studies we reviewed call for the disaggregation of data on women engineers and argue against looking at race/ethnicity and engineering separately from gender and engineering. Instead, the experiences of minority women should be understood as distinct, both from that of majority women and from that of minority men (e.g., Riley and Pawley 2011).

metaphor, since the latter implies that what is inside the pipeline is homogeneous. Researchers have also raised other questions about the pipeline metaphor, however, including criticisms of the idea that everyone enters the pipeline in the same way at the same point. Studies of community college engineering programs are particularly relevant to this criticism.

Large numbers of American students begin higher education in community colleges and eventually attempt to transfer to four-year

institutions; some do so intending to enter engineering. Entering four-year engineering programs in this way is quite different from entering directly from high school. The literature we reviewed indicated that women who enter engineering after attending community colleges have distinct experiences, in various ways.

Anderson-Rowland (2011) studied 183 community college transfer students in engineering and computer science at Arizona State University in 2010, finding that both men and women

experienced a significant drop (.449) in their GPAs during the transition. Women students had the most difficulty adjusting, as their GPAs dropped by .567. This study notes that support programs for these students are effective, as students in the program participating in an NSF-funded support program experienced much smaller GPA declines.

Packard et al. (2011) interviewed 26 female STEM students who transferred from a community college. Most (22/26) persisted in STEM after their first semester at a

four-year school, but respondents reported a difficult transition. The problems central to much of the literature on women in STEM — such as motherhood or relationships — were not the focus of the respondents' concerns. Instead, female transfer students were focused on finishing their studies efficiently, complained of financial difficulties, struggled with the challenge of combining work and school, and were unhappy about the waste caused by ineffective advising. Because this study lacks a male comparison group, it is impossible to tell whether these experiences are distinct to *female* transfer students, but its findings suggest that female transfer students are different from female students who begin four-year schools as first-year students.

Reyes (2011) described the experiences of women of color who transfer from community colleges, pointing to a potentially even more complex form of intersectionality. Unfortunately, her study focused on only four cases (although 42 participated in the program from which she drew her respondents), so the representativeness of her sample is obviously in question. The four women whose interviews she discussed reported being made to feel that they did not belong because of their identities as women, nontraditional students, and members of minority groups, and because they were transfer students, who were stereotyped as ill-prepared. Further study of larger groups of minority women who transfer into four-year engineering and other STEM programs clearly is needed,

especially because minority students are particularly likely to begin higher education in two-year schools.

Feminism and research on engineering

Seron et al. (2011) presented a paper this year entitled “I Am Not a Feminist, but...’: Making Meanings of Being a Woman in Engineering.” The title evokes the caution with which feminist ideas are treated in engineering, something that several researchers (including Seron et al.) lamented. The paper reports on a qualitative study of engineering students at several New England schools in which a small group (41) of participants made bimonthly diary submissions. Seron et al. found that while participants were aware of the male-dominated nature of the field and that it was perhaps not gender neutral, they did not question prevailing gender norms, especially regarding women’s domestic roles, and believed that they would be successful if they worked hard. They were not inclined to question taken-for-granted assumptions about meritocracy, individualism, etc. and did not embrace feminist ideas about how the gendered character of organizations created barriers for women in the profession.

Beddoes and Borrego (2011) note that a reluctance to embrace a feminist critique is characteristic not just of engineering students, but also of academics conducting research on women in engineering. They performed a content analysis of 88 articles published in major engineering education journals and found little explicit engagement with feminist theory. At best, they found evidence of a form of “liberal

feminism,” focused on “women in engineering,” that did not locate women’s problems in the field in a critique of the gendered nature of engineering organizations and knowledge. One example of this form of feminism can be found in efforts to increase the numbers of women attracted to engineering without altering the conditions of work and the overall culture of the profession. Scholars also tended to essentialize women, treating them as all the same, leading to a neglect of important differences among different types of female engineers.

Sharp et al. (2011) reported on an interview-based study of three Australian organizations that had instituted “managed diversity policies.” These researchers form part of an interdisciplinary, self-consciously feminist research team (see Mills et al. 2011) interested in exploring how feminist ideas can be applied to the analysis of gender and engineering. They argue that the types of diversity policies they examined are fundamentally flawed because they do not challenge the dominant gender power relations in organizations. Managers often didn’t see these gender power relations at all, and feared that fundamental changes wouldn’t work or would require changing practices (such as working long hours) they believed to be necessary. Even female employees were reluctant to challenge existing practices too much, for fear that they would be perceived as asking for special treatment.

All of these articles, in one way or another, point to the potential value of a feminist critique of engineering — they suggest that a more radical rethinking of engineering organizations,

practices, and knowledge are needed if gender equity in the profession is to be achieved. Schiebinger and Schraudner (2011) add to this the idea that a feminist critique can actually lead to better engineering, not just improvements in the situation of women in the field. They note that approaches to gendered innovation tend to emphasize either increasing the numbers of women in engineering (the pipeline issue) or, less often, transforming research institutions by improving classroom climate, modifying hiring and promotion systems, etc. Rarely, however, do critics examine how gender is built into the science itself. Schiebinger and Schraudner contend that the quality of the science suffers as a result and point to examples of how looking at gender would result in better research: If seat belt designers had considered gender, they would have been able to prevent subsequent problems with pregnant women; medical research would have been more likely to include women in studies of heart disease and men in studies of osteoporosis; water development projects would have benefited from awareness of the fact that women are often the ones who have knowledge about water.

Much of the literature we reviewed this year documented and attempted to explain the persistence of gender inequalities in engineering and in the STEM professions. These articles on the role of feminist ideas in engineering studies propose that a more fundamental rethinking of engineering itself might point to changes that would accelerate women's progress in the field and benefit engineering as a whole. ■

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Note: The following list of references comprises all of the noteworthy articles and conference papers found in our search of the 2011 literature on women in engineering. We selected for discussion in our review the literature that seemed to be based on the most substantial research and/or which offered interesting, fresh insights into the situation of women in engineering. For the convenience of interested readers, we have included the complete list of materials we consulted.

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Women in Engineering: A Review of the 2012 Literature

SWE's summary of the best research found in the past year's social science literature on women engineers and women in STEM disciplines also calls attention to the need for multidisciplinary approaches, and poses questions about the direction future research should take.

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Our review of 2012's scholarly literature relevant to women in engineering unearthed more than 100 publications in journals representing a half-dozen or more disciplines, including psychology, sociology, business, engineering, education, and economics. We searched for articles by examining major research databases and more than 70 journals that publish articles on gender and engineering. The research ranged from small studies of single institutions or programs to large-scale national or international surveys covering thousands of cases. As always, the studies varied tremendously in quality and rigor; they also varied in methodological approach, from complex statistical analyses of large data sets to interpretive studies of qualitative data.

Due to space considerations and the individual merits of each work, we will not address all of the studies we consulted for this review, although they are included in the bibliography. As in the past, we have focused on the most rigorous pieces of research, on peer-reviewed articles, and/or on articles that offer fresh insights and new approaches. We have also pointed to any methodological limitations, and to innovative methodological approaches, in the research we discuss.

This is the third literature review we have conducted (prior to 2010, reviews were conducted by a different team), and we are struck by the fact that, much like the film of the same name, there is a certain "Groundhog Day" quality to this process. Each year, we find ourselves reviewing many of the same issues, describing the same unresolved questions, summarizing similar studies, similar findings, and a general lack of agreement among the researchers as to what is happening, or what the solution may be to increase the numbers of women in engineering.

Moreover, as we will elaborate further, we have noticed a sense of alarm concerning trends in science, technology, engineering, and mathematics (STEM) disciplines in general, and engineering in particular. It was possible in the recent past to point to gradual increases in the numbers of women in engineering and to define those increases as positive indicators. Any confidence that it was just a matter of time before gender equality in engineering would be achieved has, instead, been undermined by the reality that those increases have either slowed or stopped altogether.

There is a sense that things have stopped changing. This has implications not just for women and for gender equity, but for the American economy

as a whole. Policymakers now worry about whether a shortage of homegrown engineers will cause the United States to lose its technological lead over the rest of the world, and finding ways to recruit more women into engineering has been identified as one of the ways in which this decline might be avoided.

In view of these developments, we are not content simply to summarize the various research articles on women in engineering published in the last year. In the context of what appears to be stalled progress toward gender equality in engineering, we believe it is appropriate to step back and take stock.

There is a need to ask researchers not just *what* they have learned, but whether they are asking the right questions; whether they are engaging with one another adequately, and taking full advantage of what researchers on gender in other fields have learned.

Thus, in this review, while we summarize the best research we found in the literature this year, we also pose questions about directions research might take in the future to effectively address this unexpected change of course.

With this in mind, we have elected to include discussion of a number of book-length works that have been published in the last half-dozen years,

and which have not been featured in the previous literature reviews produced for *SWE Magazine*. These larger works often take up broader questions and consider a wider range of literature than a narrowly focused research article or conference paper can review. Thus, discussing them provides us with an opportunity not just to summarize the major findings in this year's research, but also to consider possible explanations for the apparent impasse in the research literature and for the frustratingly limited results of decades of efforts to increase the numbers of women in the engineering profession.

Has progress stalled?

A number of the publications we reviewed this year make reference to the discouraging fact that the numbers of women in engineering are not increasing more rapidly. One example is Mills, Ayre, and Gill's (2010) book-length call for "gender inclusive engineering education," which laments the fact that, particularly in English-speaking countries, the numbers of women in engineering remain very low. They note that the numbers of women pursuing undergraduate degrees in engineering have increased, but point to the reality that the numbers working in the profession remain low, and may actually have ceased growing.

Barnard et al. (2012) released findings that are essentially the same, reporting that in the U.K., women's enrollment in engineering at university had increased from 4 percent in 1972 to 18 percent in 2008, while the percentage of women engineering professionals had increased only from 4 percent in 1972 to 7 percent in 2008. Many studies find that girls and young women continue to choose fields other than engineering and regard engineering as stereotypically masculine. Ceci and Williams (2010) also argue that because of the high percentage of foreign-born women in math-intensive fields, the underrepresentation of U.S. women in certain STEM fields such as engineering may actually be understated.

And, as we will discuss at greater

length, the retention of women engineers remains a problem, as women leave the profession at higher rates than their male counterparts (Hewlett et al. 2008). There is, in other words, a sense of frustration in the literature that progress is either too slow or has come to a standstill.

Added to this is an apprehension that the underrepresentation of women suggests a larger, more general crisis in STEM education. This is made most explicit in Hewlett et al.'s (2008) important national study of women scientists, which begins by pointing to the fear among policymakers that American superiority in science and engineering is in decline. That fear is based on the perception that American students are reluctant, perhaps increasingly reluctant, to enter STEM disciplines; and that enrollments in some disciplines may actually be declining, in spite of numerous attempts to encourage capable students to consider STEM majors.

Hewlett et al. note that women represent a great, untapped resource in the field of science. If the United States needs more scientists and engineers, one obvious place to recruit them would be among women, who now represent the majority of university students, but are not being drawn into STEM majors such as engineering. Mills, Ayre, and Gill (2010) note that reforming engineering education to attract more women has been identified as important for the future of the economy as a whole, not just for women.

Whether or not there is an actual *shortage* of engineers and scientists, as some policymakers have claimed, is in much dispute. Freeman and Goroff (2009) argue that the sense of concern about American science is not the result of an actual shortage — they note that, if there were a real shortage, demand would have pushed the salaries of engineers and scientists much higher, something that has not occurred. Xie and Killewald (2012) agree that stagnant or declining earnings challenge the view that there is a shortage. They acknowledge that there have been moderate

declines in U.S. students' interest in science and math degrees, and that the numbers of science degrees awarded to native-born males has stagnated. But, they also note that the growth of the scientific work force, including engineers, has been modest; and that virtually all of the recent growth is accounted for by the emergence of computer science.

Nevertheless, both studies acknowledge that the United States faces increasing competition, perhaps inevitably, in technical fields. Therefore, finding ways to strengthen the pool of talented students by increasing the numbers of women entering fields such as engineering appears as a matter of national economic importance. It is, thus, all the more disconcerting that women continue to be so poorly represented in those fields.

This year's research literature offers varying answers to the question of why there continue to be comparatively few women in engineering. Some of the research points to relatively traditional explanations and solutions, focusing on the need to interest girls in engineering in the first place; to improve the retention of women in engineering schools; and to strengthen the position of women in academic engineering. Other research, however, points beyond this kind of intervention and suggests that it will continue to be difficult to recruit women to engineering careers because engineering's "masculine" characteristics conflict with women's gender identities.

Recruiting and retaining female engineers

As we pointed out in last year's literature review, the pipeline metaphor has lost popularity among researchers, who acknowledge that there are multiple pathways into engineering. Nevertheless, researchers continue to focus considerable attention on understanding what might increase the supply of young women interested in engineering.

Several studies we reviewed consider the role of math preparation, of encouraging girls to take advanced math classes prior to entering university, and

in getting girls interested in engineering. Leaper, Farkas, and Brown's (2012) survey of 579 high-school age girls found that social and parental support for girls in math and science predicted their science motivation. Pearson and Miller (2012) analyzed the National Longitudinal Study of Youth (a large national data set that follows respondents over long periods of time) and found that, for both men and women, parental encouragement of math education was a significant predictor of entering an engineering program and of becoming a professional engineer.

Interestingly, parental encouragement of engineering did not have a significant effect on students' choices. Pearson and Miller also note, however, that men remain much more likely to enter engineering programs. Kimmel, Miller, and Eccles (2012) examined a subsample of math-talented men and women from the same data set and found that the women were less likely than the men to be interested in engineering or to pursue engineering degrees and careers. They found, as well, that math-talented women are more likely to choose programs in medicine and health, which Benbow's (2012) analysis of a study of mathematically talented youth also concluded.

Sadler et al.'s (2012) retrospective study of several thousand students' career interests found that far fewer women than men express interest in engineering in high school, as women are much more interested in health and medicine. The gender gap actually grows during this time, as few women but significant numbers of men *develop* an interest in engineering in the latter parts of their high school careers. A possible explanation is the persistence of powerful stereotypes regarding the male character of engineering and science. Lane, Goh, and Driver-Linn (2012) analyzed data from an online survey of 234 first-year undergraduates and found that implicit (i.e., unstated, perhaps unconscious) stereotypes about science being masculine were the main factors underlying men's greater likelihood of selecting STEM majors.

Shapiro and Williams (2012) found that stereotype *threat* may play a role in girls' interest and success in math: Girls tend to do less well in math when they are *aware* of the stereotype that gender affects math ability. Shapiro and Williams recommend various interventions designed to combat the negative view of self that underlines this phenomenon. Ross (2012) suggests that school counselors' awareness of negative stereotypes about women in STEM may affect how they advise students. With a view to combating the effects of stereotyping on counselor behavior, the study reports on the development of a survey instrument designed to assess counselors' awareness of stereotyping, implicit attitudes to gender, and practices in advising male and female students.

As is now widely recognized, *recruiting* more women to engineering programs will have little effect if those women are not *retained*. Oddly, there is no real consensus as to whether women leave engineering programs at unusually high rates. Some studies claim that this is the case: Mills, Ayre, and Gill (2010) briefly review the literature on this question and report that a major study performed in the 1990s found lower retention rates among female engineering students.

However, they note that a more recent (2008) study found that engineering students, as a group, persisted at unusually high rates and that there were no significant gender differences in retention. Marra et al. (2012) report on a mailed survey of students who left engineering at a large Eastern university and also found no gender differences (although this study is weakened by a very low response rate).

Blasick et al. found that women engineering students at Georgia Tech persisted at *higher* rates than their male counterparts, although their sample was unusual in that it had very high completion rates overall.

One clear need emerging from the literature on women in engineering is for a careful, national study of overall retention rates in engineering, and for a

thorough analysis of whether male and female students leave at different rates and for different reasons.

That said, considerable research was devoted again this year to examining factors that predict women's persistence in engineering programs and to identifying interventions that might encourage women to stay. LeBeau et al. (2012) analyzed data on 3,459 students from 229 schools in the Midwest who started college in fall 2002 or 2003. They found that the high schools attended by the students had little effect on the students' likelihood of completing STEM majors in college; however, consistent with many earlier studies, they found that students' math ACT scores and high school math GPAs were positively linked to graduating with a STEM major. Unfortunately, this study, which contained nearly equal numbers of men and women, does not analyze the effects of gender.

Buday et al. (2012) report on an online survey of 81 students who participated in a high school enrichment program and had been identified as gifted in math and science. They found that both men and women who took part in the program felt that they had more social support for pursuing a career in science and were, therefore, more likely to see this as a "possible self" they could explore. Both of these studies — LeBeau et al. and Buday et al. — point to the possibility that retention in university-level STEM programs may be affected by events that occur in high school or even earlier.

Two studies we reviewed consider the effect of students' grades on persistence. In theory, it would stand to reason that students with higher grades would be more likely to persist. However, neither study confirmed this hypothesis for girls. Haemmerlie and Montgomery (2012) report on the results of a survey of 1,342 first-year engineering students at Missouri University of Science and Technology in 2007. They found that men with higher GPAs were more likely to persist (and higher GPAs were associated with higher ACT and high school GPAs), but that the same was *not* the case for women.

Sonnert and Fox (2012) report on a much more ambitious analysis of data on more than 9,000 students from almost 500 institutions between 1984 and 2000. They note that research generally shows that women tend to have higher GPAs than men, and that higher GPAs are particularly important to women's retention, more so than men's. However, this does not translate into more women in science. They hypothesize that fields in which women have a strong GPA advantage may be male-dominated so that only the most capable women persist, while less-successful female students leave if they struggle.

They also hypothesize that women's GPA advantage will be more significant where there are programs that support women. Their findings partly confirm their argument, particularly about male-dominated fields such as the physical sciences. But, they acknowledge that their hypotheses are only partly confirmed by their analysis, and that much of the variance in the gendered GPA gap remained unexplained.

It is possible that one factor conditioning the effect of GPA on retention is confidence. Several of the studies we reviewed report that female students express lower levels of confidence in their abilities and likelihood of success. Thus, it may be that even if students are performing well, they may not be confident in their ability to continue doing so or to translate academic success into professional success, which, in turn, may affect their likelihood of persisting.

Hein et al. (2012) analyzed data from multiple surveys of engineering students at Michigan Tech between 2009 and 2011. Among their findings is that female students were less likely to express confidence in their ability to succeed in engineering courses, despite the fact that they had higher GPAs. Heylen et al. (2012) studied 851 first-year engineering students at the Catholic University of Leuven in Belgium, finding that men and women had similar GPAs (although women tended to study more than men), but women reported lower self-confidence than their male counterparts.

Women Engineering Deans

By Peggy Layne, P.E., F.SWE

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Source: American Society for Engineering Education

A possible intervention related to this problem of low confidence is described in an article by Wang et al. (2012). They examine the effects of a leadership module employed in a first-year engineering course at the University of California, Berkeley. Students who participated in the leadership module reported increased confidence in their engineering and leadership skills and experienced greater increases in confidence than students who did not participate in the module. The effect on the confidence of women was significantly greater than the effect on the confidence of men. The authors speculate that this increased confidence will translate into higher retention rates, which they intend to examine in future research.

Two final factors that may affect retention of women in engineering also emerged from this year's research literature. Creamer (2012) examined 1,629 student questionnaires as well as interview data from U.S. universities between 2006 and 2010. The quantitative data revealed that, as the number of women increased, *both* men and women were more likely to report that they anticipated being employed in engineering after graduation. The qualitative data pointed to the conclusion that increased numbers of women demonstrated to other female students that women were able to succeed in engineering; in addition, larger numbers of female students affected the social dynamics of the program (more friendships, better collaboration), which had positive effects on students of both genders.

If Creamer is correct, it may be that there is a "tipping point" at which the numbers of female students creates a positive atmosphere in which women in particular, and students in general, are more likely to persist.

Discouragingly, however, Yoshida et al. (2012) found otherwise in a complex study of undergraduates at a Canadian university. Part of this study included a survey of 142 first-year engineering students (about two-thirds of whom were male). The results indicated that

the more students were exposed to engineering, the more negative their evaluation of female engineers became. Moreover, this affected *both* male and female students, suggesting that a set of negative stereotypes about female engineers pervades the engineering curriculum and may be undermining female engineering students' self-concepts.

Within the literature on women in engineering, particular attention is paid to the status of women faculty. In part, this is the result of the NSF-ADVANCE program, which has devoted significant federal resources and prestige to the effort to increase the numbers of female scientists and engineers in the academy and to encouraging the creation of conditions under which they will thrive.

While this literature focuses on the experience of a small subset of female scientists and engineers, efforts to increase the numbers of female faculty members in STEM disciplines promise to improve the recruitment and retention of female students, by providing role models, mentors, and a climate in which women are less likely to be in a significant minority.

Again, this year, we reviewed more articles on the experiences of female academics than on virtually any other topic. Of particular note is Bilimoria and Liang's (2012) book reporting on the first two rounds of NSF-ADVANCE grant recipients. The authors judge the ADVANCE program to have been largely successful in increasing the work-force participation of women and minorities at all ranks and in creating a more equitable and inclusive workplace. They identify a number of internal factors that facilitated institutional transformation, including senior administrative support and involvement, the presence of an institutional champion, collaborative leadership, widespread and synergistic participation across campus, and the existence of visible actions and outcomes.

They also note that program success was facilitated by the fact that a network of peer institutions was developed among ADVANCE grant recipients and

by the legitimacy NSF funding granted to the program. Overall, Bilimoria and Liang's review points to the existence of effective interventions that can help increase the numbers of women on science faculties and improve the conditions under which they work.

The literature on women in academic science and engineering places particular emphasis on the importance of mentoring. Rosser (2012) devotes an entire chapter to this issue, arguing that the existence of good, supportive mentoring is essential, and pointing to corroborative evidence from the experiences of distinguished female scientists. Interestingly, she argues that it is particularly important that there be effective mentoring by men, since the numbers of senior women faculty available to mentor their more numerous junior colleagues are insufficient.

Dunham et al. (2012) report on a set of interviews with 20 female STEM faculty at Texas Tech University. Having experienced a prior unsuccessful attempt to institute a mentoring program for female faculty, the researchers decided that they needed to know more about what faculty were looking for in a mentoring relationship. Respondents emphasized that they sought rapport and trust in a mentoring relationship, and rejected the idea that gender was a major factor in the selection of a good mentor. Senior women faculty were not automatically good mentors, nor were men perceived as bad mentors, although gender did become salient if female faculty members believed that male colleagues were getting more attention. The study also noted the importance of providing mentors with training on the importance of demonstrating commitment, honoring confidentiality, and building trust.

One limitation of the studies of mentoring that appeared this year is that they focused exclusively on traditional individual mentoring by senior faculty, and didn't consider the potential of group or peer mentoring models.

Whether as a result of changes promoted by NSF-ADVANCE, or due to other changes separate from that program, it appears that the salience

of gender in academic science and engineering has been reduced. Two studies we reviewed indicate that female STEM faculty members now experience recruitment, retention, and promotion conditions similar to those experienced by men. Freeman and Goroff (2009) report that women in engineering and physical and life sciences have equal chances of obtaining tenure-track jobs and of being promoted as men. Interestingly, the same is *not* true for women in the humanities and social sciences.

Unfortunately, Xie and Killewald (2012) point to evidence that both men and women are experiencing declining chances for academic employment in science and engineering. Kaminski and Geisler (2012) examined data on almost 3,000 female faculty members at 14 U.S. universities hired as assistant professors since 1990. Like Freeman and Goroff,

they found that there were no significant differences in retention or promotion between male and female faculty members in STEM disciplines (with the partial exception of mathematics).

Of course, not all problems for female STEM faculty have been eliminated completely. Rosser (2012), for example, notes that female scientists are more likely than male scientists to have a partner who is also a scientist. For that reason, they are particularly likely to encounter the “dual science career” problem. Rosser also notes that not much research has been done on particular groups of women scientists, most notably senior women and immigrant women scientists (the latter comprise nearly 30 percent of employed female academic scientists). All of this notwithstanding, the apparent progress

toward gender equity in faculty careers is encouraging.

Changing engineering?

One of the hallmarks of ADVANCE is institutional change — the rallying cry is not to change the women but to change the institution. Another stream in the research on women in engineering applies this general principle to engineering as a whole, not just to the academy, arguing that improving the situation of women engineers, and increasing their numbers, requires transforming engineering itself to make it more compatible with the women it seeks to attract.

Many observers have noted that while women are significantly underrepresented in engineering and the physical sciences, they are present in large and growing numbers in fields related to health and medicine, many of which are equally demanding in time and intellectual rigor.

Kimmel, Miller, and Eccles (2012) argue that much research misrepresents the position of women in the sciences by focusing exclusively on STEM (science, technology, engineering, math) rather than on STEMM (which adds “medicine”). Their analysis of data from the National Longitudinal Study of Youth finds that women are much more likely to choose programs in health and medicine, and to pursue careers in those fields, than they are to choose engineering or physical science. Moreover, they note that persistence rates for women and men vary tremendously by discipline — their data indicate that women *are* less likely than men to complete an engineering degree, but this is not the case in health and medicine.

Interestingly, and counter to the argument of Ceci and Williams (2010) discussed below, they find no support for the view that family responsibilities depress female participation in STEMM careers. If one includes medical/health fields in the analysis, the effect of family responsibilities on careers disappears entirely, suggesting that there is something specific about engineering and the physical sciences that accounts for women’s underrepresentation, rather

Engineering Bachelor’s Degrees Awarded, 2011

Discipline	% Women	Women	Men	Total
Civil	21	2,552	9,602	12,154
Mechanical	11.7	2,251	16,990	19,241
Chemical	33.1	2,147	4,340	6,487
Biomedical	39.1	1,590	2,476	4,066
Electrical	11.5	1,143	8,799	9,942
Industrial/Manufacturing	29.1	1,085	2,642	3,727
Computer Science (inside eng.)	11.2	751	5,957	6,708
Other	20.1	750	2,980	3,730
Aerospace	13.4	464	2,995	3,459
Engineering (general)	24.2	355	1,110	1,465
Metallurgical and Materials	28.4	330	831	1,161
Computer Science (outside eng.)	10.9	326	2,666	2,992
Computer	9.4	318	3,063	3,381
Environmental	44.3	309	389	698
Biological and Agricultural	31.9	254	542	796
Electrical/Computer	11	237	1,916	2,153
Architectural	22.9	170	573	743
Civil/Environmental	22.3	158	551	709
Petroleum	16.8	149	739	888
Eng. Science and Eng. Physics	19.8	98	398	496
Nuclear	16.4	77	392	469
Engineering Management	24.1	76	239	315
Mining	14.6	31	182	213
				83,001

Source: Yoder, *Engineering by the Numbers*, American Society for Engineering Education, 2012

than academically challenging, time-intensive careers.

Agrowing literature on female identity and engineering suggests that the problem may be the “maleness” of engineering itself that obliges female engineers to find ways to reconcile their female identity with their identity as an engineer. As discussed above, widespread cultural stereotypes present engineering as a primarily male activity.

Reeder et al.’s (2012) study of almost 1,200 college students (most of whom were STEM majors) found that male and female students alike were able to name far more male than female scientists and engineers, even when specifically asked to think of well-known women. An engineer tends to be thought of as “male,” so women who enter the field have to contend with this reality and the predominantly male culture that pervades engineering.

Some studies of female engineers and scientists find that they are likely to play down or deny their female identity in order to claim identity as an engineer. Hewlett et al. (2008) describe female scientists and engineers who “act like men” to try to fit in; however, they also describe the fact that they cannot entirely fit in, and that denying female identity separates them from other women, creating a level of isolation that can be harmful to careers.

Erickson (2012) interviewed 20 doctoral engineering students and found that they, too, deny the relevance of gender to their own experiences in order to claim a place in a masculine culture. They are aware of gender and how it shapes engineering; but they deny its relevance to their own situation, focusing only on how it affects others.

Women in engineering and science also have to contend with stereotypes of what a *female* engineer or scientist is like. Danielsson’s (2012) exploratory study of a small group of female physics students finds that they encounter an existing stereotype of the female physicist as someone who is diligent, takes notes, follows rules, is thorough, tends

2012 Outstanding Women in Engineering

By Elsa Camargo

American Society for Engineering Education (ASEE) Awards

National and Society Award Recipients

Sharon Keillor Award for Women in Engineering Education

Mary Besterfield-Sacre, Ph.D., University of Pittsburgh

DuPont Minorities in Engineering Award

Carolyn Vallas, University of Virginia

Fred Merryfield Design Award

Maria Oden, Ph.D., Rice University

William Elgin Wickenden Award

Catherine E. Brawner, Research Triangle Educational Consultants

Michelle M. Camacho, Ph.D., University of San Diego

Susan M. Lord, Ph.D., University of San Diego

Mara Wasburn, Ph.D. (deceased), Purdue University

2012 ASEE Fellow Member Honorees

Janie Fouke, Ph.D., Nanyang Technological University, Singapore

Jane Fraser, Ph.D., Colorado State University-Pueblo

Marybeth Lima, Ph.D., P.E., Louisiana State University

Diane Rover, Ph.D., Iowa State University

ASEE Professional and Technical Division Awards

Chemical Engineering Division:

Ray W. Fahien Award

Keisha Walters, Ph.D., Mississippi State University

William H. Corcoran Award

Margot Vigeant, Ph.D., Bucknell University

Katharyn Nottis, Ph.D., Bucknell University

Civil Engineering Division:

Gerald R. Seeley Fellowship

Michelle Oswald, Ph.D., Bucknell University

College-Industry Partnership Division:

CIEC Best Presenter Award

Joy Greig, Overwatch

CIEC Best Session Award

Cath Polito, University of Texas at Austin
Linda Thurman, University of North Carolina, Charlotte

Continuing Professional Development Division:

CIEC Best Conference Presenter Award

Pamela Dickrell, Ph.D., University of Florida

CIEC Best Session Award

Candace House, University of Southern California
Ellen J. Elliott, Ph.D., Johns Hopkins University

Cooperative and Experiential Education Division:

Alvah K. Borman Meritorious Service Award

Susan Matney, North Carolina State University

CIEC Best Presenter Award

Karen Kelley, Northeastern University
Lorraine Mountain, Northeastern University

CIEC Best Session Award

Alison Nogueira, Northeastern University

Co-op Student of the Year Award

Melissa McPartland, Clemson University

Division of Experimentation and Laboratory Oriented Studies (DELOS):

Best Paper Award

Jean Jiang, Ph.D., Purdue University North Central
Manda Paul, University of California, Los Angeles

Educational Research and Methods Division:

Apprentice Faculty Grant

Maria-Isabel Carnasciali, Ph.D., University of New Haven
Alejandra Magana, Ph.D., Purdue University, West Lafayette

Benjamin J. Dasher Best Paper Award

Kristi Shryock, Ph.D., Texas A&M University

Distinguished Service Award

Jennifer Karlin, Ph.D., South Dakota School of Mines

Helen L. Plants Award

Senay Purzer, Ph.D., Purdue University, West Lafayette

Ronald J. Schmitz Award for Outstanding Contributions to the Frontiers in Education Conference

Susan Lord, Ph.D., University of San Diego

*Electrical and Computer Engineering Division:***Distinguished Educator Award**

Patricia Daniels, Ph.D., P.E., Seattle University

*Energy Conversion and Conservation Division:***Best Paper Award**

Teodora Shuman, Ph.D., Seattle University
Miriam del Rosario Fontalvo, Ph.D. (affiliation unknown)

*Engineering Design Graphics Division:***Payne Award**

Marie Planchard, Dassault Systèmes

*Engineering Economy Division:***Best Paper Award**

Yiran Zhang, University of Bridgeport

Eugene L. Grant Award

Kati Brunson, Lockheed Martin Space Systems Co.
Betsy DeLee, Lockheed Martin Space Systems Co.

*Engineering Libraries Division:***Best Publication Award**

Megan Sapp Nelson, Purdue University

Homer I. Bernhardt Distinguished Service Award

Maliaca Oxnam, University of Arizona

*Engineering Technology Division:***CIEC Best Session Award**

Lueny Morell, Hewlett Packard

*Environmental Engineering Division:***Best Student Paper Award**

Sarah Bauer, Rowan University

*Industrial Engineering Division:***Best Paper Award**

Ana Vila-Parrish, Ph.D., North Carolina State University
Dianne Raubenheimer, Ph.D., Meredith College

Distinguished Service Award

Kim LaScola Needy, Ph.D., University of Arkansas

New IE Educator Outstanding Paper Award

Elizabeth Cudney, Ph.D., Missouri University of Science and Technology
Susan Murray, Ph.D., Missouri University of Science and Technology
Heidi Taboada, Ph.D., University of Texas at El Paso

*K-12 Division:***Best Paper Award**

Malinda Zarske, Ph.D., University of Colorado Boulder
Janet Yowell, University of Colorado Boulder
Jacquelyn Sullivan, Ph.D., University of Colorado Boulder
Angela Bielefeldt, Ph.D., University of Colorado Boulder

*Liberal Education Division:***Sterling Olmsted Award**

Donna Riley, Ph.D., Smith College

*Mechanical Engineering Division:***Ralph Coats Roe Award**

Sheri Sheppard, Ph.D., Stanford University

*Mechanics Division:***Ferdinand P. Beer and E. Russell Johnston, Jr. Outstanding New Mechanics Educator Award**

Julie Stahmer Linsey, Ph.D., Texas A&M University

*Systems Engineering Division:***Best Paper Award**

Joanne Bechta Dugan, Ph.D., University of Virginia
Alexandra Coso, Georgia Institute of Technology

*Women in Engineering Division:***Mara H. Wasburn Apprentice Educator Grant**

Katerina Bagiati, Ph.D., Massachusetts Institute of Technology
Rachel Louis, Virginia Tech

Women in Engineering ProActive Network (WEPAN) Awards**Distinguished Service Award**

Julie Martin, Ph.D., Clemson University

University Change Agent Award

L. Pamela Cook, Ph.D., University of

Delaware

Educator's Award

Mimi Lufkin, National Alliance for Partnerships in Equity

Women in Engineering Champion Award

Sylvia Henson, IBM

The National Academy of Engineering**New Female Members**

Barbara Boyan, Ph.D., Georgia Institute of Technology
Mary Boyce, Ph.D., Massachusetts Institute of Technology
Joan Brennecke, Ph.D., University of Notre Dame
Victoria Haynes, Ph.D., RTI International
Diane McKnight, Ph.D., University of Colorado Boulder
Christine Shoemaker, Ph.D., Cornell University
Gordana Vunjak-Novakovic, Ph.D., Columbia University

Society of Women Engineers (SWE) Awards**Achievement Award**

Yildiz Bayazitoglu, Ph.D., Rice University

Suzanne Jenniches Upward Mobility Award

Natalie Givans, Booz Allen Hamilton

Entrepreneur Award

Loraine Huchler, P.E., MarTech Systems Inc.

Distinguished Engineering Educator Award

Dawn Tilbury, Ph.D., University of Michigan

Work Life Integration Award

Molly Laegeler, Chevron Corporation

Emerging Leaders

Deborah Caine, Intel Corporation
Regan Campbell, Ph.D., U.S. Navy
Danielle Curcio, Raytheon Company
Lt. Cmdr. Susan Faulkner, U.S. Navy
Divya Gopalan, Intel Corporation
Elizabeth Green, Northrop Grumman Corporation
Kimberly Stauffer Harr, Intel Corporation
Tameika Hollis, Northrop Grumman Corporation
Qiong Jackson, Ph.D., Northrop Grumman Corporation
Suzanne Jewett, Intel Corporation
Laura Juette, Naval Facilities Engineering Command Southwest
Ellen Lee, Ph.D., Ford Motor Company
Reena Singhal Lee, Google

continued on page 54

continued from page 53

Harmony Myers, NASA Kennedy Space Center
Linda Freeman Romer, Rockwell Automation

Distinguished New Engineer Award

Annmarie Connor, NBC Universal-Universal Parks and Resorts
Jennifer Harris Nichols, TriMedx
Holli Pheil, Medtronic
Pamela Snyder, P.E., Procter & Gamble
Tracy Van Houten, NASA Jet Propulsion Laboratory

Fellow Award

Wendy Bromenshenkel, Shell Information Technology Inc.
Stacey Culver, Babcock & Wilcox
Barbara Donoghue Darnell, The Boeing Company
Laura Gimpelson, P.E., LG Environmental Engineering
Debra Kimberling, Solar Turbines Incorporated
Marie Laplante, KBR
Mary Studlick, P.E., Exxon Mobil Corporation

Distinguished Service Award

Diana Joch, Northrop Grumman

Outstanding Faculty Advisor

Beth Holloway, Purdue University

Outstanding SWE Counselor

Angela (Angel) McMullen-Gunn, Schneider Electric

Outstanding Collegiate Member Award

Megan Adams, California Polytechnic State University, San Luis Obispo
Emily Anderson, Tufts University
Elizabeth Junkin, University of Alabama
Morgan Miller, California Polytechnic State University, San Luis Obispo
Rebecca Summ, University of Wisconsin-Platteville

The Anita Borg Institute for Women and Technology Awards

Women of Vision Innovation Award

Sarita Adve, Ph.D., University of Illinois at Urbana-Champaign

Women of Vision Social Impact Award

Sarah Revi Sterling, Ph.D., ATLAS Institute at the University of Colorado Boulder

Women of Vision Leadership Award

Jennifer Chayes, Ph.D., Microsoft Research New England

Denice Denton Emerging Leader Award

Susan Daniel, Ph.D., Cornell University

A. Richard Newton Educator Award

Barbara Ericson, Georgia Tech College of Computing

Change Agent Awards

Maria Dubovitskaya, IBM Research, Russia
Ramalatha Marimuthu, Ph.D., Kumaraguru College of Technology, Anna University, India
Evelyn Namara, Linux, Uganda

Intel Science Talent Search Awards

Clara Fannjiang, eighth place, California
Alissa Zhang, ninth place, California

National Society of Black Engineers (NSBE) Awards

Dr. Janice A. Lumpkin Educator of the Year

Ershela Sims, Ph.D., Duke University

Minority Engineering Program Director of the Year

Alaine Allen, University of Pittsburgh

Pre-College Initiative Director of the Year

Annie Carter, Lamar University

Pre-College Initiative Student of the Year (Female)

Jacqueline Thompson, Keystone School

Outstanding Woman in Technology

Sharon Meadows, Northrop Grumman Corporation

Mike Shinn Distinguished Member of the Year (Female)

Jelece Morris, Georgia Institute of Technology

Alumni Extension Member of the Year (Female)

Da'Shaun Joseph, Lockheed Martin Corporation

Society of Hispanic Professional Engineers (SHPE) Awards

Hispanic in Technology Award, Government

Iris Vazquez-Ayala, NAVEODTECHDIV

Jaime Oaxaca Award

Dora Maria Abreu, Credit Suisse

Junipero Serra Award

Denise Munoz, Exelon Corporation

to take on clerical duties, and is uncomfortable handling complex equipment. While they relate to this stereotype in various ways, they are *required* to relate to it somehow (embrace it, deny it, modify it, etc.) rather than to just be who they are as physics students.

Kyriakidou (2012) discusses how a group of 33 female Greek engineer-managers contend with stereotypical notions of female engineers. Her respondents do not deny their female identity; instead, they describe their awareness of those stereotypes and the strategies they use to create new professional rhetorics that dispel stereotypes and/or expose people to aspects of gendered engineering life with which they're not familiar. These women also talked about their efforts to find ways to show why it's actually *good* to be a female engineer, how being female makes you a better engineer.

Numerous studies have found that girls' interests tend to differ from boys' and that, when women enter fields such as engineering, they tend to do so for somewhat different reasons than their male counterparts. Hewlett et al. (2008) report that women are more likely than men to enter science and engineering to "help humankind"; Mills, Ayre, and Gill (2010) agree, finding that female engineering students are more interested in learning about the social impacts of technology and how society and engineering interact.

Purzer and Fila's (2012) study of design teams asked to develop energy-saving solutions in a first-year engineering course at a Midwestern university found that groups that included female students were much more likely to propose solutions that emphasized conservation, alternative energy sources, and reduced usage, while male-only teams focused on economics and increased efficiency.

Findings such as these underpin the argument that it is necessary to *redefine* or *reshape* engineering so as to make it more attractive and welcoming to women. An example of this approach can be seen in calls to create "gender inclusive engineering education," as proposed in a recent book by Mills, Ayre, and Gill

(2010). They contend that, as presently taught, engineering makes very little attempt to appeal to the interests of female students or to create a social situation in which they can thrive. The authors call for a wide range of changes to the engineering curriculum, from expanding the examples used beyond those that appeal to male students (cars, rockets), to paying more attention to the social impacts of technologies, to making use of multiple teaching methods so that all students' experiences will be acknowledged — and they also describe numerous models for doing so.

To counter the argument that engineering knowledge is objective and therefore cannot and should not be modified to promote gender inclusivity — which some presume would reduce rigor — Mills, Ayre, and Gill advocate explicitly talking about the role of social and cultural influences in the construction of knowledge. Only by acknowledging the gendered character of engineering pedagogy, and by taking steps to modify it, will more women be attracted to engineering, they claim.

Not everyone agrees that engineering educators should make an explicit effort to appeal to women's interests — Sikora and Pokropek's (2012) study of survey data from 50 different countries argues against this approach on the grounds that it will simply produce gender segregation *within* science. Mills, Ayre, and Gill's arguments, however, reflect the fact that some researchers are seriously considering feminist claims that engineering and science themselves are gendered in ways that tend to discourage women from entering.

Women engineers and the workplace

One major question that is not addressed in the literature reviewed thus far is what happens *after* women complete their educations. Do they go on to careers in engineering and science, and if so, do they stay? It is surprising to us how little of the research in the past year(s) focused on female engineers' experiences in the workplace. We encountered only a handful of inquiries

into the situation of female engineers working outside the academy.

Hewlett et al.'s (2008) study of the *Athena Factor* describes a “brain drain” among practicing female engineers and scientists. They find that women often describe a “chilly climate” that is hostile to women and that they encounter unclear career paths and frequently feel “stuck.” Female engineers and scientists in industry are more exposed to layoff during reorganizations because they are less likely to be employed in a business' core activities and are less likely to have a sponsor who can protect them.

They estimate that more than half (52 percent) of highly credentialed women leave private sector jobs at some point in their careers, although this is less true of engineers than of scientists. The attrition peaks when women are in their mid- to late 30s, perhaps because work/family conflicts intensify at this point; perhaps because this coincides with midcareer choices. Whatever their reasons for leaving, most of the women studied said they would like to return, suggesting that they remain *interested* in science and engineering, but find something about workplace conditions to be unacceptable.

Fouad and Singh published an update of their study, reviewed last year, called *Stemming the Tide: Why Women Leave Engineering* (Fouad et al. 2012). Their survey of more than 5,500 women with engineering degrees found that those who chose not to pursue engineering careers and those who left the profession did so primarily because of their perception of workplace climate. Lack of flexibility, respect, and support were more important than family reasons for leaving engineering employment.

Two much-discussed publications we reviewed suggest that family *is* the reason for the continued low numbers and high attrition rates among women in engineering. Stephen Ceci and Wendy Williams, two psychologists at Cornell University, have been engaged in an ongoing research program exploring why there are so few women in math-intensive scientific professions (Ceci and

Williams 2010; Williams and Ceci 2012). While they acknowledge that there are numerous factors that contribute to this shortage, they contend that the most important cause is women's preference for other disciplines. This preference, in turn, is rooted in their “fertility decisions”; in other words, women's desire to have children and to spend time with them makes careers in math-intensive disciplines unattractive to them. Ceci and Williams do not foresee this changing at any point in the near future, so they are pessimistic that the numbers of women in fields such as engineering are likely to grow rapidly any time soon.

A second major, and highly controversial publication, not focused on engineering and science, makes a related argument. Anne-Marie Slaughter, a former Obama administration official who served in Hillary Clinton's State Department, published an article in the July 2012 issue of *The Atlantic* entitled “Why Women Still Can't Have It All.” The article describes the difficulties she had reconciling the extreme demands of her high-powered State Department job with her desire and need to manage her family and attend to her children's needs.

Slaughter suggests that there is something false about the promise that women can “have it all” if they simply try; she contends that this puts too much pressure on women and imposes an unrealistic burden that no one, male or female, should be expected to bear. It is not surprising or blameworthy, in her view, when women “drop out” of demanding careers. They are simply responding to an untenable situation that is unlikely to change unless both men and workplace expectations do.

While Slaughter's focus is on government and leadership positions, it should be obvious that her argument, if correct, is relevant to the situation of women in engineering, who often find themselves in positions that impose enormous time demands and create work/family conflicts that are difficult, if not impossible, to resolve.

At first glance, both Slaughter and Williams and Ceci appear to be arguing the same point: Women are avoiding or leaving careers such as engineering because they want to have and be involved with families, which those careers make very difficult.

A closer look, however, reveals a major difference in what is being said about the obstacles. For Williams and Ceci, the problem lies with women's "choices," which are ill suited to the conditions of work they encounter in math-intensive careers. For Slaughter, the problem lies with the conditions of work and domestic life that present women with the need to make a choice in the first place.

Future directions for research

At the beginning of this review, we indicated that it may be time for researchers on women in engineering to take stock of what is known and what is not. Are researchers asking the right questions? Are they examining the right problems? Are they using the right methods and theoretical tools? If not, what might they do instead? Here we offer a few provisional answers, based on our review of this year's scholarly literature in the field.

First, it must be said that some things have gone right. The evidence that there has been real progress toward gender equity in university STEM departments is certainly encouraging and indicates that well-designed interventions such as the NSF-ADVANCE programs can actually have a positive effect. One possible direction for future research would be to examine whether there are lessons in the experiences of university women, and in the NSF-ADVANCE program, that can be transferred to other areas in which female engineers are employed.

At the same time, if one considers the overall picture, and not just the academy, the situation appears more discouraging. The numbers of women in engineering remain relatively small, and there is no real sign that the pattern is likely to change rapidly; if anything, there is evidence of slowed or even stalled progress. Thus, critical

examination of what has *not* worked and why is urgently needed.

This may involve more than doing better program evaluation, however. It may also involve engaging with the feminist critique of engineering as masculine, as some researchers have already begun. Beddoes (2012) notes that much scholarship in engineering education has engaged in a very limited way with feminist ideas, focusing primarily on "liberal" feminist efforts to increase opportunity for women and eliminate explicitly discriminatory behavior. She contends that engaging with feminist ideas about the gendered nature of knowledge and disciplines that have been applied in other fields may help researchers to understand why progress in engineering has been limited and why various policy interventions have been ineffective.

There is also a need for researchers to engage with one another more effectively and to do so across disciplinary lines. It is surprising to us that it is still possible for researchers to report contradictory findings on something as fundamental as the question of whether women are or are not more likely to leave engineering programs in university, and to do so without acknowledging the lack of agreement or the need to resolve it.

Similarly, research on *why* women leave engineering (whether this means leaving school or leaving the workplace) often is conducted without reference to the body of research on why *men* leave engineering. The obvious danger is that when a researcher finds that women leave engineering because they dislike the way it is taught, she may conclude that this is because there is something gendered about the teaching (or the student's reaction to it), whereas it may simply be that both men and women find the teaching to be unsatisfactory.

Reviewing the literature on women in engineering makes one aware of the continued power of disciplinary boundaries. Research on this issue is conducted in numerous academic disciplines — psychology, sociology, business, engineering itself, economics, and even an emerging discipline of "engineering education." Yet, more often than not, researchers in these

disciplines do not talk to one another.

For example, psychologists regularly discuss the importance of stereotype threat as a factor explaining gender differences in test outcomes. There appears to be a high level of consensus within psychology that the effects of stereotype threat are real; yet, one rarely sees reference to this phenomenon outside of journals of psychology or education.

Similarly, Ceci and Williams' research on the role of women's fertility choices in shaping decisions about whether to enter or stay in math-intensive fields makes virtually no reference to the sociological and feminist literature on the constrained nature of the choices women make. They do attempt a multi-disciplinary review of the literature on women in science and engineering, but many of the most important researchers in sociology and feminist theory are absent from their bibliography.

Researchers in other fields have noted that men also "choose" to have children and express an interest in being active parents, yet they are not forced to choose to avoid certain careers. If this is true, then Ceci and Williams' conclusions about women's choices would have to be put in a different light.

In general, research on women in engineering would be well-served by a more serious effort to engage across disciplinary lines, so that debates do not take place in disciplinary silos and so that contradictory findings can be resolved and areas of consensus identified.

Finally, there is an obvious need for more research on women engineers at work. While the pipeline model has come under critical scrutiny, and while there continues to be disagreement as to whether female engineering students are more likely to leave than their male counterparts, there continues to be general agreement that women who complete engineering programs are less likely to become practicing engineers and are more likely to leave if they do.

Clearly, we need to understand why this is the case and what can be done to change it. At the moment, however, researchers' primary focus appears to

be elsewhere — most of the literature we reviewed discusses the experiences of high school students, college students, university teachers, and researchers.

The overriding sense that progress toward gender equity in engineering is approaching a standstill should serve as a call to social scientists, educators, and industry to extend research attention to those women who actually become engineers. Even a huge increase in the number of aspiring engineers will make little difference if we do not understand the conditions that cause women to leave and/or encourage them to stay in the field.

About the authors

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Note: The following list of references comprises all of the noteworthy articles and conference papers found in our search of the 2012 literature on women in engineering. We selected for discussion in our review the literature that seemed to be based on the most substantial research and/or which offered interesting, fresh insights into the situation of women in engineering. For the convenience of interested readers, we have included the complete list of materials we consulted.

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Women in Engineering: A Review of the 2013 Literature

SWE's assessment of the best research found in the past year's social science literature on women engineers and women in STEM disciplines.

By Peter Meiksins, Ph.D., Cleveland State University
 Peggy Layne, P.E., F.SWE, Virginia Tech
 Elsa Camargo, Virginia Tech
 Katie Snead, Virginia Tech

2013 saw the publication of a large quantity of scholarly work relevant to the situation of women in engineering. Our review of the literature covered well over 100 publications, including books, major reports, and journal articles in publications representing a half dozen or more disciplines, including sociology, psychology, education, and business, to name a few. We searched for articles by examining major research databases and more than 70 journals that publish articles on gender and engineering. As always, the studies varied tremendously in quality and rigor; they also varied in their methodological approach, from complex statistical analyses of large data sets to interpretive studies of qualitative data.

We will not be able to discuss every study we read for this review. As we pointed out in last year's review, there is an element of *déjà vu* in reviewing the literature on women in engineering and STEM each year. Researchers continue to produce studies that duplicate work done previously and continue to disagree with one another about the implications of their research findings regarding the question of why women remain significantly underrepresented in engineering.

A significant portion of the published work we review each year consists of small-scale case studies focused on a single institution and/or involving very small samples, which raises a number of issues. Some of this research can be quite valuable, often pointing to

important questions that need to be asked, helping to explain the results of larger-scale quantitative research, or suggesting possible directions in which research might move. At the same time, however, exploratory research of this type is just that — exploratory. It is not designed actually to resolve, finally, the questions it raises. As a result, while we discuss some of the more interesting pieces of small-scale research we reviewed, we have tried to focus on the most rigorous pieces of research, on peer-reviewed articles, and on work that offers fresh insight and new approaches. We have also pointed to any methodological limitations, and to innovative methodological approaches, in the research we discuss. We have tried, as well, to take seriously the call we found in the literature (Beddoes 2013) for more varied methodological approaches to exploring engineering and engineering education by incorporating discussion of both quantitative and qualitative research.

Some of the material we reviewed covered familiar ground; but some researchers were able to report on interesting new findings that shed fresh light on established research questions. Thus, we review a number of studies devoted to the examination of “pipeline” issues. Researchers continue to ask whether it is the case that fewer women are attracted to STEM disciplines and careers and, if so, why. They ask, as well, whether and why women who enter STEM fields leave

at higher rates than their male counterparts. There is ongoing debate about which of these is of greater importance in explaining the underrepresentation of women in engineering, although it is safe to say that both factors play a significant role.

Continuing a development we noted in last year's literature, there were a number of essays and research articles exploring a feminist critique of engineering. Is the problem not just a matter of increasing the numbers of women in engineering but of transforming engineering itself, and making it less “gendered?” And, if that is the case, how would engineering be changed and in what sense would the profession benefit from that change? Parts of this literature explored what is now relatively familiar ground. There were, however, several interesting contributions that raised new questions about whether orienting engineering more toward issues and approaches that appeal to women would actually succeed in attracting more women to the profession and in improving their position within it.

We also noted a number of relatively new emphases in the research we reviewed this year. None of this was entirely novel, but there was more attention devoted to themes that had been less than central to previous years' research. Most notably, we were pleasantly surprised to find a significant number of research articles focused on the experiences of working women engineers

outside the academy. We have lamented, for several consecutive years, the notable absence of this type of research, as well as the corresponding preoccupation with academic engineering. The publication of several substantial studies of working women engineers represents significant movement in the direction of correcting this imbalance in the research literature.

There was increased discussion of the situation of minority women engineers this year. An important book by Camacho and Lord (2013a) takes a detailed look at the situation of Latinas in engineering. And, the Institute for Women's Policy Research published a major report on women faculty of color in STEM (Hess, Gault, and Yi 2013). As another contributor (Beddoes 2013) noted, researchers influenced by feminist ideas and methods have become increasingly sensitive to the issue of intersectionality — i.e., to the idea that women, like the population as a whole, are a diverse group and that gender has different meanings and consequences linked to race, ethnicity, sexual orientation, etc. It is refreshing to see evidence that this idea has taken root in scholarship on women in engineering as well.

Also of note, *Computer* magazine, the flagship publication of the IEEE Computer Society, focused its March 2013 issue on gender diversity in computing, with 13 articles presenting both institutional and individual perspectives on computing education and careers from academics and practitioners. While not presenting peer-reviewed descriptions of specific research projects, this special issue includes overviews of the status of women in computing from experts at the National Center for Women and Information Technology (NCWIT), the Anita Borg Institute, MentorNet, and the Computer Science Teachers Association, and case studies of recruitment and retention programs at the University of Washington, the University of Virginia, and Harvey Mudd College. Individual faculty members and practitioners reflect on their career paths in computing, the importance of mentors, and the value of diversity.

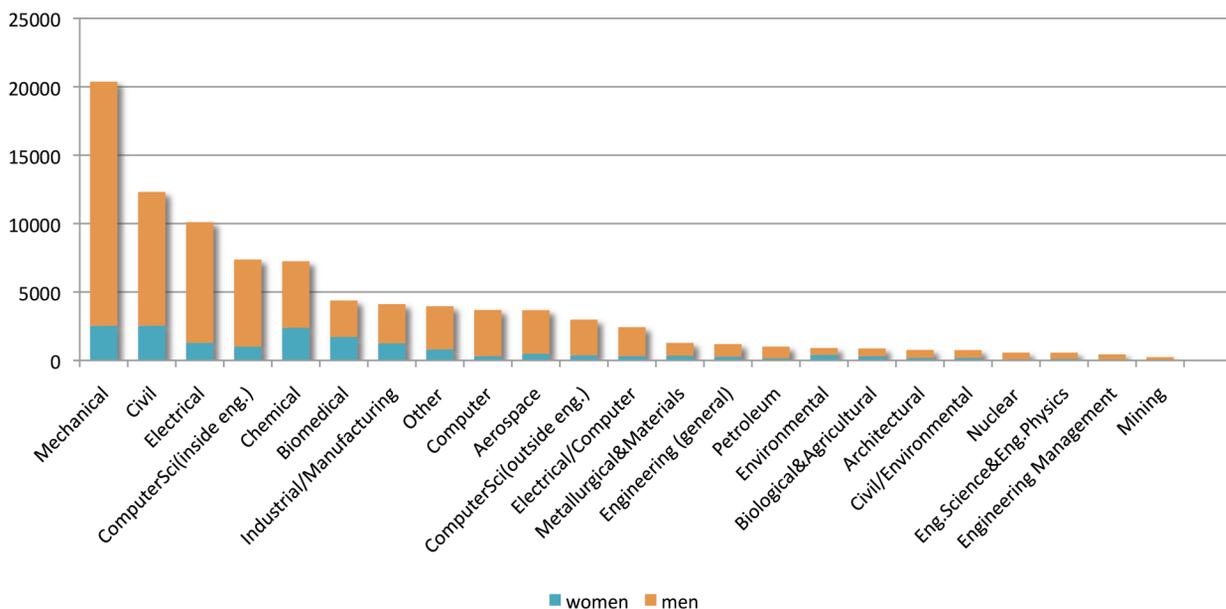
Drawing women in, pushing women out

As in previous years, much research attention was devoted to the question of why women are not attracted to STEM

majors or to careers in STEM fields, with engineering being a particularly acute case. There was also continued interest in the question of why women leave. While the “leaky pipeline” metaphor is not as widely endorsed as it once was as an explanation of women’s underrepresentation in engineering, researchers continue to find evidence that, in fact, the field does not attract equal numbers of young men and women and that women who enter engineering are more likely to leave at various points along the way.

Various familiar explanations were offered for the continued tendency for boys to show more interest in engineering and STEM than girls. One group of studies identified knowledge about the profession, as well as stereotypical beliefs about its being more appropriate for boys, as a primary cause. Sandrin and Borrer (2013) reported on their study of a large (more than 6,000 cases) sample of college and high school students in the upper Midwest. They found that male students were significantly more likely than female students to be interested in engineering careers and that female students were more likely to respond “I don’t know what it is” to questions

Engineering Bachelor's Degrees by Discipline, 2012



Source: Yoder, *Engineering by the Numbers*, American Society for Engineering Education, 2013

about their interest in engineering. Male students were more likely to report having been encouraged to consider STEM careers, perhaps reflecting prevailing attitudes toward its gender appropriateness. Significantly, interest in engineering and computer fields for both groups peaked at about sixth grade, suggesting that early interventions are needed if the goal is to encourage increased female interest in those fields. It would be important to learn whether studies of other geographical regions would yield similar results.

Archer et al. (2013) reported on a study of 9,000 primary school children in England that included follow-up interviews with a small group of participating children and parents. They found that cultural constructions of femininity tended to push against the development of girls' interest in science careers. While some did aspire to pursue science careers, there was a tendency for both children and parents to associate science with "cleverness" and for girls who didn't develop science aspirations to see themselves as not "clever" enough. Girls tended to see femininity as involving nurturing and caring for others, and were most likely to aspire to careers that were associated with these characteristics (teaching, child care) or that were glamorous and "girly" (acting, singing). Parents lacked knowledge of the range of careers available to those who had science interests, so were not in a position to offer their children concrete advice about the various directions in which an interest in science could lead. The importance of family support and encouragement to girls' pursuing STEM careers was underlined by several other studies, including those by Hobson et al. (2013) and by Skaggs (2013).

Colvin et al. (2013) report on a set of workshops designed to increase participants' knowledge of civil engineers. Forty-five elementary school students were asked to draw an engineer prior to the program; they generally drew a man wearing overalls and fixing cars with basic tools. During the workshop, the participants discussed the role of civil engineers in pursuing goals such as safety,

environmental issues, and improving the quality of life. At the end of the program, students' drawings of engineers reflected a more varied perception of what civil engineers do. The number of female engineers drawn rose from two to 10 for grade 5 students and from four to eight for grade 6 students. Participants also showed evidence that they had increased their understanding of the field, perhaps opening them to becoming interested in exploring it.

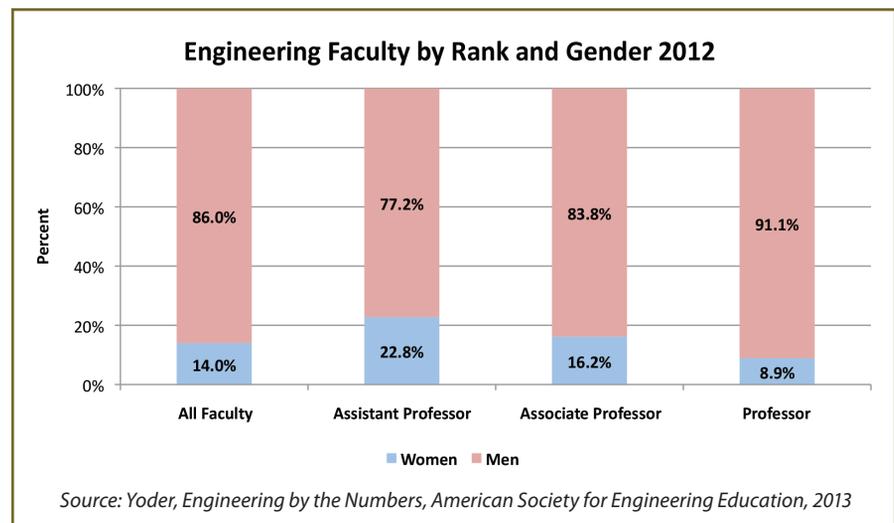
Finally, Smith et al. (2013) identified a different kind of stereotype that may discourage women from entering various STEM programs. They studied several groups of students at two western universities and found that women in male-dominated programs felt that they had to work harder than their peers and, as a result, experienced a decreased sense of academic belonging. In addition, experimental data indicated that when students were presented with descriptions of fields identified as male dominated, they expected those fields to require more effort than when the same field was described as gender equal. The implication is that male-dominated fields may seem less welcoming to female students, who perceive them as involving unusually high levels of effort and as fields in which they don't feel they belong.

Other researchers focused on girls' preparation for engineering careers, particularly in key subjects such as math and physics. Given the degree to which

strong preparation in these courses predicts entry into and success in engineering programs, the question arises whether girls are equally likely to get strong math and physics backgrounds, and, if not, why not.

Riegle-Crumb and Moore (2013) conducted an interesting study of the gender gap in high school physics using a large data set drawn from the National Longitudinal Study of Adolescent Health and the National Center for Education Statistics. They found that while the gender gap in physics persists, with boys remaining more likely to take high school physics, interestingly, there are many school districts in which this is not the case. In exploring the differences between the various schools, the researchers found that girls' participation in high school physics correlated with the percentages of women in the community who were employed in STEM occupations. While they are unable to specify the precise mechanism by which the community's characteristics influenced girls' choices, one can hypothesize that factors such as parental support, the availability of role models, and girls' perceptions of career opportunities in STEM may all be relevant.

Finally, Wang, Eccles, and Kenny (2013) conducted a large, national, longitudinal data study of a sample of college-bound students in the United States. High school seniors were surveyed in 1992, then again by telephone 15 years later. They found that students



who had high math and high verbal scores in 12th grade were less likely to have chosen STEM careers by age 33 than those in the high math/moderate verbal category. The former contained more female respondents. There were no gender differences in the high math/high verbal group in the likelihood to select STEM careers, however. Females were less likely to have chosen STEM careers, but this difference diminished if one controlled for ability (high math ability), pointing to the conclusion that high math ability accounts, partially, for gender differences in selection of an occupation. Unfortunately, the study is unable to explain the gender differences found in math ability in the sample. It would be interesting to know if a sample of students in 2014 would be similar, since girls' achievement in math has increased in the years since 1992.

Researchers also examined the question of whether and why women persisted in engineering programs once they entered them. One line of inquiry considered the question of whether female engineering students are as confident and secure in their ability as their male counterparts. Fowler and Meadows (2013) followed a group of male and female engineering students who entered a Midwestern engineering program in 2011 and found that female students began the program with lower expectations of succeeding and a weaker sense of belonging than their male counterparts. These differences tended to decrease, however, as the first year progressed, with women's expectations of success increasing, while men reported a decrease in their belief that a degree in engineering was worth the cost. Jagacinski (2013) conducted a study of another group of engineering students at a Midwestern university and found that women in first-year engineering courses reported lower competence perceptions than men, although there were no significant gender differences in grades. Pinelli et al. (2013) noted that female STEM interns in a summer program at NASA Langley Research Center tended to rate their abilities lower than their male counterparts in areas such

PACE: Project to Assess Climate in Engineering

By Peter Meiksins

PACE is a major study of undergraduate engineering programs that promises to shed light on the factors affecting the retention of undergraduate engineering students, particularly women and minority students. Its goal is to collect and analyze data on the climate of undergraduate engineering programs, with a focus on persistence and retention. The aim is to help undergraduate engineering programs improve climate and create a more inclusive environment.

A long-term, multisite research program involving 22 participating institutions, PACE is funded by the Alfred P. Sloan Foundation. It is currently headquartered at the Center for Workforce Development at the University of Washington. The program began in 2006 and was refunded in 2011. The project is led by Suzanne Brainard, Ph.D., principal investigator, and Elizabeth Litzler, Ph.D., co-principal investigator. Susan Staffin Metz was co-PI from 2006 to 2011.

PACE employs a careful, mixed-methods approach designed to ensure that its results are meaningful and valid. To ensure consistency, the research focuses on institutions that are "one-tier" — i.e., that either admit students directly as first years or provide an engineering advisor to first-year students interested in engineering. Across institutions, the sampling strategy deliberately oversamples minority students and women to ensure adequate numbers of underrepresented groups participate.

To date, the PACE research team has either completed or is in the process of completing a number of research projects:

- The PACE survey on "climate" was conducted at all institutions in 2008, and at 16 in 2012 (allowing an assessment of change)
- 179 interviews with students at 18 institutions in 2008-09 (about one-third with students who left) to learn more about climate, the reasons students leave/stay, the treatment of women/minority students, etc.
- Focus groups with undergraduates on a range of issues, including climate, retention, career goals, etc. Several focus groups were completed in 2012-13 and more are contemplated.

The PACE research team has already published several papers and presented others at conferences. The papers and more information about the project can be accessed at the PACE web page: <http://depts.washington.edu/paceteam/method.html>

as analytical thinking, computational skills, computer skills, and technical skills. Evidence such as this, of female students' lack of confidence that they belong, points to the possibility that they may conclude that engineering is not the right choice for them.

A number of studies pointed to factors that worked in the opposite direction, encouraging women to persist in engineering and STEM programs once they entered them. Watkins and Mazur (2013) report on research on a first-year physics course at Harvard that points to the value of active learning experiences as a tool for attracting and retaining students to STEM majors. They compare students who enrolled in a version of the course that involved "peer instruction," built

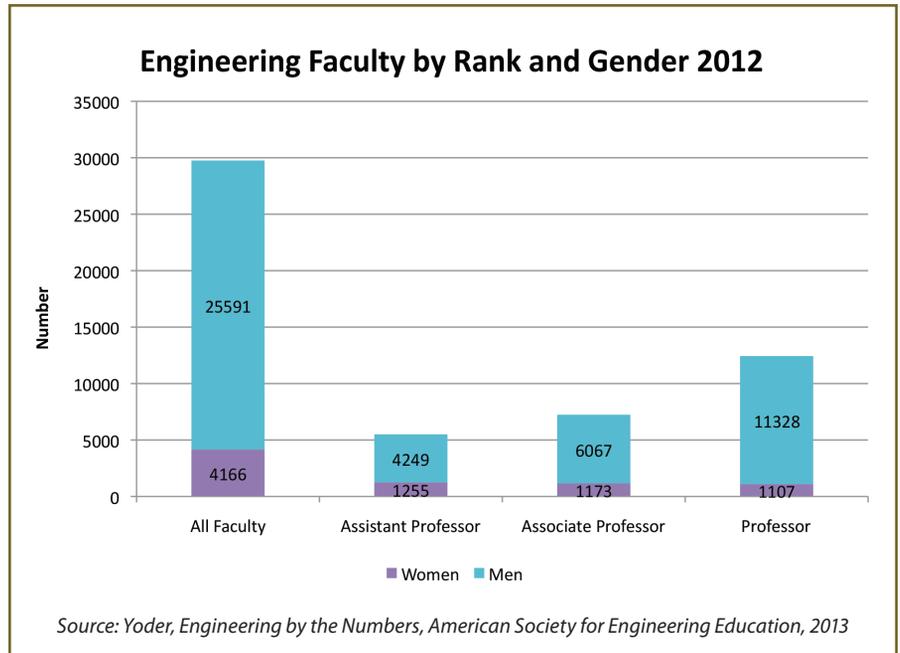
around using class time to have student-led discussions of short, conceptual, multiple-choice questions, rather than conventional lecture-based versions of the course. They found that students who enrolled in the active learning version of the course were twice as likely to continue in STEM majors than those who took the conventional one. While this study does not look specifically at the issue of whether this pedagogical approach favors the retention of female students, it is consistent with earlier research showing that female students are more likely to be drawn to and retained in STEM majors if they are given opportunities for hands-on learning.

Samuelson and Litzler (2013) report on research done as part of a larger,

Alfred P. Sloan Foundation-funded program, entitled Project to Assess Climate in Engineering (PACE), at the University of Washington. They interviewed a group of 27 women engineering students who had participated in an internship or co-op. All of the respondents spoke positively of these experiences, reporting that they contributed to their understanding of the engineering profession, provided valuable networking opportunities, and contributed to their motivation to stay in their engineering programs. Even those who had decided to leave engineering said that participation in an internship or co-op had delayed their decision to leave.

Mentoring and female role models also were identified as factors promoting the retention of female students in STEM and engineering. Poor and Brown (2013) describe a mentoring program at Washington State University that increased the retention rate among female students by helping them feel more connected and confident in their field of study — succeeding, apparently, in counteracting some of the negative feelings identified in the research discussed above, about why female students leave engineering. Young et al. (2013) examined the influence of female role models on women's implicit science cognitions. They surveyed 320 college science majors, two-thirds of whom were women, and found that men had more favorable implicit attitudes toward science and identified more with it than did women. Women did have higher science aspirations than men, however, and having a female science professor as a role model increased their implicit science identity and decreased gender stereotyping.

Ackerman, Kanfer, and Beier (2013) studied a group of almost 600 first-year students at the Georgia Institute of Technology to examine factors that predict STEM persistence. They found that persistence was affected by a combination of considerations, some of which reflected ability and achievement, as in test scores and/or high school GPA, and others of which were personal characteristics. These included math/



science self-concept; mastery/organization; openness and verbal self-concept; anxiety in achievement contexts; and extroversion. All of these factors were significantly correlated with students' GPAs in their four years in college. Gender differences appeared as well, as men scored higher on math/science self-concept, while women scored higher on mastery/organization, openness and verbal self-concept, and extroversion. The authors concluded that differences among students, including gender differences, should be taken into consideration in designing curricula aimed at maximizing student retention.

Intersectionality: minority women in engineering

Those who study the underrepresentation of women in engineering increasingly recognize that minority women represent a particularly significant untapped pool of potential female engineers. While the numbers of women in engineering remain relatively small, the numbers of women of color are even smaller. This points to the reality that attracting and retaining more minority women to engineering involves not simply dealing with gender barriers but with the ways in which gender and race/ethnicity interact and combine to impose particularly significant obstacles.

Two important full-length studies, and a small number of research articles, this year drew attention to the small numbers of minority women engineers. First, Camacho and Lord's *The Borderlands of Education: Latinas In Engineering* (2013a) reports on their own and others' research on Latinas in engineering, a group to whom little attention has been devoted previously. They note that Latinas constitute only 2 percent of all engineering degree recipients in the United States. Despite their small numbers, however, Camacho and Lord posit that much can be learned about diversity in engineering in general through an examination of Latinas' experiences.

The authors argue that Latinas are allocated to a "borderland" within engineering education and practice, where they are marginalized and defined as the "other." They encounter a culture that is not at all welcoming and experience a range of "microaggressions" that remind them of their difference and lack of acceptance. Surprisingly, Camacho and Lord report that those Latinas who make it into engineering programs are retained at unusually high rates. They attribute this to Latinas' ability to develop strategies to deal with an unwelcoming culture: They form their own support groups; avoid male groups that devalue them; seek help from faculty, not

other students, etc. Martin, Simmons, and Yu (2013) make a similar point in noting that Latina students lack the “social capital” that family members could provide if they had more experience in engineering or university education. Despite a delay in realizing that resources were available to them, however, they compensated by relying on peer groups and institutional support systems in negotiating undergraduate engineering programs at the University of Houston, where the study took place.

Other research published this year provided insight on the issue of retention of minority students in engineering. Litzler and Samuelson (2013) analyzed data on 119 engineering students at 13 U.S. universities; they were particularly interested in the 41 students who had decided to stay after seriously considering leaving. The study found that there were both gender and racial differences in students’ reasons for persisting. Women were more likely than men to cite the rewards of the degree as a primary reason for staying. Women also were more likely to give, as a second reason, an aversion to quitting and a desire to show they could do it. There were ethnic/racial differences among the women as well; black and Hispanic women were more likely than their male counterparts to say that “they had come this far and it was too late to turn back,” while the same was not true for white and Asian women.

A study by Hernandez et al. (2013) of more than 1,000 high-achieving minority undergraduates, the majority of whom were female, in STEM disciplines found that the one factor that predicted attrition was having “performance-avoidance” goals, i.e., being motivated primarily by a desire to prove that one is not incompetent, no worse than others. These findings, along with Camacho and Lord’s, suggest that the retention of minority women presents a different set of challenges than the retention of white women in engineering.

Camacho and Lord’s (2013a, b) analysis points to the conclusion that the most important step that can be taken to increase the numbers of Latinas in engineering involves recruitment: More young Latinas need to be attracted to engineering programs. They note that professional groups are eager to do precisely this, but that their efforts are negated by a broader negative social definition of Latinas (and Latinos). Young people from this background are linked with low academic performance (thus lowering expectations), are associated with the issue of illegal immigration, and are allocated to schools that are under-resourced and frequently engage in what has been called “subtractive schooling,” which divests students of their language and culture.

Camacho and Lord (2013a, b) advocate a range of educational innovations to at-

tract more Latinas to engineering. These included making the math curriculum more culturally relevant to Latinas; various forms of outreach to increase awareness of career opportunities in engineering and to mobilize the prestige of engineering careers; and efforts to bridge the classroom and community for Latino and Latina students, e.g., encouraging them to think of engineering as a way to help improve their communities. They also stress the need to be aware of and to mobilize the important support provided to Latina students by family, peers, and communities. And, they note that programs seeking to increase the number of Latina students in engineering should target two-year programs, an important “pipeline” of Latina and Latino students who can potentially go on to more advanced education.

Other research published this year echoed aspects of Camacho and Lord’s arguments about recruiting Latinas to engineering programs and extended them to African-American women as well. You (2013) analyzed data on 10,599 participants in the Education Longitudinal Study of 2002 to understand gender and ethnic differences in advanced math-course taking and their effects on choosing STEM majors in college. The results indicated that African-American and Hispanic students were less likely to take advanced math courses in high school than white or Asian-American students; racial differences were actually greater than gender differences in this study. Else-Quest, Mineo, and Higgins’ (2013) study of more than 300 participants in the Philadelphia Adolescent Life Study confirmed that Latino and African-American adolescents were the lowest-achieving students in math and science; however, they found that, within these groups, males were lower achieving than females. You (2013) added that, across all ethnic/racial groups, men were more likely to choose STEM majors than female students, although the gender differences were greater for whites. Data such as these point to the particular difficulty of recruiting minority women to engineering, since both race and gender are relevant to whether students

Engineering Bachelor’s Degrees by Gender within Race/Ethnicity, 2012

	Male	Female	Total	% Female
African-American	2489	896	3385	26.5%
Hispanic	5734	1614	7348	22.0%
Asian-American	7681	2269	9950	22.8%
Native American	276	76	352	21.6%
Caucasian	44853	9091	53944	16.9%
Foreign National	5237	1403	6640	21.1%
Other/unknown/multi	5214	1343	6557	20.5%
Total	71484	16692	88176	18.9%

Source: Yoder, *Engineering by the Numbers*, American Society for Engineering Education, 2013

take advanced math coursework in high school. On the other hand, since minority girls seem to outperform minority boys in some respects, and since gender differences in these groups are less significant, effective efforts to increase the numbers of minority women in engineering may not take the same form as those to increase the numbers of white women in the profession.

The underrepresentation of minority women is particularly apparent in the academy. In May 2013, the Institute for Women's Policy Research organized a convening of almost 50 experts to discuss the underrepresentation of women faculty of color in STEM and issued a full-scale report later in the year (Hess, Gault, and Yi 2013). The report notes that women faculty of color represent only 5.7 percent of STEM doctorates in faculty positions at four-year colleges, universities, and affiliated centers and institutes, although they represent 15 percent of the overall working-age labor force. To make matters worse, those few women of color who obtain faculty positions are less likely to advance through the ranks. Participants in the convening discussed various characteristics of women of color that help to explain these problems: Women of color are less likely to be married and have access to second incomes, although they are responsible for raising children; wealth gaps that limit personal resources to support research; and the burden of health conditions particularly likely to affect women of color. They also noted that women faculty of color encounter high community service demands that draw them away from research, insufficient social support, and ongoing discrimination. The report outlines a set of recommendations for increasing the numbers of women faculty of color in STEM. These include developing a national standard for valuing the volunteer and service work these women perform; creating funding and other programs to help overcome the resource disadvantages women faculty of color encounter; and various measures to create greater awareness of the value of diversity and the reality of barriers and inequities

among faculty, search committees, and academic administrators.

Women working as engineers

Many researchers previously have noted that the percentages of engineering degrees earned by women exceed the percentages of employed engineers who are women. The underrepresentation of women in engineering, then, is not simply a matter of women's initial lack of interest in the profession or their choices to leave engineering education before they finish their degrees. Clearly, some women earn engineering degrees and enter the labor market, but drop out of the engineering labor force at some point later in their lives. Skaggs' (2013) study of a small group of undergraduate engineering students at a land-grant university confirms this by finding that some of the women who persisted in an engineering program did so not because they planned to be engineers, but because they believed they could do anything with an engineering degree.

Given the obvious importance of understanding what happens to female engineering graduates after they complete their degrees, it has been surprising that in recent years, researchers have devoted relatively little attention to employed engineers and to engineering labor markets. This year, however, there was renewed interest in this aspect of the question, and a number of significant pieces of research were published that shed light on what may be happening.

Several pieces of research we reviewed examined why some women persist in engineering and why others leave. All noted that women had to contend with an engineering environment in which, to some degree, they did not obviously "fit." Their ability to develop a sense that they did, in fact, belong, and were competent engineers was among the factors identified as predicting persistence in engineering. Ayre, Mills, and Gill (2013) continued their ongoing research on women in engineering in Australia with a study of 56 women who graduated from a civil engineering program between 1974 and 2008. Their interest is in why these women stayed in the profes-

2013 Outstanding Women in Engineering

By Elsa Camargo

American Society for Engineering Education (ASEE) Awards

National and Society Award Winners

Frederick J. Berger Award

Marilyn Dyrud, Ph.D., Oregon Institute of Technology

Sharon Keillor Award for Women in Engineering Education

Teri Reed, Ph.D., Texas A&M University

William Elgin Wickenden Award

Deborah A. Trytten, Ph.D., University of Oklahoma
Anna Wong Lowe, Ph.D., Oklahoma Baptist University
Susan E. Walden, Ph.D., University of Oklahoma

2013 ASEE Fellow Member Honorees

Stephanie G. Adams, Ph.D., Virginia Tech
Maureen A. Barcic, University of Pittsburgh
Jenna P. Carpenter, Ph.D., Louisiana Tech University
Cynthia Finelli, Ph.D., University of Michigan
Susan Kemnitzer, National Science Foundation
Susan M. Lord, Ph.D., University of San Diego
Jessica O. Matson, Ph.D., P.E., Tennessee Technological University

ASEE Professional and Technical Division Awards

Biomedical Engineering Division:

Theo C. Pilkington Outstanding Educator Award

Ann Saterbak, Ph.D., Rice University

Women in Engineering ProActive Network (WEPAN) Awards

University Change Agent Award

Canan Bilen-Green, Ph.D., North Dakota State University

President's Award

Cathy Deno, Purdue University

Distinguished Service Award

Jenna Price Carpenter, Ph.D., Louisiana Tech University

Founders Award

Sheila Edwards Lange, Ph.D., University of Washington

The National Academy of Engineering**New Female Members**

Donna G. Blackmond, Ph.D., The Scripps Research Institute
Dawn A. Bonnell, Ph.D., University of Pennsylvania
Ursula M. Burns, Xerox Corporation
Helen Greiner, CyPhy Works Inc.
Sharon L. Wood, Ph.D., University of Texas

Society of Women Engineers (SWE) Awards**Achievement Award**

Eve Sprunt, Ph.D., Chevron Corporation

Suzanne Jenniches Upward Mobility

Cindy R. Kent, 3M

Resnik Challenger Medal

Christine E. Geosling, Ph.D., Northrop Grumman Corporation

Entrepreneur Award

Pamela Dingman, P.E., Engineering Design Consultants LLC

Distinguished Engineering Educator

Beth Todd, Ph.D., F.SWE, The University of Alabama

Work Life Integration Award

Kathleen Cullinan Bove, GE Global Research

Emerging Leaders

Linh Dang, Northrop Grumman Aerospace Systems
Lisa E. Depew, Intel Corporation
Sonja Domazet, Northrop Grumman Corporation
Elizabeth Garypie, Sikorsky Aircraft
Jessica Gullbrand, Ph.D., Intel Corporation
Ya Guo, Ph.D., Medtronic Inc.
Diane C. LaFortune, Northrop Grumman
Pushpa Manukonda, John Deere
Susan Rea Peterson, Ph.D., Medtronic Vascular
Danielle Simonelli, Ph.D., Intel Corporation

SWE Distinguished New Engineer

Holly Ann Friedt, Rolls-Royce North America
Maureen E. Masiulis, General Dynamics Advanced Information Systems
Jessica R. Mattis, General Motors
Karen E. Roth, Air Force Research Laboratory
Natalie Vanderspiegel, Solar Turbines Incorporated

Eileen Vélez-Vega, P.E., Kimley-Horn and Associates Inc.

Charlene Willenbring, UTC Aerospace Systems

Fellow Grade

Elizabeth A. (Libby) Allman, Hallmark Cards
Naomi Brill, Consultant
Virginia Counts, P.E., Medtronic Inc.
Semahat S. Demir, Ph.D., Istanbul Kültür University
Mary E. Kinsella, Ph.D., Air Force Research Laboratory, Wright-Patterson Air Force Base
Marilyn Mikulski Reeder, Westinghouse Electric Company
Linda M.S. Thomas, The Boeing Company

Distinguished Service Award

Anita E. Gale, F.SWE, The Boeing Company
Felicita Saiez, F.SWE, Ohlone College

Outstanding SWE Counselor

Helene Finger, P.E., California Polytechnic State University, San Luis Obispo

Outstanding Faculty Advisor

Elizabeth A. Thompson, Ph.D., Indiana University-Purdue University Fort Wayne

Outstanding Collegiate Member

Katherine Alfredo, Ph.D., The University of Texas at Austin
Christella J. Chavez, The University of Oklahoma-Tulsa
Rachel Hughes, The University of Alabama
Sofie Leon, University of Illinois at Urbana-Champaign
Nicole Navinsky, Southern Methodist University

The Anita Borg Institute for Women and Technology Awards**Women of Vision Innovation Award**

Genevieve Bell, Ph.D., Intel Labs

Women of Vision Social Impact Award

Vicki Hanson, Ph.D., University of Dundee and IBM Research

Women of Vision Leadership Award

Maja Mataric, Ph.D., University of Southern California

Intel Science Talent Search Awards

Sara Volz, first place, Colorado
Hannah Larson, fourth place, Oregon
Brittany Wenger, eighth place, Florida
Sahana Vasudevan, 10th place, California

National Society of Black Engineers (NSBE) Awards**Golden Torch Legacy Award**

Pat Walker Locke, Life Plan Services LLC and Seeds of Humanity Foundation Inc.

Graduate Student of the Year

Chinyere Mbachu, Tennessee Technological University

Pioneer of the Year

Toni K. Brown, The Boeing Company

Pre-College Initiative Director of the Year

Sybil Y. Brown, Ph.D., Northland High School

Pre-College Initiative Program of the Year

Helen Howell, Martinsville and Henry County NSBE Jr. Chapter

Pre-College Initiative Student of the Year (Female)

Joi Stevens, San Antonio City Wide NSBE Jr. Chapter

Outstanding Woman in Technology

Jamesha Parks, Northrop Grumman Aerospace Systems

Mike Shinn Distinguished Member of the Year (Female)

Sarah Brown, Northeastern University

Alumni Extension Member of the Year

Sheila Alves, Virginia Information Technologies Agency

Society of Hispanic Professional Engineers (SHPE) Awards**Community Service Award**

Deborah Berebichez, Ph.D., Morgan Stanley Capital International

Jaime Oaxaca Award

Diana Gomez, California High-Speed Rail Authority

Junipero Serra Award

Lynnette Madsen, National Science Foundation

SHPE Star of Today Award

Teresa Hamid, IBM Corporation

SHPE Star of Tomorrow Award

Nicole Theberge, NAVAIR

Student Role Model, Graduate

Eva Gabriela Baylon, Stanford University

Source: Yoder, *Engineering by the Numbers, American Society for Engineering Education, 2013*

Women Engineering Deans

By Peggy Layne, P.E., F.SWE

Cammy R. Abernathy, Ph.D.	University of Florida
Linda Abriola, Ph.D.	Tufts University
Emily L. Allen, Ph.D.	California State University, Los Angeles
Cristina H. Amon, Ph.D.	University of Toronto
Nada Marie Anid, Ph.D.	New York Institute of Technology
Nadine N. Aubry, Ph.D.	Northeastern University
M. Katherine Banks, Ph.D.	Texas A&M University
Gilda A. Barabino, Ph.D.	City College of the City University of New York
Julia Biedermann, Ph.D., P.Eng.	Conestoga College
Stacy G. Birmingham, Ph.D.	Grove City College
Barbara D. Boyan, Ph.D.	Virginia Commonwealth University
Mary C. Boyce, Ph.D.	Columbia University
Candis S. Claiborn, Ph.D.	Washington State University
Robin Coger, Ph.D.	North Carolina A&T State University
Teresa Dahlberg, Ph.D.	Cooper Union
Natacha DePaola, Ph.D.	Illinois Institute of Technology
Doreen Edwards, Ph.D.	New York State College of Ceramics at Alfred
Julie R. Ellis, Ph.D., P.E.	Western Kentucky University
Jacqueline A. El-Sayed, Ph.D.	Kettering University
Elizabeth A. Eschenbach, Ph.D.	Humboldt State University
Lorraine N. Fleming, Ph.D., P.E.	Howard University
Liesl Folks, Ph.D.	University at Buffalo, The State University of New York
Jane S. Halonen, Ph.D.	University of West Florida
Deborah Huntley, Ph.D.	Saginaw Valley State University
Leah H. Jamieson, Ph.D.	Purdue University
Sharon A. Jones, Ph.D., P.E.	University of Portland
Zella Kahn-Jetter, Ph.D.	Saint Martin's University
Maria V. Kalevitch, Ph.D.	Robert Morris University
Anette M. Karlsson, Ph.D.	Cleveland State University
Debra Larson, Ph.D., P.E.	California Polytechnic State University
Charla Miertschin, Ph.D.	Winona State University
Amy J. Moll, Ph.D.	Boise State University
Lynne A. Molter, Sc.D.	Swarthmore College
Mitzi Montoya, Ph.D.	Arizona State University, Polytechnic campus
Cherry Murray, Ph.D.	Harvard University
Sarah A. Rajala, Ph.D.	Iowa State University
Anca L. Sala, Ph.D.	Baker College
Elaine P. Scott, Ph.D.	University of Washington, Bothell
Laura J. Steinberg, Ph.D., P.E.	Syracuse University
Pearl Sullivan, Ph.D., P.Eng.	University of Waterloo
T. Kyle Vanderlick, Ph.D.	Yale University
Susan E. Voss, Ph.D.	Smith College
Sharon L. Wood, Ph.D., P.E.	The University of Texas at Austin
Kimberly A. Woodhouse, Ph.D., P.Eng.	Queen's University
Sandra Woods, Ph.D.	Oregon State University
J.K. Yates, Ph.D.	Ferris State University

Source: American Society for Engineering Education

sion, as research indicates that women engineers in Australia are likely to leave the profession. Ayre, Mills, and Gill argue that central to women's decision to stay were a sense of belonging and of personal fulfillment. In a context where they were not immediately accepted, women were able to persist because they found ways to redefine engineering to more accurately reflect their own experience and accomplishments; to reposition themselves to achieve recognition and respect by making changes to their personal style or visibility; working hard to demonstrate competence, being assertive in order to prove themselves; and by moving to a different group within engineering to find a more welcoming environment.

Buse, Bilimoria, and Perelli (2013) interviewed 31 American women engineers, 10 of whom had left engineering, to learn more about why some women persist in engineering. Like Ayre, Mills, and Gill, they found that the women who persisted exhibited higher levels of self-efficacy, a strong engineer identity, and strong engagement with their work. Contextual factors also mattered, as persisters were more likely to report having chosen engineering as a career rather than being pushed into it by others; they were also less likely to be married and had fewer children, on average. The authors conclude that female engineers who persisted experienced engineering in such a way as to make it possible for them to develop an engineering identity in which personal and professional aspirations came together. They encourage employers to find ways to create conditions under which women engineers can more easily develop such an identity through fulfilling work, professional development opportunities, and support for family obligations.

Singh et al. (2013) agree, based on a survey of 2,042 women who had received bachelor's degrees in engineering in the U.S. since the early 1980s. They found that a sense of self-efficacy in engineering enhanced women engineers' job satisfaction, which in turn decreased the probability of their leaving the profession. Important to the develop-

ment of a sense of self-efficacy were opportunities to obtain training and for personal development. They recommend that employers offer developmental opportunities so that women engineers would feel confident that they have the right skills and have the ability to employ them on the job.

Moore, Meiksins, and Root (2013) shed light on women who leave the STEM work force. They studied a pooled sample from the Displaced Worker Surveys, seeking to determine whether STEM workers are exposed to job loss and how they respond to it. They found, first, that STEM workers are quite vulnerable to job loss, with women and men equally affected. Most find new work after job loss. Important gender differences emerged, however, particularly when family status was taken into consideration. The study found that married women with children were more likely than married men with children to leave the work force altogether after losing a STEM job. On the other hand, women who returned to employment were more likely to leave STEM fields, a finding that was true primarily of unmarried women. This finding suggests that many women experience discomfort in STEM fields,

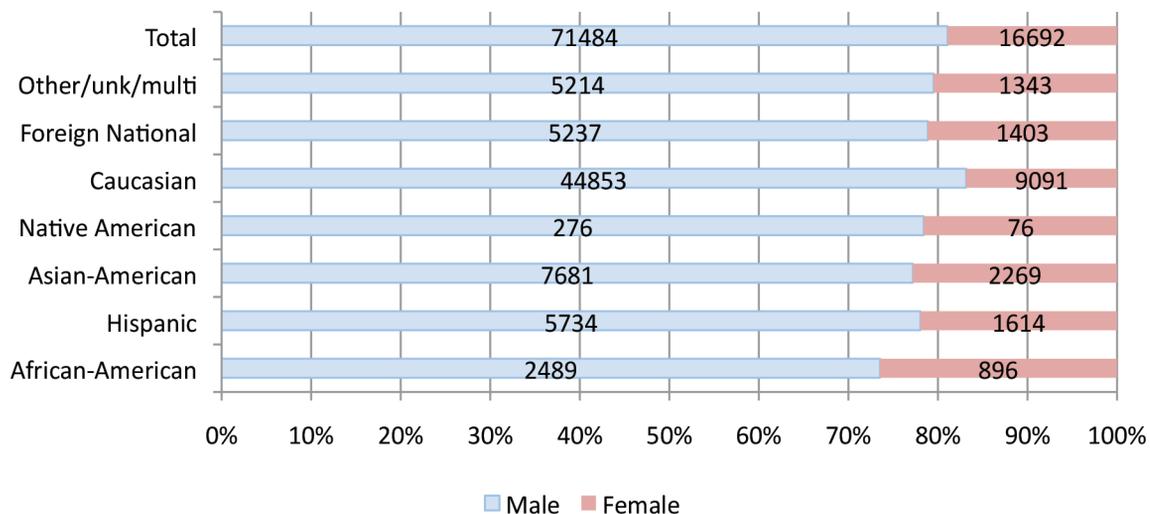
with job loss functioning as a catalyst for their eventual decision to leave, with the additional variable that family situation shapes their decision as to how to respond to that discomfort.

Finally, Glass et al. (2013) looked more broadly at the issue of women's exit from STEM careers by analyzing 1,258 cases from the National Longitudinal Survey of Youth for the years 1979-2008. They identified two groups of college-degreed recipients, some of whom had had job spells in STEM, while others had had professional/managerial job spells. The study sought to answer the question of whether (and why) women are more likely to exit STEM careers than comparable jobs in professional/managerial fields. Glass et al. explicitly avoid comparisons with males in these fields, arguing that the male/female comparison would not shed light on the question of why women leave STEM fields at rates higher than observed in other fields where women are present.

This study produced striking and significant results. First, women in STEM were dramatically less likely to persist in their field — they were more than eight times more likely to leave than women in other professional jobs.

When they leave, they do not leave the labor force altogether, shifting instead into other non-STEM professional jobs. The disparities were not the result of demographic differences between the two groups of women (e.g., there were no differences in rates of marriage and numbers of children). Glass et al. did find some evidence that family formation had a more negative effect on retention in STEM than in other fields. They also note that women with advanced degrees were particularly likely to leave STEM, suggesting that jobs in which cultural aspects of STEM are most pronounced (high-level jobs requiring substantial technical skill) intensify the lack of “fit” between women and STEM employment. They note, however, that most women leave STEM early on, before the most significant effects of marriage and family develop and before women rise to the most challenging technical positions. They speculate that there is something about the organization of STEM work, and/or about co-worker attitudes and expectations, that may be making women feel they do not belong. However, their data do not allow them to examine this hypothesis, which remains speculation.

Engineering Bachelor's Degrees by Gender within Race/Ethnicity, 2012



Source: Yoder, *Engineering by the Numbers*, American Society for Engineering Education, 2013

Glass et al. hypothesize that an important reason women feel they do not belong results from the tensions that arise when they have children and have to balance family and work responsibilities in ways that most men do not. Several other studies focused more squarely on the issue of work/family conflict and its effect on women's persistence in engineering. Beddoes and Pawley (2013) examined a group of 19 STEM faculty members at a Midwestern university and found that their respondents perceived particularly intense conflict between work and family in the academy. They tended to see jobs in industry and government as preferable for women because work/family and parental leave policies are more common in those settings.

Herman, Lewis, and Humbert (2013) studied 24 scientists and engineers who were mothers working for three different companies in France, the Netherlands, and Italy. Their respondents reported that after having children, they were no longer seen as "one of the boys" and that maternity leave and reduced work hours placed them in a stigmatized position, raising questions about the optimism shown by Beddoes and Pawley's respondents regarding the positive effects of family-friendly policies. The authors describe the various strategies the women adopted to overcome this reaction, most of which did not challenge the male culture of their work settings. Some tried to work the expected long hours and juggle their family roles; others chose to accept stalled careers and prioritize motherhood. Only a few were willing to adopt a trailblazer role and to try to break the mold. Overall, the study indicates that, in Europe at least, family roles continue to get in the way of women's ability to "fit" in to science and engineering workplaces.

Beddoes and Pawley (2013) also raise an important question that pertains both to the work/family literature and to the research on women's fit in engineering. They note that their respondents talked about work/family conflict by making use of a discourse of "choice." They recognized that women and men were in

different positions, but emphasized that women make choices that are good for them and are based on what they believe is important. Beddoes and Pawley note that this discourse tends to obscure the unequal realities faced by men and women — men do not have to choose between work and family as do many women — and reduces the pressure to change the context in which choices are being made. A similar point can be made about women's "fitting in" to engineering. Several of the studies we reviewed identified strategies that women developed to deal with and counteract the less-than-welcoming context they found in engineering. But, the ability of some women to adapt to the prevailing norms of engineering workplaces may actually obscure the gendered circumstances that require women — and not men — to adapt in the first place. This is a theme taken up in a growing feminist literature on engineering culture, to be discussed momentarily.

A very different aspect of women's experience in engineering workplaces and labor markets is the focus of Cech's (2013) study of a sample of 9,936 engineers drawn from the National Survey of College Graduates. Cech finds that the average annual gender wage gap in engineering, controlling for a variety of factors, was \$13,000. In seeking to explain this difference, she points to patterns of gender segregation within the profession. Women are segregated into technical and social subdisciplines and work activities that, on the average, are less well remunerated. Thus, women are less likely to work in electrical and mechanical engineering, fields that are better paid than fields such as chemical or industrial engineering, in which women are more common. Similarly, women are less likely to have technical primary work activities (research, development, computer applications) and more likely to have social primary work activities (management, administration, teaching), which again maps on to pay inequalities.

Hunt et al. (2013) argue that this form of gender segregation explains another aspect of the difference between male and female engineers — the underrep-

resentation of women among patentees. Although they found that women's having lower percentages of doctoral degrees played a smaller role, the basic problem is that women are underrepresented in the fields and types of work in which patents are most common.

As Reskin and Roos (1990) argued in their classic work on gender segregation, it is difficult to tell whether "female" portions of an occupation are devalued because they become associated with women, or whether men leave them to women because they are already devalued. This is an important issue that merits further exploration, particularly in view of the effort to attract more women to engineering by emphasizing elements of it that seem more consistent with women's interests and preferences (see the next section for more on this issue).

Finally, a number of studies, including several that reported on programs funded by NSF-ADVANCE, contributed to the large and growing literature on the experiences of women working in academic science and engineering. Settles et al. (2013) report on data collected at the University of Michigan regarding the consequences of personal gender discrimination, the derogation of one's own gender, and sexism toward women. They found that these negative experiences are linked to scholarly alienation and perceptions of a negative workplace climate, which in turn reduced job satisfaction. Interestingly, although it was women faculty who experienced the most negative experiences, men, too, were negatively affected by these experiences; they, too, linked them to perceptions of negative workplace culture and scholarly alienation. Whether these perceptions occurred because they feared that they, too, might one day be mistreated, or whether they simply sympathized with female colleagues was unclear. Settles et al. also found that men experienced derogation of their sex, but this did not result in negative feelings about the work environment, perhaps because men's dominant position allowed them to pass these experiences off as inconsequential or a joke.

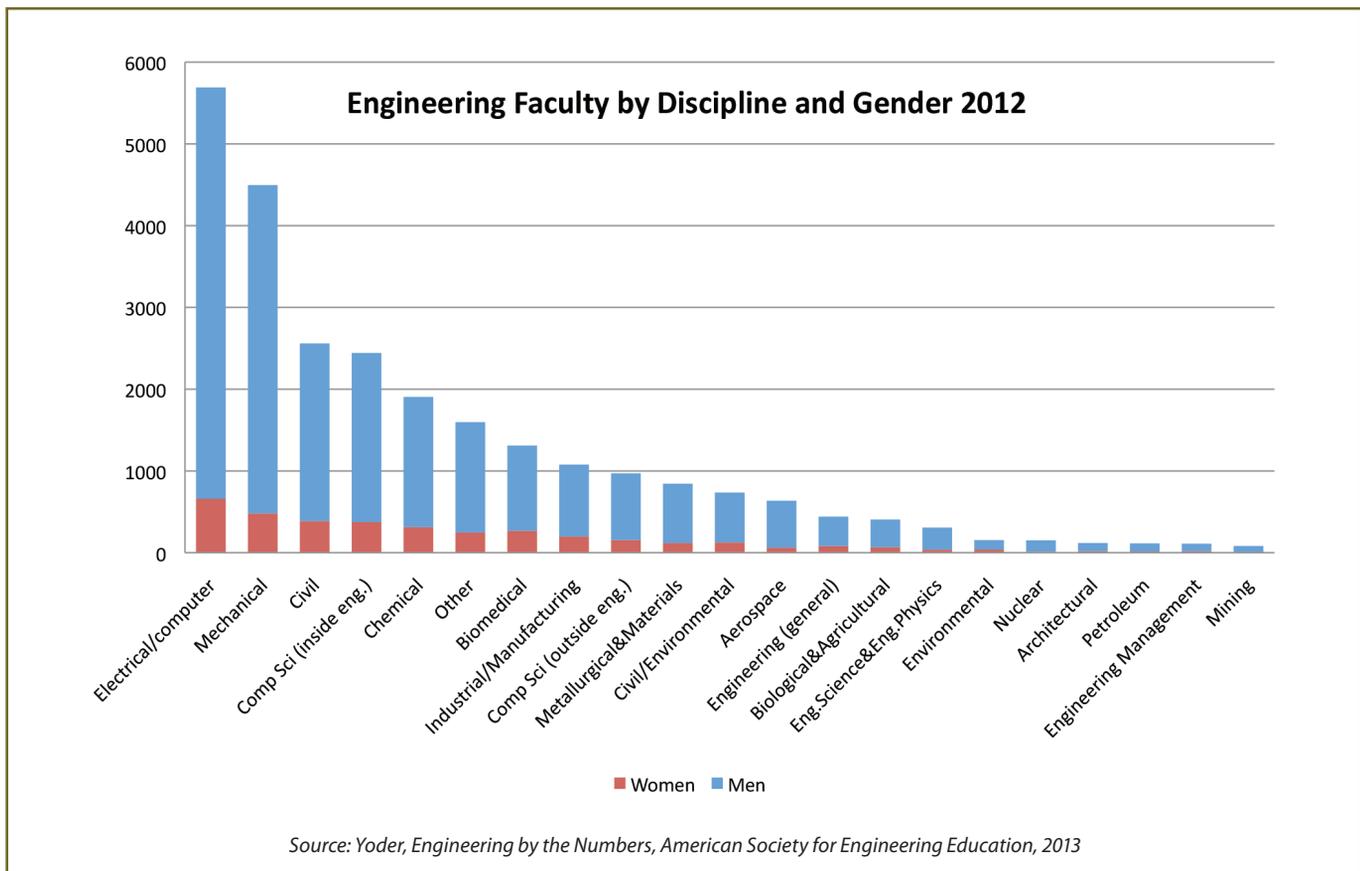
Long et al. (2013) describe interesting research at Purdue University on the mentoring networks of women faculty in engineering. The women faculty studied were not satisfied with the formal mentoring program at their institution, which they perceived as focused on progress toward promotion, having limited scope, and not meeting all of their needs. They developed a diverse set of network connections alongside formal institutional mentoring networks. These included both human and nonhuman resources, varied by whether the faculty member was tenured or untenured, with the latter tending to have more extensive networks that extended beyond the home institution; and by race/ethnicity, with minority women tending to have more extensive networks. This is a small, exploratory study, but it points to a need for additional research on the kinds of mentoring networks women faculty develop and on what works and what does not work within these networks.

Carpenter and O’Neal (2013) describe a successful ADVANCE program at

Louisiana Tech University that resulted in increased job satisfaction and work self-efficacy, increased self-confidence, and decreased sense of isolation for women STEM faculty. The program involved a range of familiar elements: a formal mentoring program; professional development and training on climate issues; creating a male advocates and allies program; and creating publicity materials to increase the visibility of female faculty on campus. While not a groundbreaking program, LSU’s experience demonstrates that it is possible to take concerted action to improve the situation of women faculty in STEM programs.

Fox and Xiao (2013) examine a question that likely will become of increasing importance in the study of academic science and engineering: involvement in entrepreneurial activity. They focus on computer science, an area in which the production of marketable products has become an important part of what faculty do, as it has for other sectors of academic science and engineering.

Fox and Xiao are interested in female faculty members’ attitudes toward such activity. They examine 170 female associate professors of computer science to determine whether they believe that time spent in entrepreneurial activity enhances their promotion chances and whether their attitudes are affected by their departments’ culture regarding entrepreneurial activity. They found that neither women’s involvement in such activity as measured by both time and quality, nor their departmental climate predicted their perceived chances of promotion to full professor. Instead, female faculty tended to view more conventional academic achievements, such as publications in well-regarded, refereed journals, as the key to promotion. Fox and Xiao lack a male comparison group, so they cannot say whether these attitudes are specific to one gender. But, they speculate that female faculty in computer science may feel less secure in their academic positions and be less willing to break the academic mold and take the risk of engaging in entrepre-



neurial activity. As universities become increasingly focused on patents and marketable products, this may work to the disadvantage of female faculty seeking promotion.

The feminist critique: transforming engineering?

One view of what needs to be done to increase the numbers of women in engineering emphasizes that focusing solely on women is not the answer. From this perspective, efforts to encourage gender equality in engineering by increasing the numbers of young women taking advanced math classes early in their academic careers; or by ensuring that potential women engineers see female role models; and/or receive the same kinds of economic and social support along the way as their male counterparts, are all inherently limited because they fail to confront the gendered character of engineering as a discipline and as a profession.

A number of articles reviewed this year renewed the call to incorporate feminist ideas into research on engineering. Riley (2013), for example, reviewed three “cases” of engagement

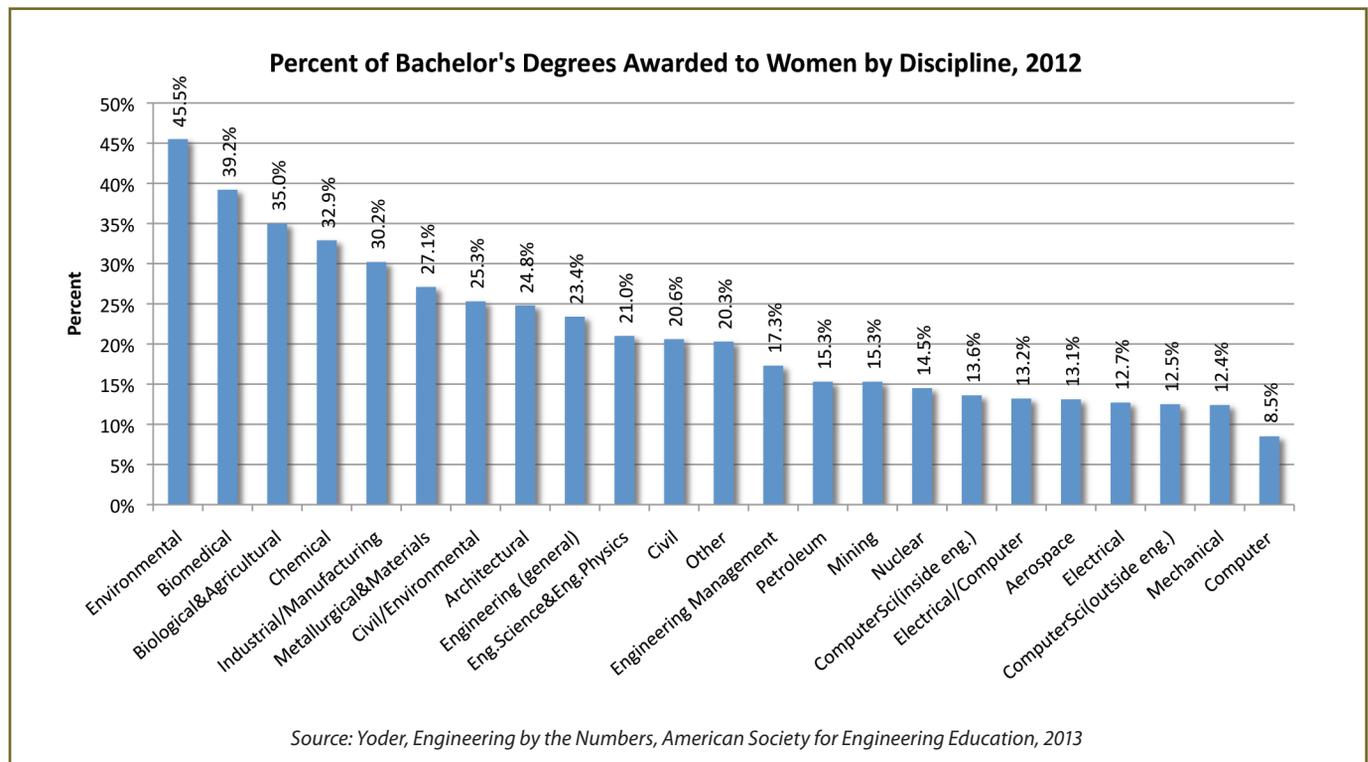
between feminism and the teaching of engineering ethics: the work of Caroline Whitbeck, Ph.D.; the incorporation of notions of “care” and “justice” into engineering ethics; and an instructional film entitled “Henry’s Daughters.” In each case, these efforts exhibited reluctance explicitly to engage with feminist ideas and thus limited the transformative possibilities of each endeavor. She is particularly critical of “Henry’s Daughters” — which attempts to encourage engineering students to think about issues of gender in engineering — for everything from its title, which defines women in relation to a man, to its approach to sexual harassment, which rehashes traditional attitudes about female attractiveness. Her contention is that a truly transformative engagement with feminism would produce a more valuable shift in thinking about engineering ethics and a corresponding improvement in approaches to women within the profession.

Beddoes (2013) interviewed 15 faculty associated with feminist research in engineering education to explore how a feminist critique could benefit the field. She argues that her respondents identi-

fied a number of potential benefits, including an awareness that changing women without changing engineering was not likely to be a successful strategy; a shift in focus from the individual to structural concerns; and increased sensitivity to the issue of who benefits from research and who should be made aware of it. She notes, as well, that feminist ideas continue to struggle to find a welcome in engineering journals, which lack reviewers familiar with feminist approaches and methods, and which continue to be resistant to qualitative methods.

Implicit in this kind of work is the idea that engineering itself needs to be problematized. If women are not attracted to or comfortable in engineering, attention must be devoted to what it is about engineering that causes this, and, presumably, to how that might be changed. Consistent with this line of argument, several studies noted that women in engineering experienced various kinds of discomfort and had to take steps to “cope” with these gendered aspects of engineering in order to persist.

The study by Ayre, Mills, and Gill (2013) discussed above provides a good



example of women struggling with gendered engineering settings. Their respondents' ability to develop a sense of belonging was shaped by the ability of the women in question to redefine engineering as something they, as women, were good at. So, while respondents took it as a given that engineers should possess technical skills, they put greater emphasis on the importance of people skills. Underlying this argument is the view that, as conventionally presented, engineering feels masculine to female engineers; to feel as if they belong, they have to redefine it as something more conventionally female. This study is limited by the lack of a male comparison group (who could, of course, similarly emphasize people skills). Nevertheless, Ayre, Mills, and Gill provide evidence that female engineers find it necessary to redefine engineering in ways that are arguably gendered in order to belong.

Hatmaker (2013) reports on a study of 52 women engineers in the United States that comes to similar conclusions. Her respondents indicate that they found their status as women marginalized their professional identity; that their expertise and competence as engineers were called into question simply because of gender. The prevailing definition of engineering competence as male forced women to engage in a range of strategies to establish their identity as engineers, rather than as women. Some of these involved coping strategies that allowed women to assert that they belonged despite their gender. Other strategies were more potentially transformative, as they involved not just saying that women could compete with men on male terms, but could actually add something new and different to the profession as women.

One of the more interesting conclusions emerging from Hatmaker's research is the reality that some of the strategies women employ to cope with the masculine character of engineering tend to reinforce that masculinity, while others offer the possibility of gender transformation in engineering. This argument seems to link well with the contention, present in many studies

of women in engineering, that the profession needs to make itself more welcoming to women, to emphasize those aspects of what engineers do that might appeal to women, such as helping people solve problems, improving the environment, etc.

Some of the research we reviewed this year provided ambiguous, perhaps even contradictory evidence about whether this approach actually appealed to aspiring women engineers or was likely to be effective. For example, Matusovich, Oakes, and Zoltowski (2013) report on a small-scale study of eight participants in the EPICS (Engineering Projects in Community Service) project at Purdue in 2006. EPICS is a program of design courses, involving multidisciplinary teams that partner with community organizations, agencies, or schools to solve problems that can be addressed with technology. The program has been shown to attract women at higher rates than is typical for engineering majors at Purdue. One possible reason for the program's success in drawing women to engineering is that it involves a "hands-on" approach to learning, something that has been argued attracts women more than the traditionally abstract, lecture-based learning typical of undergraduate engineering curricula. And, indeed, the women who participated in the program cited this as a virtue of EPICS — they emphasized the fact that the contextualized learning enhanced their understanding of the material. On the other hand, Matusovich, Oakes, and Zoltowski are not able to show that this is specific to women — in the absence of a male comparison group, they can only say that the women they spoke to enjoyed this aspect of the program (the men could have as well!). And, another aspect of the program that has been argued to be potentially appealing to women, its community orientation, was not cited by women participants as a significant motivator for joining, although they were aware that this was a feature of the program.

Perhaps even more revealing is research by Bystydzienski and Brown (2012) on a group of 138 10th-grade girls

who participated in an NSF intervention and research project called Female Recruits Explore Engineering (FREE) in 2008. The program was designed to expose girls to engineering through an exploration of engineering websites, participation in hands-on engineering projects, and by encouraging communication among participants while they were taking part in program activities. The researchers participated in the program itself, observed participants as the program unfolded, and interviewed 24 of the participants as the program drew to an end.

What they found was that young women's involvement with engineering was "gendered." They were aware of, and skeptical of it, as being more for men. But, they also gravitated toward areas of engineering perceived as more female friendly, such as environmental engineering. The study's respondents expressed skepticism about presentations that portrayed engineering as friendly to women — the presenters were not engineers, they complained, and they worried that female engineers might be marginalized if they defined themselves as different and interested in different things than men. At the same time, when they took part in engineering activities, their behavior tended to reinforce gendered binaries: They tended to adopt feminized roles pursuing altruistic projects and taking on nurturing, managerial positions.

Research such as this reveals the tightrope that feminist critiques of engineering must walk. On the one hand, the argument that there are problems with requiring women to accommodate themselves to male structures within engineering has considerable power. On the other hand, empirical studies such as those reported above point to the dangers of pursuing this argument unaware of these tensions. If women insist that they are different, and assimilate to engineering on different terms than do men, the danger exists, as participants in the FREE program were aware, that women will be ghettoized in areas of engineering that others define as not really engineering, thereby perpetuating

and even strengthening the gendered character of the profession. An interesting question for future research presents itself here: Are men also attracted to the aspects of engineering that allegedly are more appealing to women? If so, a redefinition of engineering along those lines would not only attract more women, but would reshape it in ways that redefined engineering competence as something of which both men and women are capable.

About the authors

Peter Meiksins is interim vice provost for academic programs and professor of sociology at Cleveland State University. He received his B.A. from Columbia University and Ph.D. from York University, Toronto. Major publications include *Putting Work in Its Place: A Quiet Revolution*, with Peter Whalley (2002), and *Changing Contours of Work: Jobs and Opportunities in the New Economy*, 2nd edition, with Stephen Sweet (2012). He is a member of the editorial advisory board of *Engineering Studies*.

Peggy Layne, P.E., F.SWE, joined Virginia Tech in 2003 as director of the *AdvanceVT* program and is currently assistant provost reporting to the vice provost for faculty affairs. She holds degrees in environmental and water resources engineering and science and technology studies. Layne is the editor of *Women in Engineering: Pioneers and Trailblazers* and *Women in Engineering: Professional Life* (ASCE Press 2009). A Fellow of the Society of Women Engineers, Layne served as SWE FY97 president.

Elsa Camargo is a doctoral student in the Educational Leadership and Policy Studies program at Virginia Tech. Prior to beginning her doctoral program, she worked for the Council on Teacher Education at the University of Illinois at Chicago (UIC), where she analyzed national and state statutes and policies that affected the certification of teacher candidates. She holds a master's degree in Hispanic studies from UIC and a bachelor's degree in English and Spanish. Her research interests include college access and success for minority students and advancement of underrepresented faculty in higher education.

Katie Snead is a graduate student in Industrial and Organizational Psychology at Virginia Tech. Her research interests are broadly based in the application of cognitive science to leadership and followership and studying the relationships between leaders and their followers. She is also interested in measurement development and the practical application of assessments in applied settings.

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Note: The following list of references comprises all of the noteworthy articles and conference papers found in our search of the 2013 literature on

women in engineering. We selected for discussion in our review the literature that seemed to be based on the most substantial research and/or that offered interesting, fresh insights into the situation of women in engineering. For the convenience of interested readers, we have included the complete list of materials we consulted.

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Women in Engineering: A Review of the 2014 Literature

SWE's assessment of the most significant research found in the past year's social science literature on women engineers and women in STEM disciplines.

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Interest in the underrepresentation of women in engineering and other STEM disciplines continued unabated in 2014. In addition to a large amount of scholarly and professional interest in the issue, broader public attention was drawn to it by discussion of America's competitive status in STEM fields — questioning whether the U.S. is falling behind, and if recruiting more women is the solution — and by an op-ed in *The New York Times* in which researchers Wendy Williams, Ph.D., and Stephen Ceci, Ph.D., made the controversial claim that sexism and discrimination were *not* significant factors explaining the low numbers of women in academic science. Our review of the literature covered well over 100 publications, including books, major reports, and journal articles in publications representing a half dozen or more disciplines. We searched for articles by examining major research databases and more than 70 journals that publish articles on gender and engineering. As always, the studies varied tremendously in quality and rigor; they also varied in their methodological approach, from complex statistical analyses of large data sets to interpretive studies of qualitative data.

The literature we reviewed continues to explore familiar explanations of why there are relatively few women in engineering. Some studies focus on early childhood socialization and children's experiences in the K-12 educational sys-

tem, arguing that STEM in general and engineering in particular are perceived by children as male fields, so girls either are not attracted to them or are actively discouraged from entering them. Others focus on what happens to young women who display an aptitude for math, science, and engineering when they enter university. The focus here is on whether engineering programs are supportive of female students, whether engineering curricula respond to the kinds of issues in which female students are likely to be interested, as well as on understanding why young women with strong math and science skills opt for majors other than engineering. Finally, the literature continues to recognize that engineering graduates do not always thrive or remain in the field after they enter the workplace. Studies of both academic and nonacademic settings in which female engineers and scientists work continue to investigate potential obstacles to female engineers' career progress and factors that may explain why some female engineers "opt out."

It has become fairly common to argue that the explanation for the low numbers of women in engineering lies in *all* of these areas and that there is no single cause of gender imbalance in technical fields. However, an interesting aspect of this year's literature is the increasingly lively debate over the question of whether gender bias and discrimination characterize contemporary engineering

workplaces. Are these factors keeping women out and/or holding them back when they gain admission, *or*, as some observers now hold, are women simply choosing not to enter the field, despite real progress in eliminating bias and discrimination? If gender bias and discrimination have been reduced or even eliminated, should the focus of analysis shift to the choices women make earlier in life about whether or not to enter technical fields in the first place? And, if the key is to understand women's choices, are those choices simply a matter of individual preferences or are they constrained by gendered realities that make certain choices more likely than others? Given the prominence afforded these questions, particularly by Williams and Ceci's *New York Times* op-ed piece, we have paid particular attention, in this year's literature review, to contributions that bear on the issues of bias and the nature of women's choices.

A historical overview

One of the most substantial publications we reviewed this year provides us with the opportunity to look at female underrepresentation in engineering in historical context. Amy Sue Bix's (2014) *Girls Coming to Tech! A History of American Engineering Education for Women* surveys the experiences of female engineering students at elite institutions from the late 1800s to the 21st century. Based on extensive use of

archival materials, including the SWE archives, *Girls Coming to Tech* tells the story of how women gained entry to engineering, with focused case studies of Georgia Tech, Cal Tech, and MIT making up a substantial portion of the book. A full-length review appeared in an earlier issue of *SWE Magazine* (the 2014 Conference issue), but a quick summary here will serve to introduce some of the important questions about the contemporary situation.

Bix describes the powerful forces that have served to exclude women from engineering over the past 100-plus years. She demonstrates that women in engineering colleges often encountered conscious, deliberate efforts to keep them out as well as an unwelcoming or even hostile culture that made it difficult to feel as if they belonged and to get the help that they, like their male counterparts, needed. Various forms of harassment, from sexist jokes to stereotypical comments on women’s bodies to more serious forms of sexual misbehavior, also plagued female engineering students well into the 21st century. Bix

is equally persuasive, however, in arguing that it was often unstated, implicit biases and unrecognized gendered processes and structures that blocked women’s entry or discouraged their progress. Thus, factors ranging from the absence of equal facilities for women (e.g., restrooms), to often unstated and unacknowledged perceptions of women’s inferiority, to linguistic practices (“girls” come to tech) that diminished women combined to make it difficult for them to thrive in engineering programs. She stresses the importance and consequences of conscious efforts to change attitudes and to break down the barriers that had traditionally kept women out of engineering.

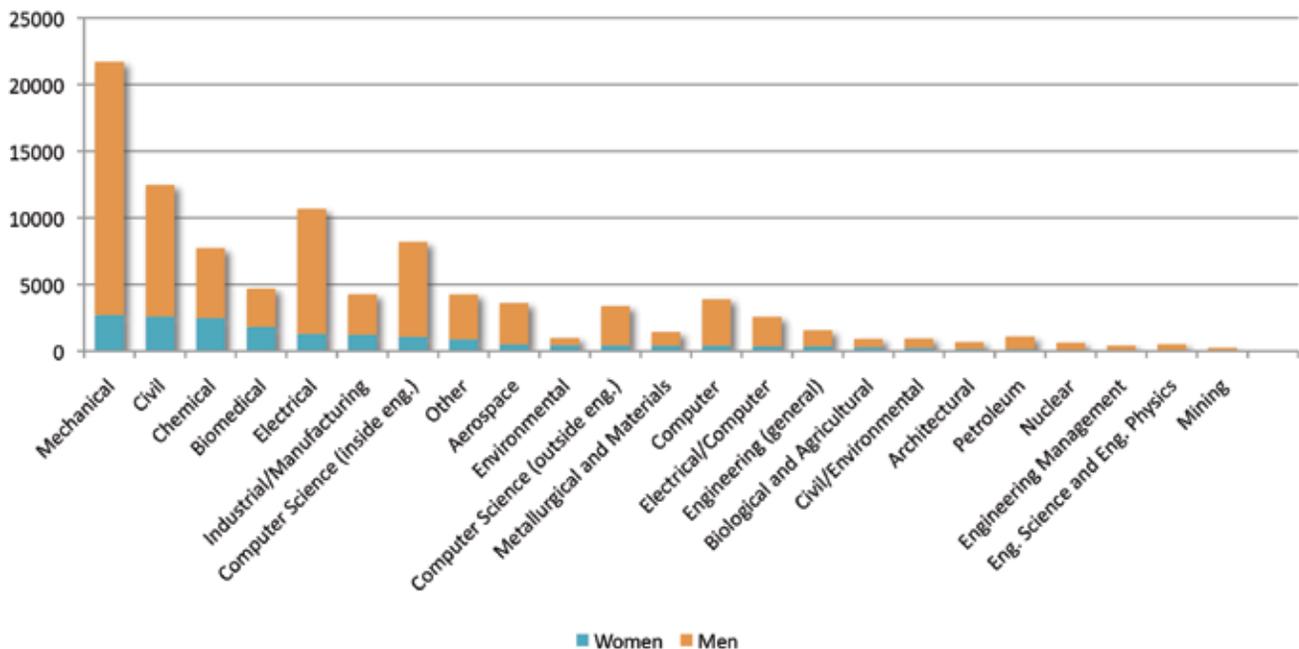
In the end, the story Bix tells is one of incomplete progress. She documents the fact that the open questioning of the propriety of women’s entry into engineering has more or less died away as women have found a place in the field. SWE is singled out for praise as one of the organizations that has played a key role in effecting this change. At the same time, she notes the persistence

of stereotypical beliefs about women’s abilities as engineers and scientists (she comments, for example, on Harvard President Lawrence Summers’ infamous comments in 2005 on women’s math abilities). In addition, she notes that observers have expressed concern that women’s progress may have plateaued; even if explicit biases may have weakened, many of the implicit beliefs and structural realities that kept women out in the past continue to be in place today. As the *SWE* reviewer put it:

“Her rich and nuanced study reminds us of how far women have come, as well as how much work remains if American engineering educators hope to cultivate the potential of all who seek its rewards” (Homsher 2014:61).

Bix’s historical review, then, leaves us with the question of why, despite concerted effort to increase the numbers of women in engineering, and some measurable progress in reducing conscious resistance to that effort, women remain a minority in the engineering profession.

Engineering Bachelor’s Degrees by Discipline and Gender



Source: Yoder, *Engineering by the Numbers*, American Society for Engineering Education, 2014

Girls' aptitude vs. interest vs. socialization?

One possible answer to the question of why girls are less likely to be interested in engineering lies in childhood. For whatever reason, girls are less likely than boys to express an interest in engineering, so are less likely to identify it as a career choice and to take the preparatory steps necessary to entering the field. Traditionally, this was attributed to girls' lesser ability in the fields critical to engineering success: math and science. Educators and parents did not encourage girls to pursue engineering, and even girls themselves were not attracted to engineering because of the belief that girls lacked the skills needed to become an engineer.

Evidence has accumulated that this lesser ability is more myth than reality (for a brief summary, see Valla and Ceci 2014). But, the *belief* that girls lack math and science ability persists. Saucerman and Vasquez (2014) published a useful review of the literature on psychological barriers to women's participation in STEM, emphasizing what they argue is girls' and women's lifelong exposure to overt and subtle messages that make them feel that their absence from STEM fields is the result of lack of ability. They note, for example, that most teachers with math anxiety are female, and that teachers transmit math anxiety to students, so girls continue to be its primary victim. Similarly, teachers continue to attribute the math success of boys (but not girls) to innate ability, while media continue to portray STEM professionals as men. They note the existence of research indicating that men actually have more egalitarian views of women's ability in science and math than do women, perhaps reflecting the continued effects of the subtle messages to which women are exposed throughout the life course.

Scholarly attention also has turned to a different explanation of the relatively small numbers of girls expressing an interest in STEM careers. Maybe it is not a matter of perceived ability but rather that girls aren't attracted to engineering because they lack knowledge about a field that is widely stereotyped

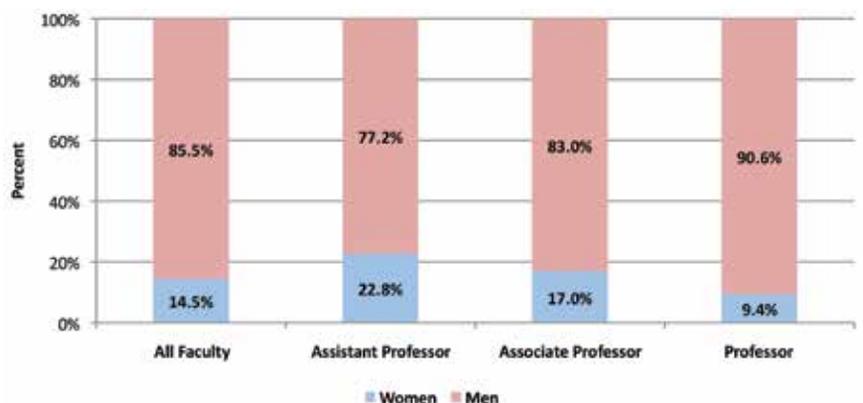
as male and which is seen to be involved with activities in which girls typically are not interested.

Several of the studies we reviewed this year focused on this explanation for female underrepresentation in engineering and what can be done about it. Hammack and High (2014) report on a study of 68 sixth- and seventh-grade girls in the Southwest who participated in an after-school mentoring program about engineering. Prior to the program, girls viewed engineers as people who "fixed things and built stuff." Participation in the program resulted in their viewing engineers as creative problem solvers who improve the world. Hirsch et al.'s (2014) study of 141 fourth- and fifth-graders also found that an enrichment program shifted students' perception of engineers (this was true for both boys and girls in their study). Interestingly, they found that girls in a girls-only enrichment group were more likely to show an increased sense of self-efficacy and to depict engineers as female, something few children of either sex did prior to the enrichment program. Each of these studies points to children's perceptions of engineering as male, and to the fact that that perception can be changed. A note of caution is introduced, however, by Robinson and Pérez-Quñones (2014), whose study of 19 middle-school minority girls found that participation in a program on

human-computer interaction changed the girls' perception of the discipline, but had little effect on their interest in pursuing a career in computer science.

One common intervention designed to combat the gender typing of engineering and STEM disciplines overall is mentoring. Underlying this approach is the idea that girls are less likely to be attracted to engineering and related fields because they see relatively few females in these occupations and have little contact with women who could serve as models. Two studies we reviewed, however, raise questions about this approach. Draus et al. (2014) surveyed 695 women in informational technology, who reported that they did not see a great deal of usefulness in mentoring; 57 percent said that mentoring had little or no effect on their decision to go into IT. Bamberger (2014) reports on a study of Israeli ninth-grade girls whose school was visited by 12 highly educated female scientists and engineers from one of the country's leading high-tech companies. Sixty girls participated in the visit, while a group of 30 did not. This intervention actually backfired, as the girls who participated in the visit had a more negative view of women in STEM and were less likely to express an interest in STEM careers afterward, while the control group showed no change. Bamberger speculates that the participants in the visit were frightened by the scientists and engineers,

Engineering Faculty by Rank and Gender, 2013



Source: Yoder, *Engineering by the Numbers*, American Society for Engineering Education, 2014

who used terms and concepts the girls found foreign and incomprehensible.

Valla and Ceci (2014), in a brief but provocative research note, point to another possible explanation for the fact that relatively few young women are attracted to careers in engineering and related fields. They raise questions about the ongoing focus on math ability in analyses of female underrepresentation in STEM, arguing that whether women have strong math ability tells only one part of what one needs to know to explain their occupational choice. The authors cite other research indicating that career choices are shaped by interests, not just aptitudes. Moreover, they note that women who score high on math ability *also* tend to score high on verbal ability, something that is less true for men. As a result, talented women have abilities in multiple areas, and may opt to enter fields in which verbal, rather than math, skills are central, whereas men who are good at math are more limited to what the authors describe as “narrow,” math-centered activities. Valla and Ceci argue for a “breadth-based model” of women’s underrepresentation in STEM, suggesting, in effect, that women choose not to enter these fields, rather than being excluded from them. This complements their contention, to be discussed below, that women are not treated unequally in science but are choosing NOT to enter math-based STEM fields, largely because of their choice to devote time to family and child-rearing activities.

Valla and Ceci raise an interesting question about whether talented young women are “voting with their feet” in avoiding science. However, the authors take for granted the definition of certain career paths (including engineering) as “narrow.” Their argument is that boys who are only good at math are drawn to engineering and computer science because these fields demand those skills exclusively. But, as the National Academy of Engineering’s Engineer of 2020 report and ABET’s 2000 reconfiguring of accreditation criteria for engineering programs advocate, engineering actually requires a variety of professional as well as technical skills.

Solving the Equation: AAUW Report Makes Recommendations for Change

On March 26, the American Association of University Women (AAUW) will release a report summarizing the latest research on women in engineering and computing. Funded in part by the National Science Foundation, the report highlights compelling recent findings and makes recommendations for increasing the representation of women in engineering and computing.

Solving the Equation: The Variables for Women’s Success in Engineering and Computing features the latest data on girls’ achievement in subjects related to engineering and computing, how few women are working in these fields, and what can be done.

Solving the Equation synthesizes the research on the underrepresentation of women in the technical work force from multiple disciplines and makes evidence-based recommendations for change. The goal is to synthesize and publicize what is known about the situation of women in these fields and to spark the attention of journalists, decision makers, and the public so as to encourage change.

In a second, future phase of the project, AAUW will publish an agenda for future research on the underrepresentation of women in engineering and computing. To form the future research agenda, AAUW will convene a working meeting of prominent researchers in the field. The resulting research agenda will identify questions that are yet to be answered and promising directions for future inquiry. The agenda will be widely disseminated to interested stakeholders.

The research report will be available for free download at www.aauw.org/what-we-do/research/.

Valian (2014) raises precisely this question in a commentary on previously published studies on the use of occupational interest inventories. Valian argues that “gender schemas” (stereotypes) are built into these scales and that sex differences in interests are changeable and sensitive to environmental cues (such as changes in which women are represented in fields formerly dominated by men). Women’s interest in math and science fields will increase if they have a feeling of belonging and an expectation of success, so that Valian concludes that “if we change the environment of math and science, we will change women’s interest in math and science” (229). Perhaps, then, if engineering and math became (or were perceived as) less “narrow,” they might attract more of the more broadly talented women Valla and Ceci describe.

What happens in university?

Many young people make their decision about a college major well before they enter the post-secondary system. But, many of them also change their minds, often multiple times, while others complete high school without a clear

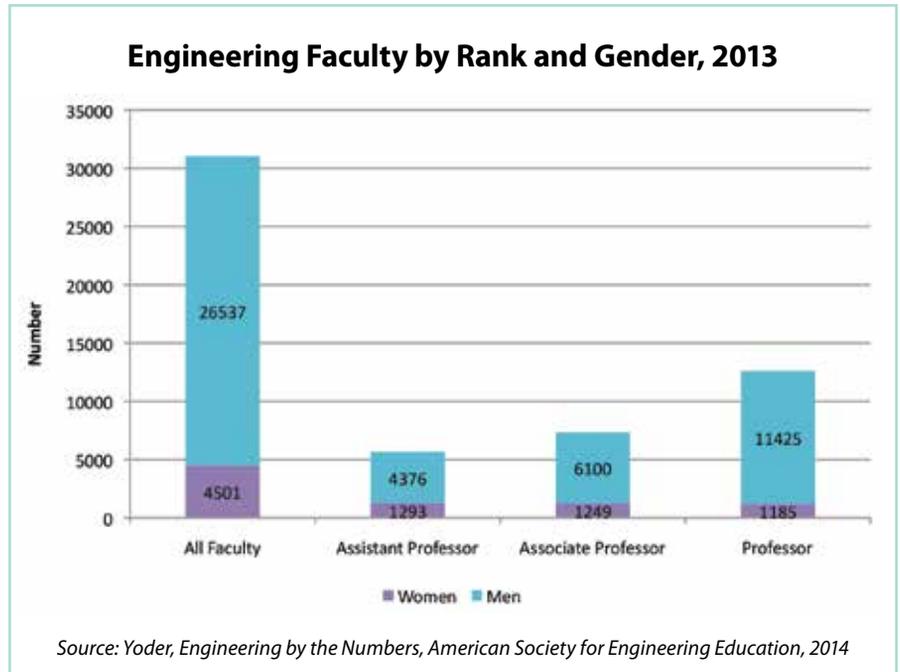
sense as to what their intended major is. Thus, explanations for the underrepresentation of women in engineering need to look not just at what happens before college, but also what recruitment practices and messages are used to attract engineering students. Moreover, since at least some students leave engineering before completing their degrees, and because there has been considerable talk about the “leaky pipeline” for female engineering students, it is also important to consider how engineering programs endeavor to retain students, particularly female students.

These issues were central to a number of the publications we reviewed this year. Holloway et al. (2014) considered the question of whether admissions criteria are contributing to women’s underrepresentation in engineering. They analyzed admissions data from the 2006–2010 cohorts at a Midwestern public university for applicants to the college of engineering. They found that there was gender bias in the admissions process and that it was built into the criteria and policy in use. The university responded by changing its admissions practices; this involved

both reorganizing the admissions office and changing the criteria. Some of the changes included reducing emphasis on math scores on standardized tests and increasing the focus on other cognitive factors such as verbal or written test scores, and on noncognitive factors such as leadership and academic motivation. Holloway et al. report that these changes were effective in eliminating gender bias in the admissions process at this university.

Several studies we reviewed discussed the question of whether engineering is, or could be, presented in ways that respond to female students' interests. Lehr, Finger, and Christine (2014) conducted online surveys with first-year engineering students at a polytechnic state university in California and report the relatively familiar finding that efforts to recruit female students to engineering may be more successful if they convey different messages about what it means to be an engineer (e.g., make a difference) and/or if they occur in different settings (e.g., English classes). Klotz et al. (2014) report on a large survey conducted as part of the larger "Sustainability and Gender in Engineering Survey" of college students in introductory English classes. They found that, in general, sustainability was a theme that could attract both male and female students to engineering. However, there were differences between male and female engineering students — men were more likely to be interested in energy, while women were more interested in addressing issues of disease and poverty. Findings such as this add support to the argument that engineering may need to present itself differently to women than to men.

Cech's (2014) findings from a study of more than 300 engineering students at four New England schools, however, raise questions about whether an emphasis on issues such as sustainability, health, or poverty is actually at the heart of engineering students' sense of self. She reports that engineering students display a culture of "disengagement" and did not put public welfare consideration at the forefront of their professional



identity. Moreover, she finds that students' commitment to public welfare concerns decreased over time, as she interviewed students as first-year students, then again as seniors. Thus, it may be that students lose their interest in these issues fairly quickly, so that basing engineering recruiting materials on their centrality may not make sense. Or, it may be that students who *are* interested in these issues will find it difficult to thrive in a student culture dominated by a very different set of concerns, resulting in high attrition rates and levels of dissatisfaction.

Brawner, Orr, and Ohland (2014) draw attention to another aspect of recruitment: When does it occur? While most engineering graduates begin their college careers in engineering, a minority does not. The authors' analysis of data from the Multiple Institution Database for Investigating Engineering Longitudinal Development shows that students who shift into engineering from other math and science disciplines are more likely to be female (the difference is not huge, but still significant). Thus, it may be that paying more attention to recruiting students from other majors will prove to be an effective way of increasing the numbers of women in the discipline, an idea that would be consistent with the

argument that there is no single pipeline into the profession. Lattuca et al. (2014) note that engineering students in community colleges are unusually likely to be minority students, first-generation college students, and non-native English speakers. Looking outside the traditional high school recruitment pipeline may be a way to increase the diversity of engineering programs in other ways as well.

Once women declare an interest in engineering or STEM disciplines, do they stay? If they stay, what contributes to their retention? Gayles and Ampaw (2014) analyzed secondary data on 1,488 female STEM majors at four-year institutions in the U.S. between 1996 and 2001. They found that regular interaction with faculty was an important predictor of completion, particularly for women. So was being a full-time student. Surprisingly, however, good social experiences were *not* predictive of completion (although women students noted negative aspects of their social experiences); and, GPA was a weaker predictor of completion for women than for men, implying that some successful female students leave STEM disciplines despite high grades.

Several studies (Raelin et al. 2014; Flores et al. 2014) point to feelings of

self-efficacy as a particularly important predictor of degree completion for women in engineering and STEM more generally, which echoes research we have reported in previous years. Raelin et al. add that contextual support is very important in encouraging women to stay in school and complete STEM degrees. Miller et al.'s study of 286 engineering students at two predominantly white and two HBCUs notes that female students mentioned seeking help from other female students as an important strategy for coping with the challenges of their minority status.

Imran, Nator, and Hayati (2014) describe an interesting case study showing how admissions criteria and curricular design can influence the retention of engineering students. They studied two groups of undergraduate electrical engineering students, one composed of students admitted *before* changes to admissions and curricular requirements, one composed of students admitted *after* those changes were in place. The changes included reducing the total number of hours required, curricular redesign to ensure a smoother transition from junior to senior years, and enhancements to the program designed to encourage interest and engagement. The authors report that the changes significantly increased retention for students in general, and for female students specifically; the percentage of women in the second study group was also larger than in the first group, perhaps because of changed admissions rules, perhaps because of more effective retention.

The workplace: a gender-biased academy?

The argument that academic departments are not welcoming to female scientists and engineers and that women encounter a hostile, chilly, even sexist climate when they enter academic science has been central to the literature on women in STEM disciplines. Part of the rationale for the existence of programs like the National Science Foundation's ADVANCE is the perceived need to take positive steps to counteract the effects of both conscious

and unconscious gender bias in the academy. Not everyone agrees that this is still a problem, however, as this year's literature review made clear. In a major monograph-length article, Ceci et al. (2014) summarize their own and others' research challenging the view that a major cause of the underrepresentation of women in academic science is gender discrimination in these disciplines. The monograph reviews the research underlying the op-ed they published this year in *The New York Times* (Williams and Ceci 2014). They contend that the most recent evidence shows that women who enter academic science disciplines fare at least as well as their male counterparts. In math-intensive fields where women are underrepresented, they find that female candidates are at least as likely to be invited to interview for tenure-track positions. Similarly, they find that manuscript and grant funding are now gender neutral, with female authors and principal investigators experiencing similar acceptance and funding rates as their male counterparts.

In their scholarly monograph, Ceci et al. argue that, instead of focusing on discrimination against women who enter academic science, researchers seeking to explain the underrepresentation of women in science should focus on precollege factors and the likelihood that women will major in math-intensive STEM disciplines. Their review of the current research does not support the view that early sex differences in spatial and mathematical reasoning are biological; indeed, they find evidence that sex differences in math ability, even at the high end (the right tail) from which most STEM academics are drawn, can and have changed over time and vary across cultures. They also note that gender differences in attitudes and expectations about math-intensive careers appear very early in children's development and lead to a lower percentage of women choosing to major in math-intensive STEM disciplines. The clear implication of their argument is that interventions designed to increase female participation in academic science should target young children, not adults, and focus

on influencing girls' attitudes to careers and STEM majors that involve advanced mathematics.

Ceci and Williams' arguments have been sharply criticized by others. Rebuttals, particularly "Sexism in Academic Science: Analysis of *The New York Times* Op-Ed" (2014), contend that Ceci and Williams make selective use of data, don't acknowledge evidence of sexism in science, and focus on individual-level data, rather than the structural characteristics of academic departments and institutions. Particular criticism is leveled at their analysis of the evidence regarding the allegedly equal treatment received by female academics in publication and tenure and promotion decisions. Ceci and Williams acknowledge that female assistant professors are less "productive" scholars, but see this as evidence not of sexism, but of choices women make to prioritize family and child-rearing over academic work. From their point of view, if women publish less and are, therefore, less likely to be granted tenure and promotion, it is *not* because they are women but because they are less successful within the gender-blind competition that is scientific work.

Critics note, however, that this normalizes a highly gendered reality in which women (and not men) are expected to and expect to have primary responsibility for child-rearing and in which definitions of scientific success assume an "ideal worker" who can devote all or most of his (or her) time to scientific work. From the critics' point of view, then, science is organized in a way that is gendered and that favors the experiences and realities of men over those of most women (unless those women are willing to "act like men"). Ceci and Williams are charged with ignoring this aspect of the social organization of gender in STEM.

Several studies we reviewed emphasized the gendered reality of academic engineering and science and challenged the view, propounded by Ceci and Williams, that academic science is now gender neutral. Beddoes and Pawley (2014), for example, interviewed 19 STEM faculty (four of whom were

2014 Outstanding Women in Engineering

By Kacey Beddoes, Peggy Layne, and Maureen McCusker

While the following achievements are worth celebrating, they should also be considered in light of new research this year on biases in award systems. Mason, Marchetti, Bailey, and Baum (2014) found that women academics receive proportionally fewer awards than male professors. Based on historical institutional data from a large technical university, they found that between 1964 and 2012, 19.8 percent of university awards were given to women, and between 2007 and 2012, women received 12.1 percent of awards, but were approximately 30.5 percent of the faculty population. The authors identified challenges to creating less-biased award systems, including unclear criteria, the use

of student evaluations, and the use of letters of recommendation, all of which have been shown to perpetuate gender biases detrimental to women. In order to minimize biases in award systems, the authors recommend giving committees the tools they need to avoid perpetuating biases: establishing clear and explicit evaluation criteria, and then critically evaluating that criteria; holding decision makers accountable; being transparent and systematically tracking progress; and legitimizing female leaders in order to establish a basis for positive ratings.

An earlier study funded by the National Science Foundation's ADVANCE program and led by the Association for Women in Science

American Society for Engineering Education (ASEE) Awards

National and Society Award Recipients

Donald E. Marlowe Award

Jean W. Zu, Ph.D., P.Eng., University of Toronto

Fred Merryfield Design Award

Maria C. Yang, Ph.D., Massachusetts Institute of Technology

Sharon A. Keillor Award for Women in Engineering Education

Susan McCahan, Ph.D., P.Eng., University of Toronto

DuPont Minorities in Engineering Award (Formerly Vincent Bendix Award)

Stephanie Luster-Teasley, Ph.D., North Carolina A&T State University

William Elgin Wickenden Award

Glenda S. Stump, Ph.D., Massachusetts Institute of Technology
Micheline T.H. Chi, Ph.D., Arizona State University

Curtis W. McGraw Research Award

Ellis Meng, Ph.D., University of Southern California

ASEE Section Awards

Outstanding Teaching Award

North Central: Mary C. Verstraete, Ph.D., The University of Akron

Outstanding Campus Representative Award

Midwest: Christi Luks, Ph.D., The University of Tulsa

Outstanding Service Award

Illinois-Indiana: Joanne Lax, Purdue University

Outstanding Community College Educator Award

Pacific Southwest: M. Elizabeth Rozell, Bakersfield College

Outstanding Mid-Career Teaching Award

Southeast: Priya Goeser, Ph.D., Armstrong Atlantic State University

2014 ASEE Fellow Member Honorees

Laura Bottomley, Ph.D., North Carolina State University

Rebecca Brent, Education Designs Inc.

Christine M. Cunningham, Ph.D., Texas A&M University

Patricia Hall, Ph.D., The University of Tulsa

Kim LaScola Needy, Ph.D., P.E., University of Arkansas

Mary A. Sadowski, Ph.D., Purdue University

Ann Saterbak, Ph.D., Rice University

Noel N. Schulz, Ph.D., Kansas State University

ASEE Professional and Technical Division Awards

Biomedical Engineering Division

Theo C. Pilkington Outstanding Educator Award

Rena Bizios, Ph.D., The University of Texas at San Antonio

Biomedical Engineering Teaching Award

Renata Ramos, Ph.D., Rice University

Civil Engineering Division

George K. Wadlin Distinguished Service Award

Kristen L. Sanford Bernhardt, Ph.D., P.E., Carnegie Mellon University

College/Industry Partnerships Division 2013

CIEC Best Session Award: Presenter

Lori Glover, Massachusetts Institute of Technology

CIEC Best Presenter Award

JoZell Johnson, Intel Corporation

CIEC Best Moderator Award

Letha Hammon, DuPont

Cooperative and Experimental Education Division

Lou Takacs Award

Kimberly Demko, GE Aviation

Alvah K. Borman Award

Louise T. Carrese, Rochester Institute of Technology

Educational Research and Methods Division

Distinguished Service Award

Daria Kotys-Schwartz, Ph.D., University of Colorado Boulder

Engineering and Libraries Division

Homer I. Bernhardt Distinguished Service Award

Amy Van Epps, Ph.D., Purdue University Libraries

K-12 and Pre-College Division

Meritorious Service Award

Elizabeth Parry, North Carolina State University

Women in Engineering Division

Mara H. Wasburn Apprentice Educator Grant

Jan DeWaters, Ph.D., P.E., Clarkson University
Mary Katherine Watson, The Citadel

Women in Engineering ProActive Network (WEPAN) Awards

University Change Agent Award

Cordelia Ontiveros, Ph.D., California State Polytechnic University, Pomona

President's Award

Mary Anderson-Rowland, Ph.D., Arizona State University
Brenda Hart, University of Louisville

Distinguished Service Award

Beth Holloway, Ph.D., Purdue University

Founders Award

Tricia Berry, The University of Texas at Austin

Betty Vetter Award for Research

Amy Sue Bix, Ph.D., Iowa State University

The National Academy of Engineering

New Female Members

M. Katherine Banks, Ph.D., P.E., Texas A&M University, College Station

Virginia S.T. Ciminelli, Ph.D., Universidade Federal de Minas Gerais, Brazil

Katherine Whittaker Ferrara, Ph.D., University of California, Davis

Maria Flytzani-Stephanopoulos, Ph.D., Tufts University

Naomi Halas, Ph.D., D.Sc., Rice University
Geraldine Knatz, Ph.D., University of Southern California

Ellen M. Pawlikowski, Ph.D., U.S. Air Force, LA AFB

Indira Vasanti Samarasekera, Ph.D., University of Alberta, Canada

Jennifer Rexford, Ph.D., Princeton University
Stacey I. Zones, Ph.D., Chevron Energy Technology Co.

Women Engineering Deans

By Peggy Layne, P.E., F.SWE

Cammy R. Abernathy, Ph.D.	University of Florida
Linda Abriola, Ph.D.	Tufts University
Emily L. Allen, Ph.D.	California State University, Los Angeles
Neslihan Alp, Ph.D., P.E.	The University of Tennessee at Chattanooga
Nada Marie Anid, Ph.D.	New York Institute of Technology
Nadine N. Aubry, Ph.D.	Northeastern University
M. Katherine Banks, Ph.D., P.E.	Texas A&M University
Gilda A. Barabino, Ph.D.	City College of the City University of New York
Stacy G. Birmingham, Ph.D.	Grove City College
Barbara D. Boyan, Ph.D.	Virginia Commonwealth University
Mary C. Boyce, Ph.D.	Columbia University
Tina Choe, Ph.D.	Loyola Marymount University
Candis S. Claiborn, Ph.D.	Washington State University
Robin Coger, Ph.D.	North Carolina A&T State University
Teresa A. Dahlberg, Ph.D.	The Cooper Union
Natacha DePaola, Ph.D.	Illinois Institute of Technology
Persis S. Drell, Ph.D.	Stanford University
Doreen Edwards, Ph.D.	New York State College of Ceramics at Alfred University
Julie R. Ellis, Ph.D., P.E.	Western Kentucky University
Elizabeth A. Eschenbach, Ph.D.	Humboldt State University
Lorraine N. Fleming, Ph.D., P.E.	Howard University
Liesl Folks, Ph.D.	University at Buffalo, The State University of New York
Christine E. Hailey, Ph.D., P.E.	Utah State University
Jane S. Halonen, Ph.D.	University of West Florida
Leah H. Jamieson, Ph.D.	Purdue University
Sharon A. Jones, Ph.D., P.E.	University of Portland
Zella Kahn-Jetter, Ph.D., P.E.	Saint Martin's University
Maria V. Kalevitch, Ph.D.	Robert Morris University
Anette M. Karlsson, Ph.D.	Cleveland State University
Debra Larson, Ph.D., P.E.	California Polytechnic State University, San Luis Obispo
Denise M. Martinez, Ph.D.	Tarleton State University
Charla Miertschin, Ph.D.	Winona State University
Amy J. Moll, Ph.D.	Boise State University
Lynne A. Molter, Sc.D.	Swarthmore College
Mitzi Montoya, Ph.D.	Arizona State University, Polytechnic campus
Cherry Murray, Ph.D.	Harvard University
Elizabeth Jane Orwin, Ph.D.	Harvey Mudd College
Sarah A. Rajala, Ph.D.	Iowa State University
Kristina M. Ropella, Ph.D.	Marquette University
Julia M. Ross, Ph.D.	University of Maryland, Baltimore County
Anca L. Sala, Ph.D.	Baker College
Elaine P. Scott, Ph.D.	University of Washington, Bothell
Melodie Selby, P.E.	Walla Walla University
T. Kyle Vanderlick, Ph.D.	Yale University
Susan E. Voss, Ph.D.	Smith College
Terese Wignot, Ph.D.	Wilkes University
Sharon L. Wood, Ph.D., P.E.	The University of Texas at Austin
J.K. Yates, Ph.D.	Ferris State University

Source: American Society for Engineering Education

men) at a Midwestern public research university between 2009 and 2011. The participants in this study all note that there are significant conflicts between being a female faculty member and having children and a family. Within the university, views similar to Ceci and Williams' prevail: These conflicts, while acknowledged, are generally regarded as a matter of individual choice, not of inherent, structural conflicts between prevailing models of family life and work. The respondents identified this as a primary reason for the underrepresentation of women in academic STEM departments and expressed the view that jobs in industry were actually more accommodating.

Cherkowski and Bosetti (2014) in a study of female faculty in all academic disciplines reported that academic women feel pressure to "do it all," to observe academic publication norms but also to be excellent mothers, a kind of pressure not experienced by their male counterparts. Finally, Cech and Blair-Loy (2014) surveyed 506 STEM faculty members at a research-intensive university regarding their perceptions of the consequences of taking advantage of the university's "family-friendly" policies. They found that faculty believed that using the work/life policy would have negative consequences for their careers because of the perception that parents have lower worker commitment. Like Beddoes and Pawley's respondents, these academics were more likely to want to leave for industry, where family-friendly accommodations were perceived as more widely accepted. Cech and Blair-Loy found no difference between mothers and fathers in their attitudes toward family-friendly policies. Because it is women, far more than men, however, who take the primary role in child care and other care work, the effects of these perceptions are experienced primarily by female faculty.

Other research we reviewed points to evidence of continued biased or discriminatory practices in academic science, questioning Ceci and Williams' view that academic STEM departments have become gender neutral. For example,

Milkman, Akinola, and Chugh (2014) report on an interesting experimental study examining whether bias persists in graduate education. They conducted an “audit study” involving more than 6,500 professors at top U.S. research universities; faculty were contacted via e-mail by prospective graduate students whose names signaled their gender and race/ethnicity (male/female, Caucasian/African-American/Hispanic/Chinese/Indian). The e-mails asked faculty to meet with prospective graduate students about possible research opportunities prior to applying to the doctoral programs in which they taught. The authors hypothesized that faculty would be less responsive to female and minority applicants, and that the pattern of discrimination would be stronger in fields in which women and minorities were underrepresented because faculty would be less accustomed to female and minority colleagues; and in which pay was higher because these fields tend to be dominated by white males.

The results largely confirmed Milkman, Akinola, and Chugh’s hypotheses, although there were interesting exceptions. Female and minority applicants did receive fewer responses,

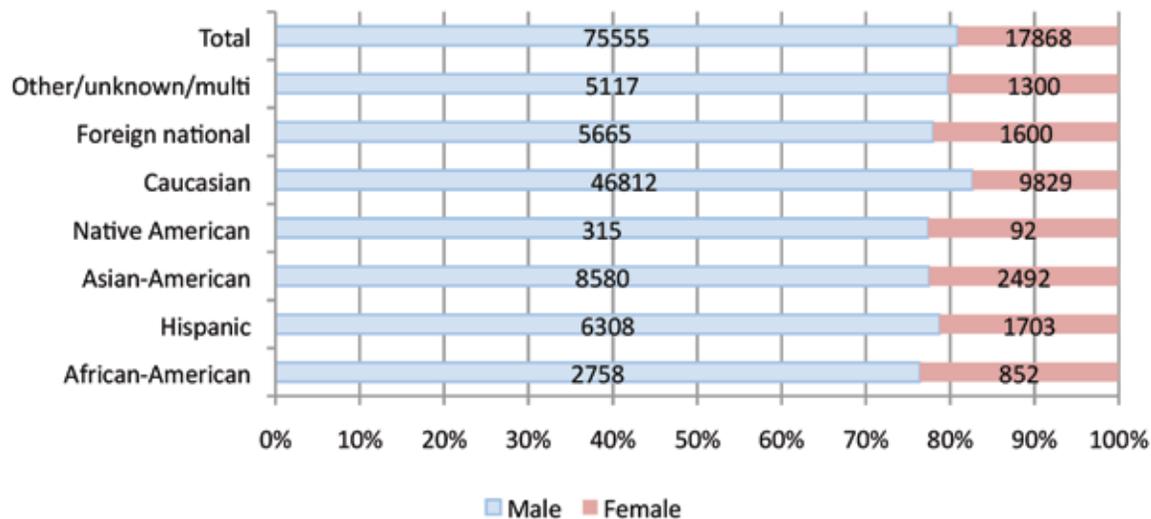
with Indian and Chinese students encountering particularly pronounced discrimination. For the most part, the pattern held across disciplinary areas, although there was no discrimination found in the health sciences and, in the fine arts, women and minorities were actually *avored*. Somewhat surprisingly, and contrary to what many other analyses would have predicted, the representation of women and minorities in the various disciplines was *not* a predictor of discrimination; the treatment of women and minorities was not better in disciplines with higher female and minority representation. There also was little evidence in this study that female students benefited from contacting female faculty, or that minority students benefited from contacting faculty in the same minority group, with the exception of the Chinese students. The study did find that discrimination was greater in disciplines in which faculty earn higher salaries. Faculty in public universities were less discriminatory than those in private universities; however, the ranking of the university was not a predictor of the level of faculty discrimination against female and minority candidates.

While this study is not exclusively

focused on engineering or even STEM programs, it does provide evidence that engineering/STEM faculty continue to be affected by implicit biases that lead them to favor white male applicants to graduate school. As the authors of the study point out, the kind of discouragement a student receives from a nonresponse to the kind of request simulated in this study may lead them to not apply to a particular graduate program or to give up on their plans for graduate study altogether. This study revealed the importance of combating this kind of bias if the numbers of female faculty in STEM disciplines are to increase. Moreover, if the evidence found by this study proves to be correct, eliminating the effects of implicit bias is not simply a matter of increasing the numbers of female and minority faculty in academic departments, since the demographic composition of departments did not appear to affect the level of discrimination prospective students encountered. Instead, it would appear to be a matter of directly confronting the implicit biases of faculty of all kinds (male/female, majority/minority), a major component of many NSF-ADVANCE-funded projects over the years.

Joshi (2014) conducted online surveys

Engineering Bachelor’s Degrees by Gender within Race/Ethnicity, 2013



Source: Yoder, *Engineering by the Numbers*, American Society for Engineering Education, 2013

with more than 400 participants in interdisciplinary research centers at a U.S. public university. The goal of the study was to see whether researchers judged men's and women's contributions differently. Results showed that recognition and utilization of the expertise of male and female scientists was contingent on the gender and gender identification of the actors assessing that expertise, the team's gender composition, and the degree of female faculty representation in the discipline in which the teams were embedded. Thus, men who strongly identified as male tended to evaluate women's contributions more negatively. Teams with more women were more likely to utilize the expertise of highly educated women. And in fields with more female representation, teams that had many women were found to be more productive.

Mason et al. (2014) found that women receive proportionally fewer awards than male professors. Based on historical institutional data from a large technical university, they found that between 1964 and 2012, 19.8 percent of university awards were given to women, and between 2007 and 2012, women received 12.1 percent of awards, but were approximately 30.5 percent of the faculty population. Challenges to creating less-biased award systems are identified, including unclear criteria, the use of student evaluations, and the use of letters of recommendation, all of which have been shown to perpetuate gender biases detrimental to women. The authors recommend methods for combating these clear indicators of remaining bias in academic science, including more explicit evaluation criteria, holding decision makers accountable, and legitimizing female leaders in order to establish a basis for positive ratings.

Finally, the argument that the workings of academic science have become increasingly fair, rational, and gender blind is called into question by research pointing to the ambiguity of tenure and promotion processes (Jones et al. 2014; Beddoes, Schimpf, and Pawley 2014). Intensive interviews with male and female faculty at a large public university

in the Midwest revealed that faculty members described the tenure and promotion process as opaque, confusing, subjective, arbitrary, and blurry. Formal university and departmental policies, which spelled out ostensibly rational, measurable, and gender-neutral tenure and promotion criteria and processes, were seen as playing little or no role in defining the criteria for *actual* tenure and promotion decisions. Although the authors of these studies do not present direct evidence of the link between this "foggy climate" for tenure and promotion and gender inequality in STEM departments, they raise the question of whether gender bias may be at play if tenure and promotion decisions in academic science and engineering are governed by the subjective and ambiguous procedures they describe.

The question of whether academic science is still affected by sexist attitudes and practices is obviously critical to determining whether programs such as NSF-ADVANCE remain necessary. Clearly, those programs continue; our literature review turned up several descriptive accounts of ADVANCE programs on university campuses — e.g., Carpenter (2014) on Louisiana Tech and Wadia-Fascetti et al. (2014) on Northeastern. McClelland and Holland (2014) provide a particularly interesting examination of the role of departmental leadership in increasing gender diversity in STEM departments. They interviewed a group of 31 STEM chairs and deans, most of whom were male, and 11 of whom were in engineering. They noted that these leaders varied in terms of how much they saw it as their responsibility to effect change; those who were low on responsibility tended to play down the need for change and/or to see it as something that female faculty needed to be responsible for. More generally, McClelland and Holland reported that leaders of both kinds tended to ask men to make relatively small changes — be more sensitive, learn more about your female colleagues — while women were asked to make significant life or attitudinal changes to foster gender diversity.

Interestingly, we also reviewed a

"feminist reflection" on NSF-ADVANCE by Morimoto and Zajicek (2014) that took a very different view from the one propounded by Ceci and Williams. The authors accept that academic sexism persists, but wonder whether NSF-ADVANCE programs are up to the task of effectively combating it. They ask whether it is reasonable to expect that a program developed within a major scientific institution can be expected to be the agent through which that institution itself is transformed. Their verdict is somewhat mixed. They criticize many ADVANCE programs for focusing on "individual-level" solutions that don't attempt to transform existing structures (e.g., mentoring or networking programs that seek to help individual women scientists do better within unchanged organizations). They also note that ADVANCE-funded efforts at organizational transformation can also, inadvertently, reproduce the status quo. For example, programs that seek to raise consciousness and change attitudes in academic departments often make women the consciousness raisers. Similarly, programs to encourage the development of family-friendly policies risk perpetuating traditional gender structures unless both men and women take advantage of those policies. Nevertheless, Morimoto and Zajicek hold out the hope that ADVANCE can be a truly transformative program. They add that it might be possible for programs such as ADVANCE to encourage openness to alternative models of scientific work and scientific success, models that do not construct the scientist as an "ideal worker" with unlimited time and a support structure at home and instead reward activities other than individual grant getting and publication, such as successful mentoring and fostering collaboration.

The workplace: gender bias in industry?

As has been the case for several years, relatively little research published this year focused on employed professional engineers outside the academy, and several of the studies we did find were about countries other than the United

States. We reviewed, for example, articles describing the disadvantages faced by female engineers in Portugal and their efforts to cope by trying to make their femininity “invisible” (Saavedra et al. 2014). Tacsir, Grazzi, and Castillo (2014) review the literature on women engineers in Latin America and report a familiar pattern of disadvantage and slow progress. There is a fairly obvious need to find ways to encourage more researchers to examine engineering employment and the experiences of female engineering graduates, especially since research published in previous years shows that many female engineering graduates do not go on to engineering jobs and that at least some women who do, eventually leave. There is an extensive literature on the experiences of women in professional and managerial occupations and the conflicts they encounter, but without focused studies on female engineers, we are forced to

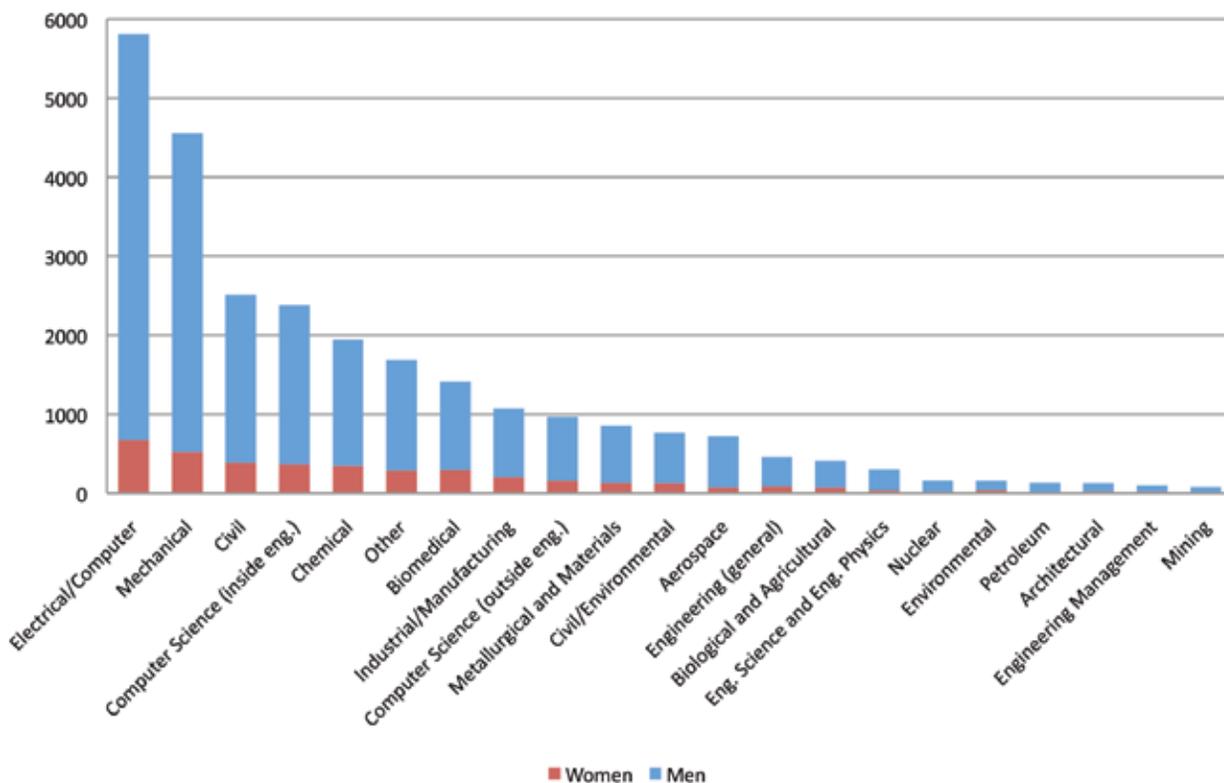
assume, without real evidence, that they are simply the same as women in other occupational roles.

We did review a few studies of working female engineers, most of which focused on the issue of bias and employer attitudes. Braun and Turner (2014) conducted a survey and a small, interview-based study with managers in STEM settings to examine their intention to engage in “women-friendly behaviors.” Importantly, they found that what managers believed others expected them to do was not an important predictor of their willingness to engage in these behaviors, although this was the case for a subgroup of female managers. The managers were aware of the benefits attributed by advocates of promoting women, but also freely expressed reservations about female managers. Braun and Turner note that they were surprised by the openness with which managers talked about these reserva-

tions and acknowledge the existence of stereotypically negative views of women in these fields. The authors are encouraged, however, by the fact that managers’ beliefs and past histories are important predictors of their willingness to behave in woman-friendly ways — those who did so previously continue to do so; those with more positive attitudes to women are more likely to do so. They also note that supportive organizational settings can help encourage managers to be woman friendly. The logical inference is that managers’ practices can be made more woman friendly through efforts to promote attitudinal change, through hiring managers with positive attitudes toward women, and by creating the appropriate organizational climate.

Reuben, Sapienza, and Zingales (2014) point to a more discouraging reality — the persistence of stereotypical beliefs about women’s ability in scientific fields. They conducted an

Engineering Faculty by Discipline and Gender, 2013



Source: Yoder, *Engineering by the Numbers*, American Society for Engineering Education, 2014

experimental study of 191 undergraduate students to examine their gender preference when it came to performing a math-based task. They found that both men and women prefer to hire men for such tasks. The discrimination is reduced when the candidate self-reports performance data, but the authors note that men are more likely to brag about their achievements, so that limits the degree to which bias is reduced. The authors see this experimental evidence as indicating that actual managers may be affected by the same stereotypical attitudes, which may, in turn, hinder women’s careers in STEM disciplines.

In August, Nadya Fouad reported on the ongoing research project at the University of Wisconsin–Milwaukee focused on the retention of women engineers. Invited to address the American Psychological Association’s annual meeting, her presentation, titled “Leaning in, But Getting Pushed Back (and Out),” received wide media coverage. It was picked up by national newspapers, radio, and online media, perhaps due to the tie-in with

Sheryl Sandberg’s book, *Lean In*, and concurrent media attention to the dearth of women in “tech.” Fouad’s research is based on a national survey of women engineers and has been discussed in previous literature reviews. Fouad’s team concludes that workplace climate and lack of advancement opportunities drive women out of the profession. They are currently collecting additional data from both women and men engineers for the next stage of their study.

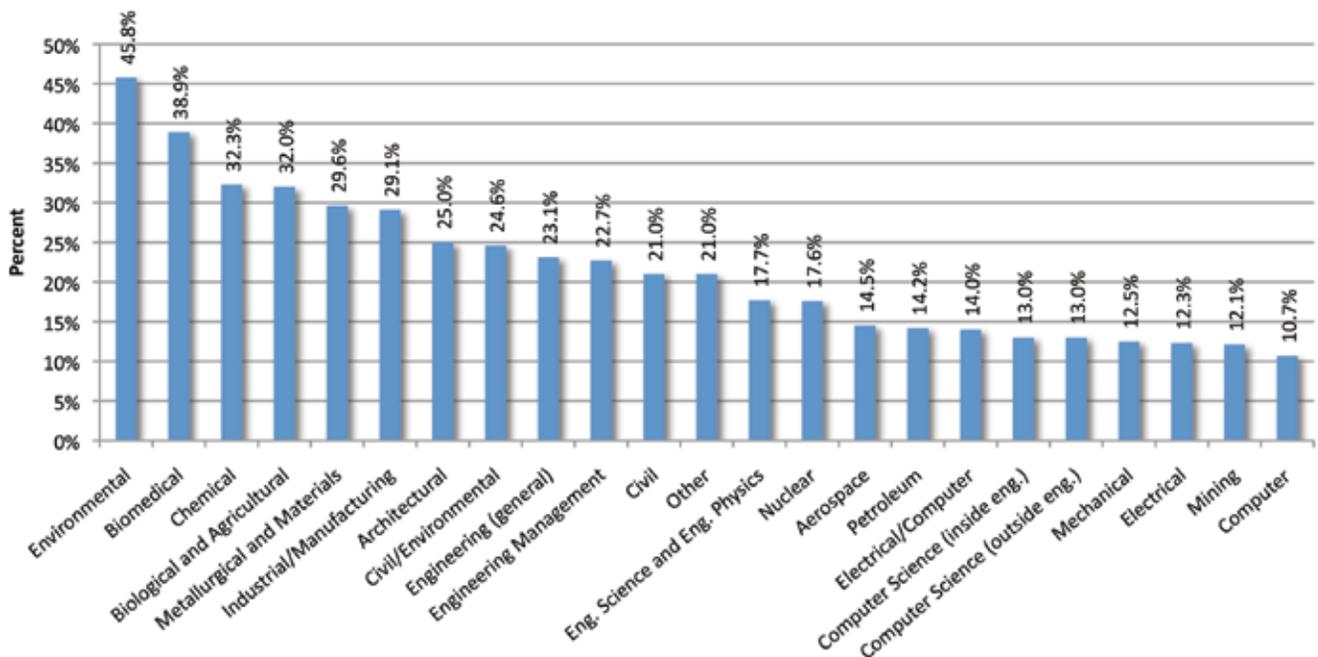
There was one major contribution to the literature on women in engineering workplaces this year: Bilimoria and Lord’s (2014) edited volume on *Women in STEM Careers*. The collection includes research from the U.S., Europe, and Australia, examining women’s work experiences, advancement, and leadership roles in STEM fields, both in industry and in the academy.

The most important contribution of the volume is to ask readers to pose a different question. Typically, we ask why women leave engineering — the metaphor of the leaky pipeline is clear

evidence of this focus. Bilimoria and Lord suggest that we ask, instead, why women *stay*. The essays collected in the volume examine a variety of organizational initiatives that have been shown to make a positive difference for women’s careers in STEM. In addition, the final section of the volume emphasizes the need to reframe organizational discourse and practice to create the conditions under which women will stay.

Among others, the essays in this section discuss the gendered character of definitions of success in STEM (which assume the ability to devote all of one’s time to one’s work), the ways in which care work and family responsibilities, while important to both male and female professionals, are not seen as an appropriate topic for discussion, and the need to make gender a more visible part of STEM curricula. Asking why women stay encourages us to examine the characteristics of the organization and the institution, not just the individual characteristics of the women who leave, thereby responding to the criticism that,

Percent of Bachelor’s Degrees Awarded to Women by Discipline, 2013



Source: Yoder, *Engineering by the Numbers*, American Society for Engineering Education, 2014

sometimes, efforts to promote gender equity focus too much on “changing the women.”

Conclusion — closing the gap?

Readers of the literature on women in engineering and STEM are generally accustomed to the notion that these fields are a particularly extreme case; that they are quite unlikely to attract women and, while there has been progress, that progress has been slow, limited, and may have stalled. Economist Claudia Goldin (2014), however, constructs an argument that may give us reason to think that things may not be quite so bad, after all. In an important article addressing the residual pay gap between men and women in the United States, Goldin offers another lens through which to examine the status of women in engineering and STEM disciplines in general.

Goldin’s concern is with the overall pay gap between men and women in the United States. She notes that average female pay has not yet caught up to average male pay, but the gap has narrowed significantly over recent decades. Goldin asks what would eliminate the last of the pay gap. She argues that the remaining pay gap is not the result of differences in human capital (e.g., education, skill) between men and women, nor can it be attributed to occupational differences (i.e., the concentration of women in different occupations than men). Instead, she argues that the remaining pay gap is primarily the result of the fact that, in certain occupations, value is placed on working long hours and on continuous employment. Women in these fields are more likely to seek to restrict their hours to accommodate family roles, or may interrupt their employment for childbirth and child-rearing, therefore suffering economic penalties and falling behind their male counterparts. Interestingly, Goldin finds that technology and science jobs are *more flexible*, and impose *fewer* economic penalties of this type on female employees.

Although Goldin’s article doesn’t specifically address the case of engineering, it delivers a good news/bad news report

on STEM fields and, by extension, on engineering. In some occupational fields, reformers need to worry about both a pay gap and gender balance. Goldin’s argument implies that the problem in STEM isn’t a pay gap; it is primarily access — women who enter STEM fields do reasonably well economically, compared with men. They are better off relative to their male counterparts than are women in business. For various reasons, however, few women find their way into the field, so only small numbers of women benefit from this relative equity.

Goldin’s analysis implies that finding ways to increase the numbers of women entering the field, rather than combating pay inequity in engineering, should be the focus of equity-oriented policy. It is also interesting to note that Goldin’s analysis suggests that, at least in economic terms, the conditions for women in engineering appear to be relatively good. Given that, it would be important to look again at arguments suggesting that women leave engineering because they find it unwelcoming. Are women leaving engineering in unusually high numbers, or are we simply ignoring the reality that women are leaving other occupations, where conditions are less favorable, in even larger numbers? Subsequent research on women working in industry, particularly addressing the perspectives raised by Goldin, is needed to adequately shed light on these questions.

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Note: The following list of references comprises all of the noteworthy articles and conference papers found in our search of the 2014 literature on women in engineering. We selected for discussion in our review the literature that seemed to be based on the most substantial research and/or that offered interesting, fresh insights into the situation of women in engineering. For the convenience of interested readers, we have included the complete list of materials we consulted.

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Effective or Limited Strategy?

Over the years, the rhetoric of both national security and economic competitiveness has been used to argue gender equity in STEM. Two recent books dissect these approaches.

The most obvious reason to increase the numbers of women in engineering, and STEM fields more generally, is gender equity. However, proponents of gender integration in these fields have often turned to other arguments to try to persuade the reluctant. Two significant books published this year describe these arguments and point to the limitations of relying on them too heavily.

Laura Micheletti Puaca's *Searching for Scientific Womanpower: Technocratic Feminism and the Politics of National Security, 1940-1980* focuses on how advocates for women have used the rhetoric of national security to open doors for women in science and engineering from World War II through the Cold War. Puaca describes initiatives to recruit women into formerly male technical roles during World War II to "free men up" for the "more important" work of winning the war. Groups such as the American Association of University Women (AAUW) and the Society of Women Engineers made active use of Cold War fears to encourage women to pursue engineering and science (leveraging, for example, concerns about the Russian Sputnik launch).

During the 1970s and '80s, as second-wave feminism emerged, national security language faded into the background somewhat, and the language of rights and equity began to have more traction. But, as the Reagan era ushered in a more conservative political context and renewed concern about national security, women's organizations returned to the rhetoric of national security and economic competitiveness.

Puaca's book points to the continuity, and partial effectiveness, of this kind of rhetoric in persuading Americans that more women should be recruited to engineering and science. However, she also argues that it is limited in the end by the fact that it does not provide a critique of women's status in science and society.

A second book that raises related issues is *Falling Behind? Boom, Bust, and the Global Race for Scientific Talent*, by Michael Teitelbaum. The book is not focused on gender equity in STEM per se; rather, Teitelbaum's concern is the question of

whether the United States is falling behind because there is a shortage of qualified STEM professionals in the United States. He notes that concern about America's competitiveness in STEM has been a recurring concern since World War II and documents five rounds of alarm in postwar American history.

According to his analysis, however, the available evidence provides little support for these concerns. In the most recent period, for example, concerns have been raised about American students' performance on tests of scientific and mathematical knowledge, about America's ability to compete with rising powers abroad, and about "shortages" of STEM professionals. Teitelbaum carefully calls these claims into question, noting that the top quartile of American students (from which STEM professionals are recruited) continue to do very well and that salaries in STEM fields have not risen as they should have if there truly were a shortage.

Previous alarms, often led by special interest groups, resulted in an overproduction of STEM graduates, resulting in periodic "busts" that actually made scientific and engineering careers less attractive. Teitelbaum notes how the rhetoric of STEM shortages and declining competitiveness has been used to argue for increasing the numbers of women in these fields: Women are portrayed as one of the great, untapped domestic sources of technical expertise. If Teitelbaum is right, however, that there is no shortage, and if he is right about the cycle of boom and bust in STEM fields since World War II, it is easy to see how exclusive reliance on this type of rhetoric can backfire when the next period of overproduction arrives and the resulting competition for scarce jobs intensifies.

These books raise important questions about what is the best strategy for advocates of gender integration in engineering and STEM. Should they argue that increasing the numbers of women in STEM will help solve problems unrelated to issues of gender? Or, should they take a more direct approach and make the case that gender equity *in itself* is the strongest argument for gender integration?

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Women in Engineering: A Review of the 2015 Literature

SWE's assessment of the most significant research found in the past year's social science literature on women engineers and women in STEM disciplines.

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Have engineering, and scientific and technological fields overall, become more welcoming to women, or are the traditional barriers to entry into these fields still standing? Readers of the popular press over the past few years have seen entirely contradictory answers to this question. On the one hand, there has been much-publicized social scientific research presenting evidence that sexism no longer affects the hiring process in science, technology, engineering, and mathematics (STEM) fields. According to this research, and to some popular writers on the general situation of women in the contemporary workplace (e.g., *Lean In*), if women are not progressing in fields like engineering and science, it is because of things they themselves do, because of the choices they make. On the other hand, this year saw reports of several extraordinary examples of the most blatant, obvious kinds of sexist behavior by senior, distinguished male scientists (see sidebar). Incidents such as these make it difficult to accept arguments that gender bias in engineering and science is a thing of the past.

The purpose of the annual literature review on women in engineering is to present the readers of *SWE Magazine* a summary of the best scholarly research on the position of women in engineering and related fields. Each year, significant quantities of scholarly research on women in engineering and STEM are

published. This year was no exception, as we reviewed almost 200 articles, books, and scholarly presentations that attempt to explain why there continue to be relatively few women in engineering and many other technical fields; to describe whether and how those fields are changing to try to attract more women; and to assess programs intended to help recruit and retain more women engineers and scientists. Those with an interest in getting to the bottom of the question of why gender continues to matter in engineering and science can learn much from this published research.

Of course, the quality of the research published each year varies tremendously. As in previous years, we read some exemplary studies that drew on extensive research, employed the best scientific methods, and limited their conclusions to what the evidence would support; other studies were based on limited data and imperfect samples, and often marked by personal opinion. In the review that follows, we have tried to focus our attention on those studies that genuinely merit serious attention because they were scientifically sound and/or because they raised important questions or pointed to significant new lines of inquiry.

As authors of this literature review for several years, we would like to be able to say that we have identified a gradual increase in knowledge, to report that

research has led to an emerging consensus regarding the causes of women's underrepresentation in engineering and other technical fields. Unfortunately, this is not the situation we discovered. In part, the lack of consensus reflects the reality that the causes of women's underrepresentation are complex and that it is not really possible to identify a single cause that is clearly and unambiguously the most important. But, it is also the case that the literature on women in engineering is handicapped by the fact that it is multidisciplinary but not truly *interdisciplinary*; research is conducted in multiple fields, but researchers in one discipline often seem unaware of related research in another. In addition, it is striking that researchers often fail to make use of work done previously, even in the same field, resulting in frequent reinvention of the wheel.

Our hope is that literature reviews such as this one will help to encourage the development of a truly interdisciplinary approach to research on women in engineering.

Still, a number of themes do emerge from the literature we reviewed this year that represent the current state of thinking on the reasons for the persistently small percentage of engineers who are women. While not a consensus, these themes form a solid basis for the construction of a comprehensive explanation and for the development of

interventions that might, finally, effect change:

- While there is evidence that explicit bias against women in engineering has been reduced in some areas (e.g., entry-level hiring), there also continues to be evidence that stereotyping has negative effects on women’s experiences in the field.
- Engineering continues to be regarded by both men and women as a male field, which makes it difficult to attract more young women.
- Although women’s math attainment has increased significantly over time, this in itself has not been enough to fundamentally change the gender balance in engineering.
- Just as recruiting women to engineering continues to be difficult, there is evidence that part of the reason for the low numbers of women in the field is that at least some women who enter it leave at various points along the way.
- The dynamics of teams continue to affect women’s experience in engineering. Teams are an important part of engineering work, but the

gender composition of teams continues to shape women’s participation and level of comfort.

- Race and ethnicity intersect with gender in various ways within engineering. Many of the same factors that account for the underrepresentation of women also affect the representation of minority groups. At the same time, minority women’s experience is different, in some ways, from that of white women, a reality that has not been directly addressed by many programs designed to increase the numbers of women in engineering generally.

We have highlighted these themes here and will develop them at greater length in the literature review that follows. We will conclude the review with a discussion of interventions and how they can be effective, as well as some suggestions regarding possible directions future research should take.

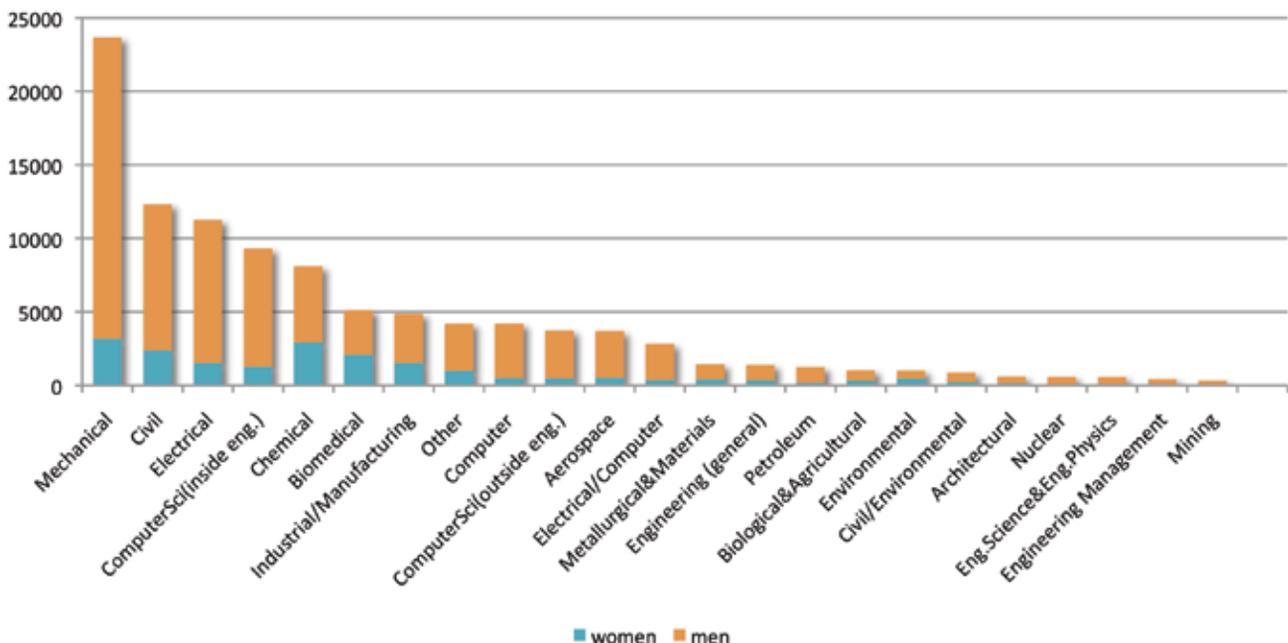
How much progress has there been?

One point that is *not* in dispute is that engineering and many other technical fields remain far from gender integrated,

although there has been measurable progress (for suggestions as to where to find detailed statistical information on degree recipients, labor force, etc., see sidebar, p. 60). *Science and Engineering Indicators*, published this year by the National Science Foundation (NSF) (2015), reports that the percentage of workers in science and engineering occupations who were women had grown from 22.9 percent in 1993 to 29 percent in 2013. Obviously, this is a significant gain, but still left women in a distinct minority.

Moreover, the distribution of women across science and engineering occupations remains very uneven. The same NSF document reports that in 2013, women were the *majority* of social scientists and accounted for nearly half of biological, agricultural, environmental, and life scientists. In contrast, women represented a mere 30.7 percent of physical scientists and only 14.9 percent of engineers. The latter number represented a near doubling of the 8.6 percent of engineers who were women in 1993, but would have to be doubled twice more for there to be gender parity in the profession.

Engineering Bachelor’s Degrees by Discipline and Gender, 2014



Source: Yoder, *Engineering by the Numbers*, American Society for Engineering Education, 2015

Sexual Harassment and Bias

2015 was a year in which there were a number of highly publicized incidents that drew general attention to the problems facing women in STEM disciplines. These served as a reminder that, although progress may have been made, female scientists and engineers still may encounter both a hostile environment and male colleagues and supervisors who do not treat them as equals.

In June, major news media reported (Quinn, 2015) that Nobel laureate Tim Hunt, Ph.D., had resigned his position as an honorary professor at University College London. Dr. Hunt, a noted biochemist, made comments at the World Conference of Science Journalists on June 9 in Seoul, South Korea, that eventually led to his resignation. He went on record as favoring single-sex labs and described himself as a chauvinist, although he added that he didn't want to block women's progress. Dr. Hunt was also quoted as saying the following: "Let me tell you about my trouble with girls ... three things happen when they are in the lab ... You fall in love with them, they fall in love with you and when you criticise them, they cry."

Later in the year, in October, Geoffrey Marcy, Ph.D., a prominent astronomer at the University of California-Berkeley, resigned in the aftermath of his being found responsible for sexually harassing female students over a period of years. The

university had found him guilty in June, but initially placed him on probation and agreed with him to a set of strict conditions regarding his behavior with students. When the investigation became public later in the year, however, a public outcry resulted, with many members of the faculty, including a number of his colleagues in astronomy, protesting what they saw as the leniency with which he was being treated. The protests eventually led to Dr. Marcy's resignation. The incident received considerable public attention, including coverage in *The Chronicle of Higher Education*, which published a feature article under the headline "Female Astronomers: Outsiders in Their Field" (Wilson, 2015).

Academic researchers emphasize the importance of taking incidents such as these seriously. Sojo, Wood, and Genat (2015), for example, reported on research they conducted on the effects of harmful workplace experiences on women's well-being. While their study is not specifically focused on STEM occupations, they found that both high-frequency/low-intensity experiences (such as a hostile climate) and low-frequency/high-intensity experiences (such as sexual coercion) were significant job stressors and had negative consequences for women at work. This was particularly true for male-dominated work environments, such as the ones from which Drs. Hunt and Marcy emerged.

Women are also unequally distributed within engineering. For example, in 2013, they represented 33.8 percent of environmental engineers, 32.1 percent of bioengineers or biomedical engineers, and 22.7 percent of chemical engineers. In contrast, they represented smaller percentages of the three largest engineering specialties: 17.5 percent of civil engineers, 10.7 percent of electrical/computer hardware engineers, and a mere 7.9 percent of mechanical engineers.

Women are also receiving a somewhat greater share of engineering degrees but still represent a significant minority of degree recipients. According to data collected by the American Society for Engineering Education (Yoder, 2015), women received 19.9 percent of under-

graduate engineering degrees in 2014, up from 17.8 percent in 2009. Women's share of engineering master's degrees has also risen, but at a more gradual rate: Women earned 24.2 percent of engineering master's degrees in 2014, an increase of 1.5 percentage points over 2005. Women's share of doctoral degrees in engineering actually *decreased* slightly in 2014, to 22.2 percent, but this did represent an increase of about 4 percentage points over 2005. ASEE projects that women's share of doctoral engineering degrees is likely to remain stable in the near future. As with engineering practice, women are unequally distributed across engineering specialties in universities. At one extreme, in 2014, women earned 48 percent of undergraduate degrees in environmental

engineering and 40.6 percent of those in biomedical engineering; at the other, women received only 12 percent of undergraduate degrees in computer engineering and 13.5 percent of those in mechanical engineering.

Not only do women represent a persistently small percentage of engineers, but research published this year points to a persistent earnings gap between women and men in engineering and other STEM fields. Xu (2015) used data from the *Baccalaureate and Beyond Longitudinal Study*, which follows a 1993 sample of more than 11,000 students, to examine gender gaps in earnings over time in technical fields. The research shows that women's incomes trailed behind men's in the same field 10 years following graduation and that women's disadvantage grew the further away from graduation they were. On a more positive note, Xu found that advanced degrees had a more positive effect on women's incomes than on men's in STEM fields. The gender earnings gap varies across occupations, but it exists in all of the technical occupations Xu examined. The gap is unrelated to college GPA (so appears not to be linked to ability or achievement). Xu argues that family responsibilities played a major role in shaping the income gap, because the number of children had a negative effect on women's incomes, but not on men's.

Why so slow: Is bias still a factor?

There continues to be disagreement — perhaps even growing disagreement — on how to explain the persistent underrepresentation of women in STEM and the persistent inequalities between men and women who enter these fields. One aspect of this controversy that has received a great deal of attention in recent years concerns the question of whether women who enter engineering and science encounter a "hostile" environment and whether bias and/or stereotyping affect women's ability to enter and thrive in these fields.

At the forefront of the controversy is a research program led by Stephen Ceci and Wendy Williams at Cornell University, who have challenged the prevailing

view that women in STEM face significant hiring bias. This year, Williams and Ceci (2015) reported on research evaluating the question of whether female applicants for academic positions do encounter significant bias. Noting that there is evidence that women are less likely to *apply* for tenure-track positions, Williams and Ceci wonder whether this is the result of having experienced bias when they do apply.

Williams and Ceci conducted a series of five experiments, involving 873 faculty responses from 371 colleges and universities across the U.S. The experimental design examined hiring preferences in four fields: two in which women were underrepresented and that were math-intensive (engineering, economics), and two in which women were well represented and that were *not* math-intensive (biology, psychology). They asked respondents to compare the likelihood that identical candidates (differing by gender) would be ranked first in a search for an assistant professor position.

The first three panels involved sending summaries describing matched applicants (with a third, less-qualified male included to conceal the purpose of the study). Information about lifestyle (married, not, children, divorced, etc.) was also included to see whether this was a factor. A fourth panel involved

the use of whole resumé, while a fifth asked respondents to rate single candidates (in case comparison elicited the “desired” response).

Williams and Ceci’s general finding was that there was a clear preference for *women* candidates — roughly two to one in all studies across all fields. Lifestyle issues did not appear to eliminate this preference at all, although they did acknowledge some modifications: e.g., women preferred divorced mothers to married fathers; men preferred mothers who took leaves to mothers who did not. They conclude that the reason for women’s not applying is not because there is sexism in hiring. Perhaps the perception that these fields are hostile has become self-reinforcing.

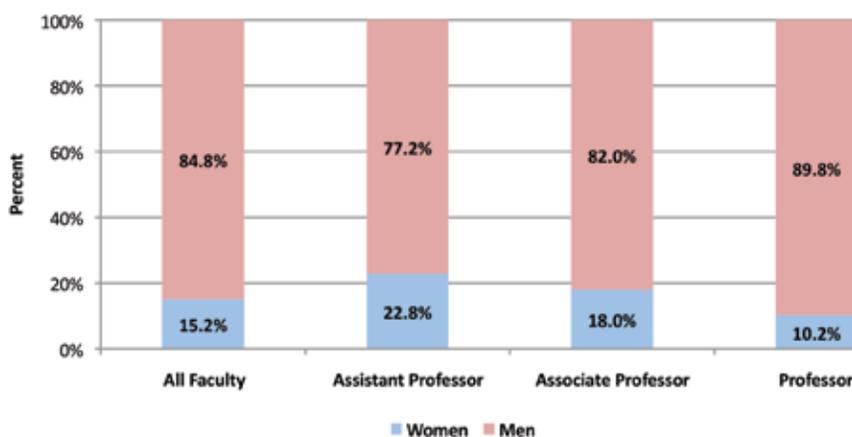
Ceci and Williams (2015) also report on another aspect of their research, which examined what happens when a female candidate is competing with a better-qualified male competitor. They asked a sample to indicate which candidate they would prefer from among two similar male candidates and a slightly less well-qualified female candidate. They found very few respondents who preferred the female candidate in this situation, indicating, they believe, that affirmative action has not caused academics to give preference to less well-qualified female candidates. In

sum, the two articles they published this year based on their research point to the conclusion that there is no evidence of bias against women in hiring and, if anything, there may be evidence that female applicants are preferred (assuming comparable qualifications).

While Ceci and Williams find no indication of bias in hiring, other research published this year *did* present evidence that hiring decisions were affected by gender bias. Wessel et al. (2015) reported on experimental research in which participants evaluated male and female candidates applying for an engineering manager position. Respondents were 674 undergraduates at a large Midwestern university. The study examined the effectiveness of two methods of gender presentation that women might employ in employment contexts where males predominate: verbalizing “agentic” traits (describing oneself in masculine terms) or gender acknowledgment. Results indicated that women who verbalized agentic traits were evaluated more favorably (although this did not happen for male applicants). Respondents who acknowledged their gender were evaluated less positively, irrespective of whether they were male or female. The authors conclude that female applicants for positions in predominantly male environments do better if they do not acknowledge their gender.

Other research published this year indicated that there continued to be gender bias in STEM fields outside the context of hiring decisions. Leslie et al. (2015) conducted a survey of 1,820 faculty, postdocs, and graduate students at U.S. universities in 30 fields, the majority of which were STEM disciplines. Their study examined whether the stereotype that women lack “natural” talent (brilliance) is linked to their underrepresentation in fields where it is believed that this kind of ability is needed. Their findings confirmed that respondents believed that the explanation of female underrepresentation in certain fields was the result of their lacking “natural” talent. While the study does not explore whether these beliefs play a role in ac-

Engineering Faculty by Rank and Gender, 2014



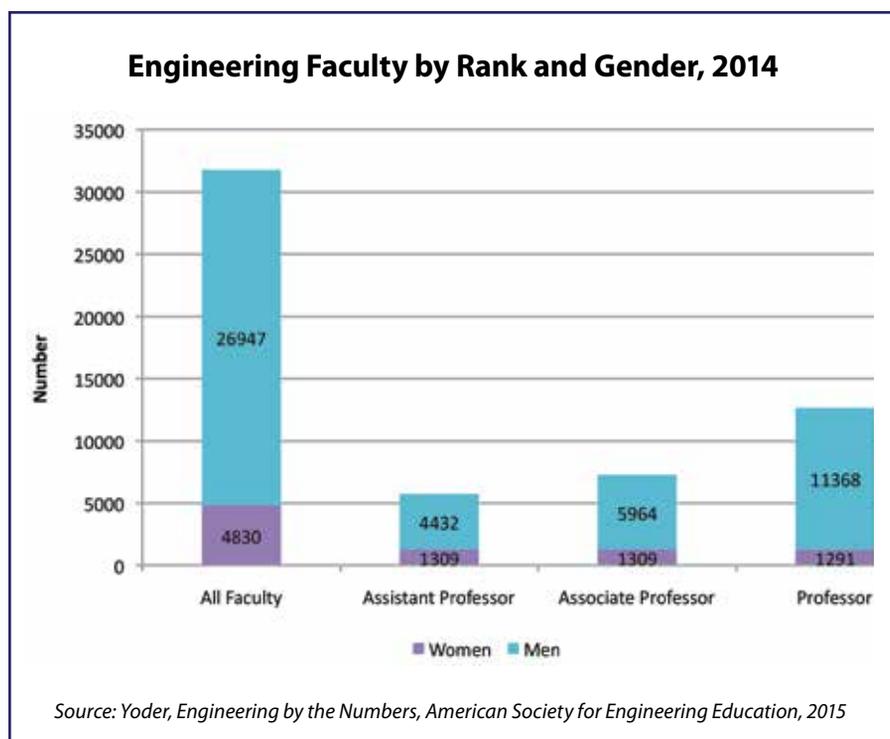
Source: Yoder, *Engineering by the Numbers*, American Society for Engineering Education, 2015

tual hiring decisions, it does point to the possibility that a more careful examination of hiring in particular fields might modify Ceci and Williams' findings.

Osei-Kofi and Torres (2015) report on an ongoing study of college admissions viewbooks and how they depict gender and race in STEM. They examined the top 10 and bottom 10 institutions listed in *U.S. News and World Report's* national universities diversity index. They found that these viewbooks tend to portray science as the domain of white male superheroes who fix problems, to position women as "brainy babes," both smart and physically attractive, who often are shown learning from a white male faculty member; and that members of racial minority groups are routinely depicted in subordinate, "sidekick," and marginal roles.

Rottmann et al. (2015) found evidence that subtle forms of bias affected engineers employed outside the university. They studied 175 engineers (26 percent of whom were women) working for two international organizations with headquarters in Canada. They found that men are considerably more likely than women to be "shoulder-tapped" by both men and women as "exemplary leaders" and that promotion on the basis of this "shoulder-tapping" is more likely to privilege men than promotion on the basis of individuals' aspirations or working preferences. The authors of the study do not claim that their study is more than a preliminary exploration of the issue (small sample size, convenience sample, only two companies, etc.), but their findings certainly point to the possibility that gender bias continues to be a factor within engineering.

Koch, Konigorski, and Sieverding (2014) found evidence that sexist behavior can affect women's behavior in job application situations. Their research on a small group (92 respondents, half of whom were female) in Germany found that female participants who encountered sexist conditions performed significantly worse on tests of mathematical ability than female participants in the control condition. The effect of sexist behavior



was not observed for tests of language ability, indicating that "stereotype threat" (women's awareness of stereotypical beliefs about their abilities) may affect women's outcomes on tests of mathematical ability, which, in turn, may have negative effects on their entry into math-intensive fields.

Whether or not one *believes* that there is gender bias in STEM also may be affected by gender. Handley et al. (2015) analyzed a sample of adults' and a second sample of professors' reactions to articles that presented evidence of the existence of bias against women in STEM. They found that, in general, men evaluated research showing gender bias less favorably than women did. This was particularly true for male faculty in STEM fields. This was *not* the result of men's judging research in general more negatively — men did not evaluate studies showing no gender bias more negatively, indicating that their evaluation of the research depended on what it actually reported. Moss-Racusin, Molenda, and Cramer (2015) also found that men were more likely to have a negative response to articles reporting on experimental evidence of science faculty members' gender biases. So, if

research continues to find evidence of bias in engineering and science, it may prove difficult to persuade men to accept those findings.

The strength and existence of gender stereotypes about women in STEM appears to be affected by the reality on the ground: Where the percentage of women in science is higher, the stereotype that science is "male" tends to be weaker. Miller, Eagly, and Linn (2015) analyzed data from a study of more than 350,000 people in 66 nations who logged onto a website that examined respondents' explicit and implicit gender stereotypes. They obtained data from UNESCO about the percentage of women among science majors and the percentage of women employed as researchers in each country and correlated this with respondents' answers to the survey about stereotypes. They found that explicit stereotypes of science as male were stronger in countries where the percentage of female science students and female researchers was lower. Implicit stereotypes were associated only with the representation of women among science students, but the researchers' conclusions still were that gender stereotypes of science were very much

affected by respondents' experience of women as scientists or science students.

Other research indicates that the effect of stereotypes is affected by one's self-concept. Smyth and Nosek (2015) analyzed data from more than 175,000 visitors to a website where one can take a variety of implicit association tests. They found that, overall, respondents tended to stereotype science as male, but noted important variations within this. Men with a strong science identity had stronger male stereotypes of science, while women with a strong science identity had weaker ones, as one might expect. They also expected implicit gender stereotypes to be stronger for disciplines where there were relatively few women, but found this not to be the case. They suggest that this may reflect the stronger effect of self-concept: The evidence that a discipline is heavily male may be outweighed by one's self-concept — e.g., a strong sense of being female combined with a strong sense of being a scientist may cancel out the evidence that a discipline such as mechanical engineering is heavily male.

It is not possible to come away from this literature with a firm sense that gender stereotypes are no longer a factor in engineering. On the other hand, it is apparent that they are in flux, and that it is certainly possible that the persistent stereotyping of gender as masculine could be weakened further. As we emphasize in the concluding section of this review, this is an issue on which there is a need for continued research.

Why doesn't engineering appeal to more women?

Another approach to explaining why engineering and some scientific disciplines continue to struggle to recruit and retain significant numbers of women focuses on whether those disciplines appeal to women. Erin Cech (2015), for example, in a study of a sample of 312 undergraduate engineering students at four diverse engineering schools in the Northeast, examined how women's self-concept affects their professional identities while they are students, and whether gender differences in the

professional identities students develop affect women's desire to stay in the field. She examined four measures of self-conception, two that are gendered (emotional, illogical) and two gender-neutral (social and generality-oriented), and how they affected four professional identity traits of problem-solving prowess, technological leadership, managerial/communication skills, and social consciousness. She found that women's self-concept did lead them to value social consciousness more, and to be less likely to value technological leadership by the time they were in the final two years of their program. Her findings indicate that students who value technological leadership and problem-solving prowess are more likely to intend on staying in engineering, and that female students' professional identity, which included a lower value on technological leadership, weakened their commitment to the field and might explain why some don't stay in engineering after graduation.

Wang, Degol, and Ye (2015) also explore how aspects of women's identity can affect their willingness to enter STEM careers. They examine the issue of math preparation, but not just through the traditional lens of women's math attainment. They note that, although there still are differences in math attainment — e.g., they found that in their sample, from the Longitudinal Study of American Youth, women still scored below men on standardized tests — girls actually get higher grades in math courses than boys. Still women are underrepresented in STEM careers. An important part of the story, they argue, is the “value” that women place on math, not their achievement level alone. Their analysis showed that women tended to value math less, and that this, in turn, was associated with lower math achievement and a lower interest in entering math careers. Thus, increasing the numbers of women in STEM requires not simply that women achieve at higher levels in math, as this is already happening, but that ways be found to increase the degree to which women regard math as a valued and meaningful activity.

Lachney and Nieuwsma (2015) note that

there has been an attempt to make engineering more appealing to girls in the K-12 educational system. However, they find a kind of “bait-and-switch” in place, as approaches in the post-secondary engineering educational system differ substantially. K-12 engineering programs increasingly emphasize engaging, open-ended, hands-on projects and involve design and creative synthesis by the student. Part of the reason for this emphasis is a desire to increase diversity and to draw students such as young women who historically have not been attracted to the field. When these students reach university, however, the authors find that they encounter a “fundamentals first” approach to learning that emphasizes rote learning of basic principles in math and science. They describe this approach as more exclusionary and suggest that students recruited to engineering by the approach taken in K-12 may be put off by the very different approach characteristic of the early portions of college-level engineering curricula.

Su and Rounds (2015) report on a meta-analysis of gender differences in interest as an explanation of the unequal distribution of women across subdisciplines in STEM fields as well as the general underrepresentation of women in STEM. Their analysis examined 52 norm samples from 33 inventories published from 1964 onward, covering more than 200,000 men and 200,000 women. They found that differences were not associated with distinctions in quantitative ability. Rather, women were found to be more interested in people-oriented than object-oriented fields, and this was central to their career choices among STEM fields.

Cheryan, Master, and Meltzoff (2015) conducted a meta-analysis of research regarding why young women and girls are less likely to pursue engineering and computer science careers than boys, even if they took advanced math classes in high school. They conclude that this is not the result of an intractable lack of interest in these fields among girls. Rather, they argue that it is the result of stereotypes about the kinds of people who enter these fields, the nature of the

2015 Outstanding Women in Engineering

American Society for Engineering Education (ASEE) Awards

Chester F. Carlson Award

Barbara A. Oakley, Ph.D., Oakland University

DuPont Minorities in Engineering Award

Helene Finger, P.E., California Polytechnic State University

Sharon Keillor Award for Women in Engineering Education

Mia K. Markey, Ph.D., The University of Texas at Austin

William Elgin Wickenden Award

Beth M. Holloway, Ph.D., Purdue University
Teri Reed, Ph.D., Texas A&M University

Women in Engineering ProActive Network (WEPAN) Awards

Founders Award

Paige Smith, Ph.D., University of Maryland

Betty Vetter Award for Research

Mary Anderson-Rowland, Ph.D., Arizona State University

Women in Engineering Initiative Award

Learning Resource Network, Boston University

Women in Engineering Program Award

Women in Science and Engineering (WISE) Program, University of Illinois, Chicago Center for Research on Women and Gender

Women in Engineering Champion Award

Tracy Drain, NASA Jet Propulsion Laboratory
Lisa Freed, iRobot

National Engineers Week Award

Introduce a Girl to Engineering Day
Argonne National Laboratory

University Change Agent Award

Shobha Bhatia, Ph.D., Syracuse University
Cristina Crespo, Ph.D., Oregon Institute of Technology

The National Academy of Engineering

New Female Members

Ewa A. Bardasz, Ph.D., ZUAL Associates Consulting
Sangeeta Bhatia, M.D., Ph.D., Massachusetts Institute of Technology, Laboratory for Multiscale Regenerative Technologies
Cheryl R. Blanchard, Ph.D., MicroCHIPS Inc.
Ingrid Daubechies, Ph.D., Duke University
Karen Klinecicz Gleason, Ph.D., Massachusetts Institute of Technology
Janet G. Hering, Ph.D., Swiss Federal Institute of Aquatic Science and Technology
Ellen J. Kullman, M.B.A., E.I. du Pont de Nemours and Co.
Radia Perlman, Ph.D., EMC Corporation
Virginia M. Rometty, IBM Corp.
Daniela Rus, Ph.D., Massachusetts Institute of Technology
Virginia C. Sulzberger, North American Electric Reliability Corp.
Lynn F. Gladden, University of Cambridge

Society of Women Engineers (SWE) Awards

Achievement Award

Naira Hovakimyan, Ph.D., University of Illinois at Urbana-Champaign

Suzanne Jenniches Upward Mobility Award

Endowed by Northrop Grumman Corporation
Barbara Brockett, Honeywell Aerospace

Work Life Integration Award

Karla Tankersley, Cornerstone Brands Inc.

Distinguished Engineering Educator

Nandika Anne D'Souza, Ph.D., P.E., University of North Texas

Advocating Women in Engineering Award

Casee Eisele, John Deere
Roberta Banaszak Gleiter, F.SWE, Global Institute for Technology & Engineering (GIFTE)
Agnes Chau Klucha, UTC Aerospace Systems
Patty Lopez, Ph.D., Intel Corp.
Lynn Tinker, Sikorsky Aircraft Corp.

Global Leadership Award

Juliette J. McCoy, Ford Motor Company
Mary D. Petryszyn, F.SWE, Northrop Grumman Aerospace Systems
Joan Tafoya, Intel Corp.

Prism Award

Rosalind Fox, John Deere
Lakecia N. Gunter, Intel Labs
Rahima K. Mohammed, Intel Corporation

Spark Award

Lisa Gable, IBM Corporation
Barbara McAllister, Intel Corporation Diversity in Technology Initiative
Jane Orsulak, Raytheon Company
Shawn Emerson Simmons, Ph.D., Exxon Mobil Corporation

Emerging Leader

Sumita Basu, Ph.D., Intel Corporation
Jennifer Braganza, Bank of America
Noramay Cadena, The Boeing Company
Jocelyne Gray, P.E., Mason County Public Utility District No. 1
Kerrie L. Greenfelder, P.E., Burns & McDonnell
Irma Khan, Caterpillar Inc.
Lori A. Masso, Raytheon Company
Katherine Medalle, Northrop Grumman Corporation
Shailla Murty, Intel Corporation
Jessica Snyder, The Dow Chemical Company

SWE Distinguished New Engineer

Michelle C. Andersen, Sikorsky Aircraft Corp.
Ester Barbuto, Booz Allen Hamilton
Dana Day, The Boeing Company
Brittney Elko, Genentech
Susie Martinez Kirkland, General Atomics Aeronautical Systems Inc.
Kalyani Mallela, Philips Healthcare
Rachel Diane Morford, The Aerospace Corporation
Shelley Stracener, Heads Up Technologies Inc.
Victoria Borchers Tinsley, Total Petrochemicals and Refining USA, Inc.
Kate Van Dellen, Consultant

Fellow Grade

Margo Bubb, Caterpillar Inc.
Stacey DelVecchio, Caterpillar Inc.
Lynda Grindstaff, Intel Corporation
Sandra L. Pettit, Ph.D., P.E., Georgia Institute of Technology
Beth Snyder, The Boeing Company

Outstanding Faculty Advisor

Marca Lam, Ph.D., Rochester Institute of Technology

Outstanding SWE Counselor

Charlene Willenbring, UTC Aerospace Systems;
SWE Counselor to University of Minnesota

Outstanding Collegiate Member

Emily Deas, The University of Texas at Austin
Katharine Brumbaugh Gamble, Ph.D., The University of Texas at Austin
Carina Hahn, The University of Utah
Melissa Lindsey, The Ohio State University
Leah Meeks, Utah State University
Sangeetha Mylvaganam, The University of Texas at Austin
Leabeth Peterson, Humboldt State University
Abigail M. Spohn, University of Dayton
Brooke Sroczynski, University of Dayton
Dhanalakshmi Thiyagarajan, University of Pittsburgh

The Anita Borg Institute for Women and Technology Awards

Technical Leadership ABIE Award

Lydia E. Kavrakli, Ph.D., Rice University

Social Impact ABIE Award

Daniela Rajjman, Google
Michal Segalov, Google

Denice Denton Emerging Leader ABIE Award

Lydia Tapia, Ph.D., The University of New Mexico

A. Richard Newton Educator ABIE Award

Joanne Cohoon, Ph.D., University of Virginia

Change Agent ABIE Awards

María Celeste Medina, Ada IT
Mai Abualkas Temraz, Gaza Sky Geeks

National Society of Black Engineers (NSBE) Awards

Lifetime Achievement in Academia Award

Helen Howell, American National University

Pre-College Initiative Director of the Year

Kamili Jackson, Ph.D., Future Innovative Rising Engineers NSBE Jr. Chapter

Pre-College Initiative Student of the Year (Female)

Eryn Williams, San Antonio City Wide NSBE Jr. Chapter

Outstanding Woman in Technology

Sherette Constant, Morgan Stanley Wealth Management

Society of Hispanic Professional Engineers (SHPE) Awards

Community Service

Marjorie Blanco, The Boeing Company

Diversity Award

Raquel Romano, Ph.D., Google

Hispanic in Technology, Government

Margarita Varela-Rosa, Department of the Navy

Junipero Serra Award

Naomi Hernandez, Booz Allen Hamilton

Manager of the Year

Nestor Alexis Bautista Alvarez, Ford Motor Company

SHPE Star of Today Award

Lauren Hamburg, Newport News Shipbuilding

Young Investigator Award

Lydia M. Contreras, Ph.D., The University of Texas at Austin

work involved, and the values of these fields. They find that these fields are stereotyped, whether accurately or not, as involving social isolation, a focus on machinery, and inborn brilliance, resulting in women's reporting less interest in them. These stereotypes serve as gatekeepers, encouraging girls to self-select out — but they also can be changed, if the representation of the work itself and the people who perform it is broadened.

Recruiting and retaining women in engineering

One traditional focus of research on women in engineering and STEM disciplines has been the “leaky pipeline,” i.e., the idea that, whether or not women are being attracted to these disciplines, a major problem is that many of them don't persist. Over the past several years, questions have been raised about this metaphor, and this year was no exception to that trend. Miller and Wai (2015), for example, used data from two sources — the National Survey of College Graduates and Survey of Doctorate Recipients — to examine whether there is a leak in the pipeline leading from undergraduate to graduate degrees in STEM disciplines. Their conclusion is that, while in the '70s and '80s, women were less likely to persist from the B.S. to the Ph.D. in STEM, gender differences had closed by the 1990s. Their optimism is muted, however, by their observation that women's share of undergraduate STEM degrees has stabilized, and even declined in recent years, so women's share of doctoral degrees, assuming stable persistence rates, will not continue to grow. Miller and Wai's data cover STEM as a whole, not only engineering. Since we saw that women's share of undergraduate *engineering* degrees has continued to grow, albeit slowly, it is possible that one can be more optimistic about the situation in engineering. On the other hand, Miller and Wai's caution about the prospects for more female doctoral degrees in STEM is consistent with ASEE's projection that women's share of engineering Ph.D.s is unlikely to grow in the near future.

Kamphorst et al. (2015) report on

research conducted in the Netherlands, in which they administered online questionnaires to more than 1,000 first-year engineering students at five universities of applied sciences during the 2008-09 academic year in an effort to explain why women outperform men in Dutch engineering programs and why they are more likely to persist beyond the first year. They found that developing strong relationships with faculty was predictive of persistence for women, as was being involved in independent learning. Somewhat surprisingly, they found that involvement in active learning actually had a negative effect on women's retention. Kamphorst et al. speculate that this may reflect the larger working groups typical of university in which women, as a minority, may feel uncomfortable; it may also reflect faculty conservatism and a tendency to overorganize, which tends to demotivate women, who are independent learners. Perhaps most interestingly, Kamphorst et al. found that women were more likely to decide to persist in engineering *before* they became academically integrated, a finding that confirmed earlier research indicating that women made a firmer decision to stay in engineering before they entered their undergraduate programs. Men, in contrast, seemed to be more likely to decide whether or not to persist during their first year, and only after they developed a feeling of integration into their programs did they actually decide to persist.

It is obviously necessary to exercise caution in comparing studies focused on different countries. Nevertheless, it is worth noting the very different implications of these studies regarding efforts to increase the recruitment and retention of women in engineering. Kamphorst et al. suggest that women make up their minds to stay in engineering almost before they start their programs, although at least certain experiences in their first year still matter. If they are correct, then efforts to recruit more female engineers should focus on what happens to girls in the high school years and before, a conclusion consistent with the view that the small numbers of female

engineering students reflect the fact that women choose not to enter engineering programs in the first place.

Miller and Wai, however, push back against this argument, pointing to evidence that retention has been improved with a resulting increase in women's share of doctoral degrees in STEM. They also point to evidence that significant numbers of STEM degree holders, *particularly* among women, did not intend to earn STEM degrees when asked about their plans in the 12th grade. If correct, this would suggest a need to focus on what happens to women in post-secondary education, since there may be significant movement both in and out of STEM fields at this stage.

The contrast between Kamphorst et al.'s and Miller and Wai's arguments is but one example of the frustrations involved in reviewing the literature on women in engineering and STEM. Both studies seem well-researched, are based on large samples, and cite previous research, but neither is very successful in resolving the disagreement that separates their contrasting conclusions. Instead, each adds another study to the existing body of literature supporting their perspective. Examples such as this indicate the need for a type of meta-analysis, or a study specifically designed to test the competing arguments, which would be a significant contribution to this discussion.

While Miller and Wai find that the “leak” in the pipeline from bachelor's to doctoral degrees may have been repaired, Thomas, Poole, and Herbers (2015) conducted research that points to the existence of a different leak — one that occurs *after* women who earn Ph.D.s enter academic work. They examined rosters of tenured and tenure-track engineering and science faculty at a large research university in the U.S. between 1998 and 2012, finding that while women were being recruited at rates exceeding their current representation in these departments, women faculty, both pre- and post-tenure, were more likely to resign voluntarily than men, resulting in a gender retention gap. Although women's share of full professorships

Women Engineering Deans

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Sharon L. Wood, Ph.D., P.E.	The University of Texas at Austin
Judy Wornat, Sc.D.	Louisiana State University

Information provided by the American Society for Engineering Education. Note that smaller engineering programs may have a chair or director rather than a dean.

had grown significantly, the authors of this study argue that the retention gap is large enough that it will continue to negate the effects of increased female recruitment to these departments.

Yet another kind of “leak” is revealed by Ellis, Fosdick, and Rasmussen’s (2015) study of students’ decisions to leave the STEM pipeline after completing calculus I. Using survey data collected in fall 2010 by the Mathematical Associations of America (sample size = 2,266 college and university students), they found that women were significantly more likely than men to say they did not intend to continue on to calculus II after completing calculus I. Women who did not intend to persist to calculus II were more likely than male nonpersisters to cite lack of understanding of the material as a reason for doing so, despite no difference in ability. In addition, women began calculus I with lower confidence than men and finished it with lower confidence as well. Other factors were also associated with a failure to persist to calculus II (e.g., intention to pursue a medical field). Nevertheless, this study indicates that increasing women’s math attainment at the high school and early-college level does not equate to an increase in women pursuing STEM majors such as engineering later in their university careers.

The dynamics of teams

One of the trends we observed at the American Society for Engineering Education (ASEE) Annual Conference this year was a growing interest in exploring the gendered dimensions of teamwork. These papers highlight important, but underexplored, facets of engineering education that affect women’s participation in engineering. They are timely, given recent research receiving attention in *The New York Times* showing disadvantages for women economists who conduct research in teams with men (Wolfers, 2016).

One set of three related papers from a group of researchers at The University of Oklahoma examined Student, Experiential Learning, Engineering Competition Teams (SELECT), such as Formula

SAE® and the Human Powered Vehicle Challenge. Participation in these and similar teams is important both for skill development and career connections leading to job offers. One paper, based on a survey of 30 student participants from around the country found that SELECT are typically characterized by low participation from female and other minority groups, recruitment through friends already on the team, and minimal engagement or guidance from faculty advisors (Pan, Shehab, Foor, Trytten, and Walden, 2015). These characteristics do not support recruitment or retention of more diverse SELECT participants, and the researchers recommend that partnering with industry advisors and adopting best practices from industry could improve opportunities for diversifying SELECT.

Similarly, a second paper compared two teams that were representative of other SELECT and found that while the teams differed in some regards, they both lacked opportunities for students to develop leadership and management skills, especially as they pertain to leading diverse teams, and that to succeed on the teams women had to prove they had advanced technical skills or have a male ally on the team, and even that was not always sufficient (Walden, Foor, Pan,

Shehab, and Trytten, 2015). In order to increase diversity in SELECT, they recommend recruiting from different disciplines, making project topics more inclusive, not letting students self-select their teams, and teaching leadership and management skills for diversity.

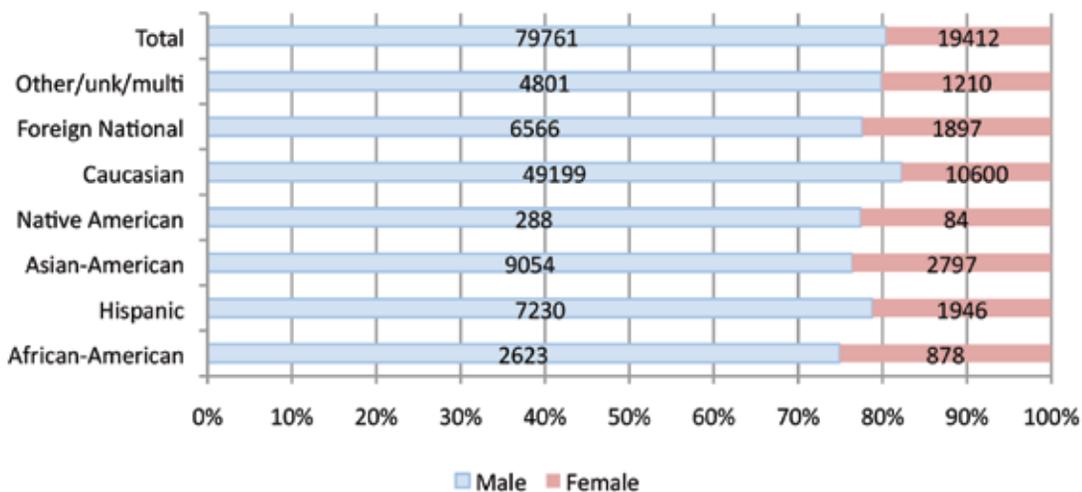
The third paper compared the experiences of two women on the same team to demonstrate that race/ethnicity, gender, socioeconomic status, and team culture intersect to affect women’s experiences and outcomes in SELECT (Trytten, Pan, Foor, Shehab, and Walden, 2015). This intersectional analysis, based on interviews, questionnaires, ethnographic observations, and documents, revealed that there are invisible barriers to SELECT participation, that we cannot automatically assume women have increased awareness about diversity or discrimination, and that the size and complexity of the project, size of the team, cost, team composition, timeline, and rules of competition affect who can successfully participate.

In addition to the set of papers about SELECT, there were several papers that explored other aspects of teamwork, including challenges of and best practices for minimizing gender biases in teamwork settings at the undergraduate and K-12 levels. One was a companion

paper to an interactive panel held at the conference in which the authors identify examples of how teamwork can further marginalize some students and presents strategies to minimize marginalization (Meadows et al., 2015). Likewise, although conducted in a high school setting, another relevant study provides evidence that parts of students’ identities (such as gender) and their relationships with team members affect their experiences and the extent to which they feel able to participate in a discipline (Quan, Gupta, and Elby, 2015). Another paper took up the issue of biases in peer evaluations and found that across multiple years in one course at the University of British Columbia, gender, in combination with Myers-Briggs Type Indicator® personality traits, affected peer evaluations (Ostafichuk, Sibley, Germaine d’Entremont, and Shirzad, 2015). For example, Female-Introversion received higher scores than Male-Introversion and Male-Extraversion; Female-Sensing received higher scores than Male-Sensing and Male-iNtuition; and Male-Judging received higher scores than Male-Perceiving.

In addition, there were some preliminary findings from an ongoing study of how project tasks in design course teamwork relate to self-efficacy

Engineering Bachelor’s Degrees by Gender within Race/Ethnicity, 2014



Source: Yoder, *Engineering by the Numbers*, American Society for Engineering Education, 2015

(Hirshfield, Chachra, Finelli, and Goodman, 2015). The authors emphasize that despite the quantitative findings showing no correlation between tasks completed and gender, it is important to look at qualitative data on students' *perceptions* of their activities because that data revealed women were not satisfied with the amount of time they spent on "nontechnical" tasks, such as shopping and "arts and crafts." Additionally, they caution that:

"Although it is encouraging to see that female students may be becoming as or more confident than their male counterparts (in contrast with previous studies that suggest that female students do not benefit as strongly from project work), this may simply mean that engineering programs are selecting strongly for high-performing women with high self-confidence, rather than women who are more comparable to their male counterparts, which is itself an indication that students expect to have strongly gendered experiences in engineering programs."

Dasgupta, Scircle, and Hunsinger (2015) also describe research on teams in a paper published in the *Proceedings of the National Academy of Sciences*. They report on an experimental study of 122 female engineering undergraduate students at a large public university in which female participants were randomly assigned to groups of varying sex composition (female minority, female majority, or sex parity groups). They found that the gender composition of the group had significant effects, particularly for first-year students: First-year female students felt less anxious in female-majority and sex-parity groups (more advanced students did not); women participated more in female-majority groups whether or not they were in their first year; women, particularly first-year students, felt less threatened and more challenged in female-majority groups. In sum, the results of this study indicate that the presence of other women can have a significant, positive effect on women's experience in the engineering workplace.

Intersectionality

As in previous years, the literature on women in engineering intersects with the literature on the underrepresentation of minorities, particularly African-Americans and Latina/Latinos, in the field. In addition to noting the parallels between the forces shaping the underrepresentation of women and of minority groups, the literature emphasizes the importance of paying attention to "intersectionality," i.e., the idea that forms of disadvantage, such as being female, being African-American, are not simply additive but interact in complex ways. As Armstrong and Jovanovic (2015) emphasize in their theoretical reflection on these issues, it is important not to treat all women as the same, as African-American women may experience gender in different ways than do women in other groups, for example.

At the same time, however, there is a danger in not recognizing the links and parallels among various forms of disadvantage if one is to avoid what they term the "Oppression Olympics," in which different disadvantaged groups compete with one another for scarce resources and a place at the table. Ross et al. (2015), in their review of the literature on African-American women engineering faculty, note that such women often have difficulty distinguishing the effects of racism and sexism, so, the parallels between various forms of minority status are apparent in people's lived experiences.

Ross et al. (2015) note that there is a relatively small amount of research on African-American female engineers. However, a major contribution to the literature on African-American engineers was made this year with the publication of *Changing the Face of Engineering: The African American Experience* (Slaughter, Tao, and Pearson Jr., 2015). The essays collected in this volume document the continued underrepresentation of African-Americans in engineering — for example, the percentage of engineering degrees awarded to African-Americans peaked in 2004 at 5.4 percent and had declined to 3.8 percent by 2014. The editors lament the lack

of progress and stress that the ability of the United States to remain competitive in technical fields is being jeopardized by its continued inability to tap into the pool of African-American students, a point that has frequently also been made about the continued small numbers of women recruited to engineering careers.

Although the volume brings together essays on the African-American experience in engineering generally by documenting examples of successful African-American engineers, discussing obstacles to increasing the numbers of African-Americans in engineering, describing programs that have been or could become effective in increasing their numbers, two essays touch on questions concerning the situation of African-American *women* in engineering.

The first, "African-American Women and Men into Engineering: Are Some Pathways Smoother than Others?" (Malcom-Piqueux and Malcom, 2015), is devoted to explaining the decline in the percentage of engineering degrees going to African-Americans. The authors point to four factors:

- An unusually high percentage of African-Americans attend community colleges or for-profit schools. The latter lack engineering programs, while transfer rates from two-year to four-year schools remain discouragingly low.
- There has been a sharp decline in the percentage of African-American students attending historically black colleges and universities, which have traditionally been the most successful in retaining and graduating African-American students in STEM disciplines.
- It continues to be the case that fewer than half of the African-American students who express an interest in engineering actually enroll in an engineering program.
- Significantly more African-American *women* than men attend college (and the gap is growing). Malcom-Piqueux and Malcom underline this last fact, arguing that any effort to grow African-American enrollment in engineering *must* simultaneously

focus on increasing the numbers of women pursuing engineering degrees.

A second article in the collection (Legon and Barabino, 2015) points to the conclusion that increasing the numbers of African-American women pursuing engineering degrees is not simply a matter of appealing to women in general. Efforts to improve the situation for African-American women in engineering must address the fact that they are African-American, as well as women. They describe a program aimed at supporting African-American women in tenure-track positions on engineering faculties. The program provided participants with opportunities to strengthen their professional skills, including laboratory and grant management, and provided help with professional socialization such as career planning, developing a research agenda, and networking. Importantly, the authors stress that one of the key lessons of the program was the value of

community. They attribute some of its success to the formation of a community among the participants, which helped to overcome the isolation many felt in departments where they were the only woman of color.

Another study emphasizing the importance of being mindful of the ways in which gender and race/ethnicity interact is Ro and Loya's (2015) study of learning outcomes among engineering students. The research is part of a larger study called "Prototype to Production." Using data on a sample of 5,249 students (sophomore, junior, and senior students in engineering) at 32 four-year colleges that offer at least two engineering disciplines, they examine whether gender and race/ethnicity affect students' self-assessment on two sets of learning outcomes:

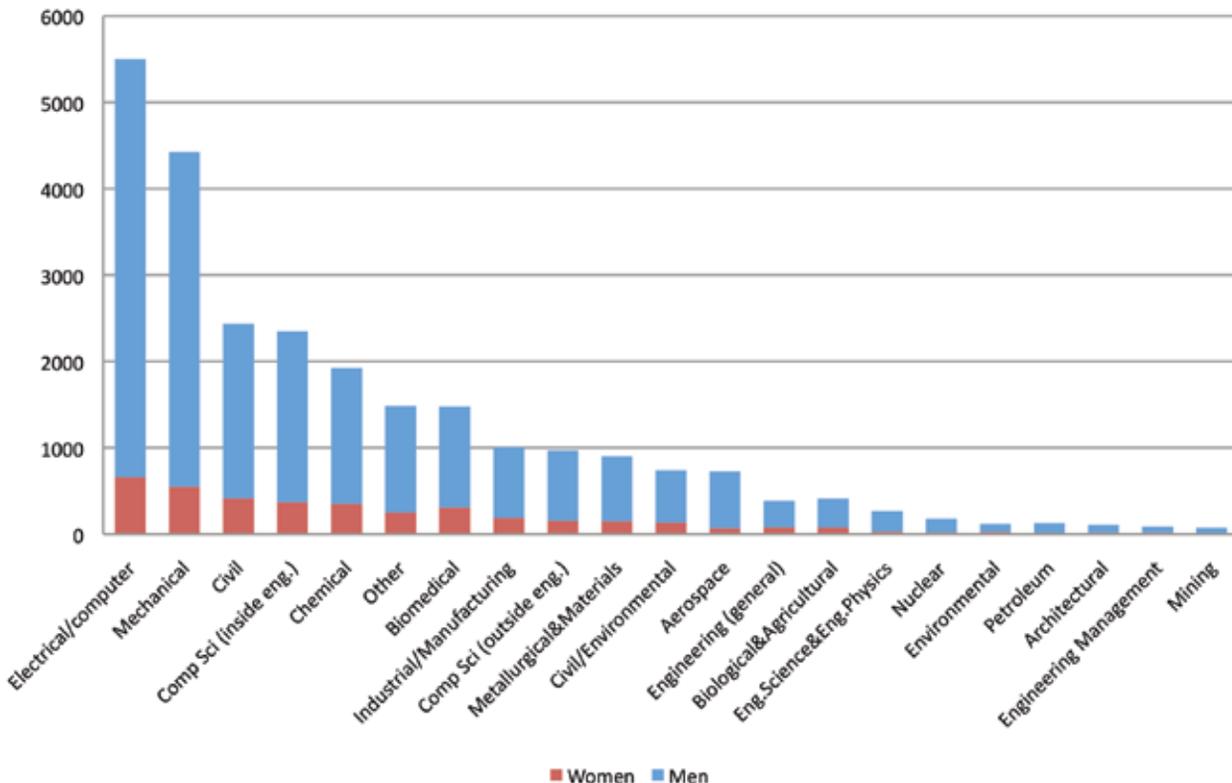
- engineering-focused skills: fundamental skills (basic math and science skills, design skills, and contextual competence [the ability

to see engineering issues in a larger social context])

- professional skills: leadership, teamwork, and communication skills

Importantly, Ro and Loya attempt to go beyond previous studies of these issues, arguing that they grouped all "nonwhites" together, missing the specificity of different racial and ethnic minorities in the process. Like previous studies, they found that, on the whole, men tended to rate themselves higher on engineering-focused skills, while women scored higher on self-assessments of professional skills. However, there were significant differences by race/ethnicity. For example, while blacks generally rated their design skills lower than did whites, the effect was statistically significant only for women. Similarly, the negative effect of race/ethnicity on self-assessment of leadership skills was stronger for Asian men than for Asian women. Ro and Loya conclude

Engineering Faculty by Discipline and Gender, 2014



Source: Yoder, *Engineering by the Numbers*, American Society for Engineering Education, 2015

that efforts to increase the numbers of women, and the number of people from underrepresented minority groups in engineering, should not simply target “women” or “minorities”; rather, efforts directed at the characteristics and needs of women of each underrepresented minority group are what is needed.

Many of the other articles and papers we reviewed this year that touched on the intersection of race, ethnicity, and gender drew on small samples, not necessarily a problem for qualitative research, and confirmed familiar ideas from the rather limited literature that already exists on the subject. This is perhaps understandable given that most were ASEE conference papers not yet ready for publication in journals and may represent the beginning of further analyses. Findings included that the situation of African-American men is different (and perhaps better) from that of African-American women (McGee et al., 2015); that developing a community that unites those with similar minority statuses can provide a buffer against the effects of a “chilly climate” (Alonso, 2015); that strong family support can

help, especially in cultures in which family is central to ethnic identity (Talley and Martinez Ortiz, 2015); that minority women experience cumulative disadvantage because they deviate in multiple ways from the norm expected of STEM professionals (Kachchaf et al., 2015); and that good, well-designed mentoring can help (Smith and Paretti, 2015). Given the very small numbers of African-American and Latina women in engineering, there is clearly a need for more thoroughgoing, rigorous research if we are to understand why those numbers remain as they are.

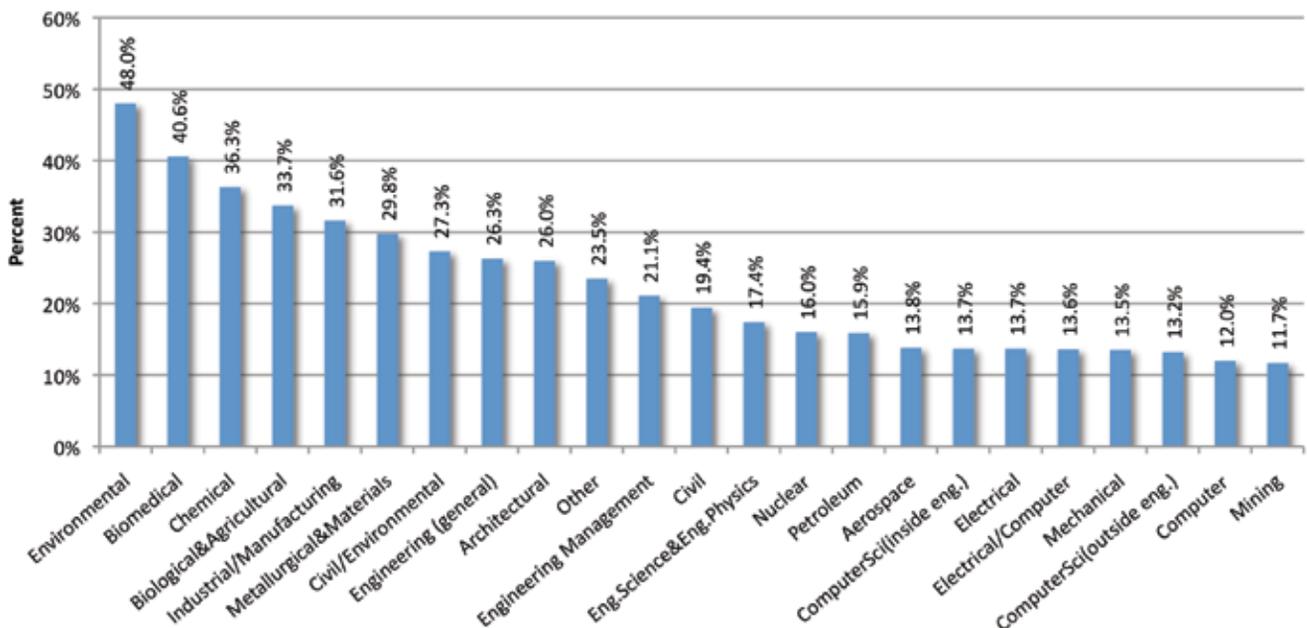
Making interventions effective

It is one matter to point out that there is a problem and to understand its causes. It is quite another to develop effective techniques for addressing the problem and its causes, and for assessing the effectiveness of the interventions attempted. Fortunately, this year’s literature, as in the past, contained descriptions and assessments of several interventions that indicate change is actually possible. In addition, several contributions to this year’s literature outlined some of the general conditions

that determine whether interventions are likely to work.

Walton et al. (2015) report on two interventions designed to counter the effects of the “chilly climate” women may encounter in engineering programs. They conducted an experiment involving 228 first-year engineering students at the University of Waterloo, Canada, 92 of whom were women, and all of whom participated in two interventions. The first was designed to foster a sense that one belongs in engineering by conveying the idea that encountering adversities and being worried were typical and dissipate over time; the second was designed to help students cope with stress and “stereotype threat” (the idea that one could not do the work because of one’s gender) by incorporating values and aspects of identity important to women into stress-management strategies. Both interventions had positive effects on women’s GPAs and improved women’s confidence for succeeding in engineering. There were, however, differences in how the interventions affected female participants. The first intervention helped women feel more valued in engineering

Percent of Bachelor’s Degrees Awarded to Women by Discipline, 2014



Source: Yoder, *Engineering by the Numbers*, American Society for Engineering Education, 2015

and facilitated friendships with male engineers. The second did not promote similar social integration; instead, it helped women by encouraging them to place greater value on their gender identity, which they might otherwise have suppressed, and to strengthen their ties to women *outside* engineering.

Another example of successful intervention is described in Carnes et al.'s (2015) report on a gender-bias-habit-changing intervention at a large public university between 2010 and 2012. The intervention involved 92 departments (46 of which were control departments) and 2,290 faculty members. Experimental departments were offered a gender-bias-habit-changing intervention as a 2.5-hour workshop. Pre- and post-intervention surveys allowed the researchers to examine whether the intervention had any effect on participants. They found that members of departments that participated in the workshop were significantly more likely to report increased feelings of self-efficacy to engage in gender-equity promoting behaviors; in cases where more than 25 percent of the faculty participated in the intervention, there were significant increases in self-reported action to promote gender equity three months after the workshop. While this is a study of a single university, and while the long-term effects of the intervention are not yet apparent, it is encouraging to learn that a relatively short-term intervention can have a significant effect on habitual gender bias.

Huziak-Clark et al. (2015) describe an effective Ohio program designed to enhance students' confidence and retention in STEM majors. They studied 240 high school and community college students (115 of whom were female) selected through competitive application to a summer program between 2009 and 2013. High school students participated in a four-week summer bridge program, while community college students participated in an intensive 10-week summer research program. Both programs were intended to strengthen participants' STEM knowledge, to provide mentoring, and to create sup-

port networks that would carry over into the academic year. Results included a significant increase in students' STEM confidence and attitudes. While this is not a program aimed specifically at women, the fact that there were no gender differences in outcomes in this study indicate that interventions such as this can be effective in improving the chances of retaining female students in fields such as engineering.

McClelland and Holland (2015) make the important point that the prospects for changing the gender dynamics in STEM departments depend significantly on leaders' perceptions of who is responsible. They studied interview data gathered in 2004 from 26 STEM department chairs and five deans involved in NSF ADVANCE programs. They found that some of the leaders had "high" personal responsibility, meaning they saw it as *their* responsibility to effect change and were more likely to see their male colleagues as having concurrent responsibility for doing so. Others displayed "low" responsibility, resulting in their describing women as the ones who needed to change. It is fairly obvious that the latter group would be much more likely to emphasize strategies that involve "changing the women," while the former opens up the possibility of asking men to change. But, McClelland and Holland also found that both groups tended to expect men to make changes that were largely attitudinal ("be more sensitive"), while women were expected to change more fundamentally (be more aggressive, make different choices about family). Both groups also tended to have relatively low expectations about how much men needed to change, and to view male changes as voluntary. Research such as this points to the importance of targeting the attitudes of leaders, or the burden of improving the situation of women in engineering and other STEM fields is likely to fall primarily on women themselves.

Beddoes, Schimpf, and Pawley's (2015) review of the literature on department heads finds that it, too, has a limited view of the role of the department head's responsibilities and often fails to chal-

lenge the gendered assumptions that organize life in departments. While this literature underlines the need for department heads to take an active role in promoting gender equity, the emphasis tends to be on training, not on changing the gendered social arrangements and expectations that disadvantage women. Moreover, the focus tends to be on limited problems such as sexual harassment, and the literature often subtly portrays female faculty as problems, again placing a significant portion of the burden for effecting change on women themselves, while simultaneously limiting department heads' responsibility.

Camargo, Wood, and Layne's (2015) study of the impact of work/life balance policies on female engineering faculty also emphasizes the importance of leadership responsibility. They surveyed 64 faculty members who had used such policies in place at a research university in the southeastern United States. Their respondents reported that organizational commitment, as expressed in policy changes, had had a significant effect on the work culture. For example, making the extension of the tenure clock automatic — rather than a department head's decision — for those who could benefit from the work/life balance policy encouraged more people to use it, and had removed some of the stigma. Still, respondents called for more training for department heads, who need to be better informed about the existence of the policy and its use. Respondents also complained more broadly that the policy is seen as primarily for women, as something that men do not need and/or are not responsible for.

Tartari and Salter (2015) also point to the importance of organizational commitment in overcoming gender differences. They examined gender differences in university-industry collaboration activities. Such collaboration is of growing importance to careers in academic science (*viz.* the growth of contract research, university emphasis on patents, etc.), so if women engage in it less than their male colleagues, gender disadvantages in STEM are likely to persist or even grow. Tartari and Salter

Solving the Equation Report Focuses on Engineering and Computer Science

In March 2015, the American Association of University Women published a 160-page report, *Solving the Equation* (<http://www.aauw.org/research/solving-the-equation/>). The report is, in effect, a follow-up to AAUW's 2010 report, *Why So Few: Women in Science, Technology, Engineering, and Mathematics*, focusing this time on the fields of engineering and computer science.

The report focuses on these fields because they are so large (the report estimates they represent as much as 80 percent of STEM employment) and offer the greatest opportunity for future employment in STEM. It argues that the continued underrepresentation of women in these fields, despite girls' increased achievement in math and science, both deprives women of important employment opportunities and impoverishes these fields, which would benefit from the diversity increased numbers of women would bring.

Solving the Equation brings together a series of research findings that shed light on why there continue to be relatively few women in engineering and computer science. Contributors highlight the continued existence of stereotypes that disadvantage women in these fields and can lead to implicit and/or explicit bias against them. Related to this is the reality of stereotype threat, i.e., the self-fulfilling prophecy that develops when women are aware of the stereotype that they are not as well-prepared or naturally predisposed for fields such as engineering or computer science.

The report goes beyond familiar analyses of stereotypes and the sometimes chilly climate for women in engineering and computer science by pointing to the need for these fields to do more to appeal to young women. For example, it features research by Amanda Diekman and her collaborators, who show that women tend to assign greater importance than men to "communal" goals, and somewhat less importance to "agentic" goals focused on self-advancement. The implication is that engineering might more effectively attract young women by featuring its communal aspects.

In support of this approach, *Solving the Equation* features a positive report on Harvey Mudd College's successful effort to increase the percentage of its female computer science graduates. The school's success is attributed to its efforts to emphasize real-world applications and social relevance in its first-year courses, to provide women with research experiences early on in their academic careers, and their decision to involve female students in a conference on women in computing, the Grace Hopper Celebration of Women in Computing.

Solving the Equation does not neglect traditional problems such as bias and the need for more role models and networking opportunities for female students and professionals in engineering and computer science. By pointing to the potential value of emphasizing their "communal" aspects, however, the report moves beyond what was called for in the earlier report, *Why So Few*. In an interview with *The New Yorker* (Vara, 2015), some of the contributors expressed a concern that this might lead people to think that bias and sexism were no longer important or that they might unintentionally reinforce stereotypical notions about the differences between women and men. The editors felt, however, that it was important to acknowledge research that showed positive efforts to attract women to engineering and computer science, while at the same time take steps to eliminate barriers. It will be interesting to see whether *Solving the Equation* will have as much impact as its predecessor did.

surveyed a wide range of collaborative activities from less-common ones such as licensing agreements to more common ones such as consulting and confirmed other research showing that women engage in such collaborations less than their male counterparts, even when one controls for professional and institutional status. This was particularly true for women in fields

where women are scarce. Importantly, however, they also found that an organizational commitment to women's scientific and engineering careers could mitigate these gender differences in collaboration and increase the likelihood that women would engage in partnership with industry. Hence, encouraging employers (both universities and companies with whom they might collaborate)

to take positive steps to encourage women can help to foster behaviors that will help women be more successful.

Suggestions for future research

Regular readers of this literature review are aware that a great deal of research on women in engineering has been conducted over the past decade, and this has resulted in many insights into the reasons for women's underrepresentation in the profession as well as changes to the recommended solutions advocated by parties interested in promoting gender equity (see sidebar on AAUW's report *Solving the Equation* for an example). Readers will also be aware of the ongoing lack of consensus in the literature (e.g., the ongoing debate about hiring bias) and that there are persistent gaps in the research thus far. While increasing the quantity of research and targeting unanswered questions will not, by themselves, bring about gender equity in engineering, filling in the research gaps and resolving ongoing debates will certainly help to create the knowledge base on which effective policies can be built. Our review of the literature over the past five years suggests that further areas of study include:

- Is it possible to resolve the conflicting findings in the research literature on hiring bias?
- Continued research on stereotypes: Where have they changed and where do they still have effects?
- Do more women than men leave engineering? Why and at what points?
- More studies of the workplace experiences of engineers outside the academy: Where do engineering graduates work? How do men and women engineers progress through their careers? How do male and female engineers in different career paths balance work and family demands?
- What can be done to make engineering more appealing to women?
- What are the gendered structures of engineering education and workplaces that impede change?
- More rigorous studies addressing the intersections of race, ethnicity,

gender, and sexuality

- Meta-analyses that look across disciplines to make sense of conflicting findings and provide grounds for moving forward to advance research
- More studies of teamwork that explore the dynamics of under-representation (given that all except one of the papers reviewed this year were conference papers)

We hope that this review will make a small contribution to encouraging researchers to pursue these and other important areas of inquiry regarding the status of women in engineering. ■

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Note: The following list of references comprises all of the noteworthy articles and conference papers found in our search of the 2014 literature on women in engineering. We selected for discussion in our review the literature that seemed to be based on the most substantial research and/or that offered interesting, fresh insights into the situation of women in engineering. For the convenience of interested readers, we have included the complete list of materials we consulted.

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Data Sources

Where can you find statistics and other information about the current status of women in science and engineering?

Two federal agencies collect and report information about science and engineering education and employment in the United States. The American Society for Engineering Education's (ASEE) website contains the most up-to-date information on engineering enrollments and degrees available.

The National Science Foundation's (NSF) National Center for Science and Engineering Statistics (NCSES) is the go-to place for information about research and development; the science and engineering workforce; STEM education; and U.S. competitiveness in science, engineering, and technology (www.nsf.gov/statistics). NSF publishes two major reports in alternate years: *Science and Engineering Indicators* and *Women, Minorities, and Persons with Disabilities in Science and Engineering*. Both reports are available for download in their entirety and by chapter, and highlights, including data tables and figures, are also available on the NSF website. The *Indicators* report includes sections on research and development investment and public understanding and attitudes toward science and engineering, as well as data on STEM education and workforce issues. The *Women, Minorities, and Persons with Disabilities* report breaks out information on education and employment by gender, ethnicity, and disability.

The Department of Education's National Center for Education Statistics (NCES) collects education data at all levels, including early childhood, elementary and secondary, postsecondary, and adult learning. The center's website (<http://nces.ed.gov/>) contains reports and access to online databases and search tools. A recent data brief (Cunningham et al.) explores gender differences in high school course taking, test scores, and interest in science and math.

ASEE surveys member institutions each year and compiles the data into a variety of publications and online resources, some of which are available only to members. A summary of enrollment and degree statistics is publicly available at <https://www.asee.org/papers-and-publications/publications/college-profiles>. These data are the most current available, and the summaries presented here are from that source.

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Women in Engineering: A Review of the 2016 Literature

SWE's assessment of the most significant research found in the past year's social science literature on women engineers and women in STEM disciplines, plus recommendations for future analysis and study.

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The amount of public attention devoted in 2016 to the role of women in engineering and science can only be called striking. Several “popular” historical books (see sidebar) drew attention to the important contributions women made to scientific and engineering achievements, particularly in their role as “computers” in an era before complex, precise calculation became something done largely by computers designed and programmed almost entirely by men. One of these books, *Hidden Figures* (Shetterly, 2016), was made into a successful Hollywood film that made large audiences aware of the previously little-known story of the centrality of African-American women to the space program at NASA.

By drawing attention to these hidden stories of female achievement in science and engineering, these books (and film) make contemporary audiences aware both of the often unacknowledged contributions women have already made in these fields and of the potential for them to contribute far more. At the same time, they create a sense that there has been real progress — the overtly sexist and racist practices described in *Hidden Figures*, for example, come from another era, making it hard not to think that “we’ve come a long way” since scientific and engineering institutions were shaped by deliberate racial segregation and policies that treated women as second-class members.

The sense that women have made significant progress in gaining equal status within engineering and science was strengthened by the fact that

2016 also saw the nomination for the National Book Critics Circle Award of a memoir by a successful female scientist (see sidebar on *Lab Girl*) describing her journey to scientific prominence at a relatively young age. Journalistic accounts aimed at broad audiences painted a more complex picture, however, drawing attention both to the progress women have made in engineering and scientific fields and to the obstacles they continue to face. *Inside Higher Ed* published an extended review (2016) of *Failing Families, Failing Science*, a scholarly book arguing that American academic science is jeopardized by its continued failure to address work/family balance (see sidebar). There was continued coverage of the problem of sexual harassment in STEM, a subject that had received much attention from news outlets in 2015 because of a series of major incidents (Ganim, 2016).

Scientific American published a brief essay by Hannah A. Valantine, the first chief officer for scientific workforce diversity at the National Institutes of Health, arguing that women continue to face discrimination in science despite real progress and recommending that immediate action be taken to address work/family conflict and to hold academic administrators responsible for creating pay equity in academic science (Valantine, 2016). In the United Kingdom, the BBC issued a report on “The Engineering Gap,” documenting the reality that women represent an unusually small percentage of the engineering workforce in that country

and that recruiting girls to university engineering programs continues to be difficult (Goodrich, 2016). The report also describes successful initial efforts to improve the situation, such as universities' experimenting with dropping math and physics standardized tests as prerequisites and offering courses on "humanitarian engineering" designed to be attractive to a more diverse student body.

Of course, not all of the popular media attention was entirely sympathetic to women's involvement in science. Facebook accounts continued to "share" an article published in 2015 in *Breitbart* by Milo Yiannopoulos, the controversial conservative speaker who has received much attention during 2016 and early 2017 (Yiannopoulos, 2015). The article, making rather loose use of research done at Cornell University by Ceci and Williams (discussed in this literature review in previous years), proposes that there should be limits on the numbers of women allowed to enter STEM fields since the research "shows" that they either can't compete or drop out voluntarily when they decide that they want to pursue other goals. Yiannopoulos' argument runs directly counter to the predominant theme in popular coverage of women in STEM, exemplified by the article in *Scientific American* mentioned above: the view that American science *needs* more women if it is to compete with emerging scientific and technical powerhouses across the globe.

So, this year more than most, nonspecialist audiences heard (and learned) a great deal about the situation of women in engineering and STEM more broadly. But, these popular accounts can take us only so far. They certainly made us aware of the fact that women have made important contributions to American engineering and science and that we have made some progress toward gender integration. But, how much progress has been made and how many of the traditional barriers to gender equity have been eliminated? Indeed, what do we know about what actually *causes* the underrepresentation of women in engineering? Answers to these and similar questions can be answered only by careful, objective attention to scholarly research.

The selective, misleading use of academic research by public figures such as Yiannopoulos also points to the importance of engaging directly

with what that research actually says. We offer this year's literature review summarizing current research on women in engineering as part of SWE's continuing effort to deepen our understanding of the current realities by improving access to the best research in the field.

We reviewed more than 125 books and articles published in the past year, located by an extensive search of the social scientific and engineering literature. We were impressed, this year, by the significant number of well-designed studies we reviewed. Of course, the quality of the research published each year varies tremendously. As in previous years, we read some exemplary studies that drew on extensive research, employed the best scientific methods, and limited their conclusions to what the evidence would support; other studies were based on limited data and imperfect samples, and often marked by personal opinion. In the review that follows, we have focused on those studies that genuinely merit serious attention because they were scientifically sound and/or because they raised important questions or pointed to significant new lines of inquiry.

As we will argue in greater detail below, this year's scholarly literature on women in engineering has much to tell us. We learn from it that the small numbers of women in engineering have less to do with ability and more to do with the reality that engineering continues to be perceived as a masculine field and to present itself in ways that don't speak to the values and objectives that many young women emphasize. This gendering discourages women from entering engineering in the first place and, when they do enter, makes it hard to feel they belong. We also learn that women are more likely than men to leave engineering, especially after they have earned a degree. And, the reasons for their departure are becoming increasingly clear: Women leave engineering because of work/family conflict, and because they discover that they don't find the kinds of opportunities and support to pursue their professional and personal goals. There are also lessons to be learned from this literature about the possibilities for change: There are, in fact, interventions that work, or that have real promise, so we needn't accept women's underrepresentation as inevitable.

Still, as we have noted in the past, the scholarly literature on women in engineering is not without its limitations. In fact, one article we reviewed this year did an excellent job of summing up the weaknesses in that literature. Pawley, Schimpf, and Nelson (2016) conducted a content analysis of articles published in ASEE's *Journal of Engineering Education* over the 15-year period from 1998-2012. They found much excellent research, but also that much of it (probably *too* much of it) adopted similar methods and focused on similar issues.

Specifically, they found that most of the research utilized quantitative methods to the exclusion of other methodological approaches. Researchers also utilized a narrow set of theoretical frameworks, particularly the idea that a pipeline metaphor was useful for understanding women's situation in engineering. Finally, Pawley and her collaborators found that the vast majority of the articles they reviewed were conducted in university research

continued on page 8

Lab Girl

Hope Jahren, Ph.D., a distinguished geobiologist who is the only woman to receive a Young Investigator Award in the health sciences, has written a memoir of her still young career, titled *Lab Girl* (Jahren, 2016). In it, she describes how she first discovered her interest in science while accompanying her father to the community college labs he oversaw. She goes on to tell a series of engaging stories detailing the experiences she and her longtime lab partner, "Bill," had as she moved through the various stages of an academic scientist's career.

The title of the work implies that Dr. Jahren intended to write a book about being a *woman* in the world of scientific research. In the end, however, this does not seem to be her real goal. Rather, her focus is much more on conveying the excitement that accompanies scientific research; on describing the hard work, the peculiar hours, and work conditions; and the camaraderie she enjoyed with her lab partner and graduate students. One gets a real feel, from the memoir, of what it is that Dr. Jahren really enjoys in scientific work and a sense of the sacrifices required and the rewards available to a dedicated research scientist.

Is *Lab Girl* the sort of book that might inspire young women to consider a scientific career? Might it spark changes in research science that would make it more welcoming to a larger number of young women? Dr. Jahren certainly communicates how much she enjoys the work she does and describes a world in which creativity, curiosity, and initiative are central. She also acknowledges the reality that being a woman in research science is both unusual and difficult. Thus, she discusses being

accepted as a scientist *despite* being a "girl." She describes the sexist attitudes and behaviors she encountered among male scientists with whom she worked on a field trip in the Arctic and the difficulties she encountered with male colleagues and superiors as a pregnant woman in a lab. She also notes her realization, early on, that to be successful, she would have to be twice as strategic and proactive as her male counterparts.

In the end, however, she seems to accept that being a scientist and being a woman in any conventional sense are more or less incompatible. As she puts it early on, "On some deep level, the realization that I could do good science was accompanied by the knowledge that I had formally and terminally missed my chance to become like any of the women I had ever known." (p. 71)

Although she eventually does marry, and have a child, she treats this almost as a happy accident and emphasizes the importance of her husband's unusual ability to move his career to accommodate the demands of her work. Dr. Jahren seems to take for granted, even to celebrate, the enormous demands of a scientific career that make being a "normal" woman impossible. As she puts it, "I am a female scientist, nobody knows what the hell I am, and it has given me the delicious freedom to make it up as I go along." (p.277)

One wonders whether a "typical" young female reader, interested in a scientific career, would be as accepting of the fact that a woman just has to deal with sexism and unreasonable work arrangements. Or would she be as confident of her ability to make a go of it in the absence of institutional supports?

Failing Families, Failing Science

Where *Lab Girl* (Jahren, 2016) documents the experiences of a female scientist who has had a successful career (and a family) by adapting to and dealing with the unrelenting demands of academic science, another book published this year, this one an academic study of work/family conflict in academic science, makes the case that science must adapt to the needs of families if it is to attract and retain the nation's best and brightest.

Failing Families, Failing Science: Work-Family Conflict in Academic Science, by Elaine Howard Ecklund, Ph.D., and Anne E. Lincoln, Ph.D. (2016), reports on research conducted on a group of biologists and physicists at the top 20 American universities between 2008 and 2011. The authors make an impassioned case that the inflexible expectations of academic science pose a threat to the quality of science itself. As they put it: "It is a national problem if the family-unfriendliness of academic science is a turnoff for the most talented men and women." (p. 15)

Drs. Ecklund and Lincoln find that there continues to be an expectation in academic science that all research scientists should be "ideal scientists," willing and able to make work their top, and more or less exclusive, priority. This ideal emerged in an era when most scientists were men, married to women who could devote time to the family work that *male* scientists were unable and unwilling to do. While this ideal persists, however, realities have changed. Increasing numbers of scientists are women, most of whom hope to have conventional family lives as well as scientific careers. Importantly, Drs. Ecklund and Lincoln report that increasing numbers of young male scientists also report that they are looking for career/family balance. At the same time, the demands of an academic career have *increased*: It takes longer to achieve a stable academic position, as prolonged graduate training and postdocs have become increasingly normal; and, the time demands of the scientific career have grown as the pressure (and difficulty) of obtaining funding have increased.

The result, according to Drs. Ecklund and Lincoln, is that many young scientists actively consider careers outside academic science (or even outside science altogether) and many actually follow through and leave. Both female and male scientists are frustrated by the time demands involved in managing a scientific career and a family, and few have a nonworking spouse at home to shoulder the domestic burden (in fact, many are married to *other* scientists, creating

the "two-body" problem of finding two professional jobs in one location). Many feel guilt, either because they are not able to devote sufficient time to scientific research (which many experience as a moral obligation to pursue ultimate truths) or because they are pulled away from their children and the family activities they value. And some are frustrated by the need to have fewer children than they want, later in their lives than they had wanted.

Although Drs. Ecklund and Lincoln are at pains to argue that men as well as women experience these conflicts, their research shows that the problem continues to be most acute for female scientists. Female scientists report experiences of discrimination (being blamed for missing meetings because "you're a mother") and not being rewarded (or even being viewed negatively) for doing "supportive" work such as advising and mentoring students. Although the women surveyed report working similar hours to their male counterparts, they also report feeling more time conflicts and state, inaccurately, that they cannot work the same hours as their male colleagues. Likely, this reflects the greater pressure on women to perform domestic work and the different ways in which that work is framed for men and women: "Men may value time with family and help with child care, but they are not yet culturally expected to care for household activities. Scientist mothers, on the other hand, are expected to fulfill the obligations of two full-time roles." (p. 98) Thus, women talk about being "lucky" (if their husbands help out at home), while men are described as "making sacrifices" when they devote time to family.

The authors argue that academic science is losing some of its most promising young practitioners, both male and female, to this conflict. Unless the "ideal scientist" model is abandoned, and universities begin to do things such as extending family-friendly policies to graduate students and postdocs, making stopping the tenure clock routine, and taking steps to moderate the time demands involved in grant management, many scientists are likely to leave the academy for the more accommodating opportunities available elsewhere. Abandoning the ideal scientist model involves more than just changes in policy; Drs. Ecklund and Lincoln argue that it requires a fundamental cultural change in academic science that will make it a very different experience from the one Hope Jahren, Ph.D., describes in *Lab Girl*.

continued from page 6

settings and that very few focused on business and industry. Our literature review is broader than the one conducted by Pawley, Schimpf, and Nelson, but it leads us to support their calls for a greater diversity of theories and research designs and for increased focus on the nature of engineering outside the educational system.

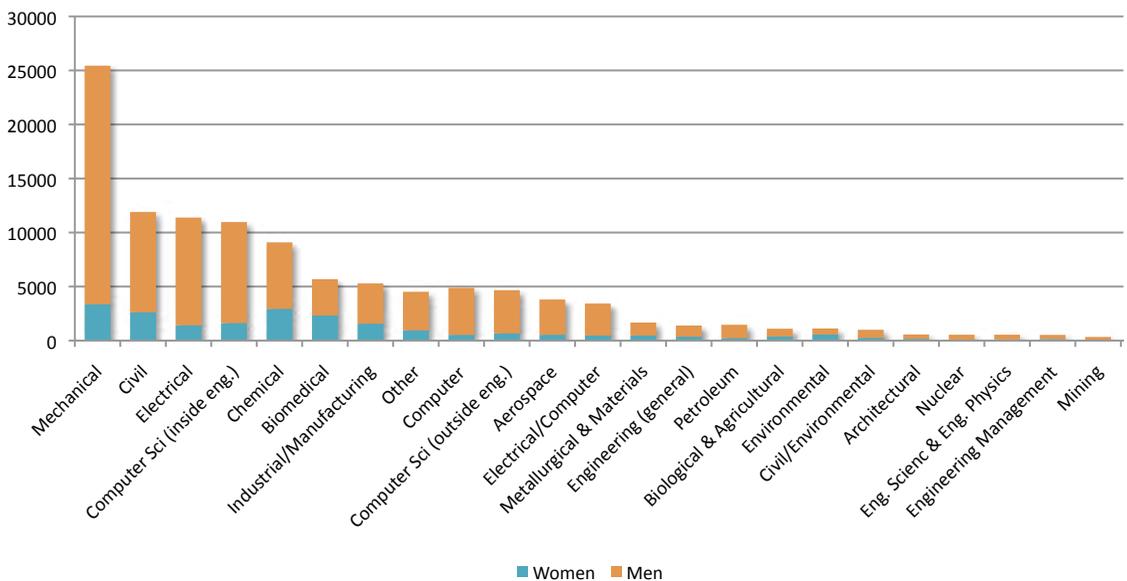
WHERE DO THINGS STAND?

First, it is worth emphasizing that women continue to be underrepresented in engineering by virtually any measure one can find. The data presented in this review and in greater detail in Yoder (2016) reveal that, in 2015, women earned 19.9 percent of engineering bachelor's degrees, 25.2 percent of master's degrees, and 23.1 percent of doctoral degrees, in each case reflecting a slight increase over the previous year. Women represented only 15.7 percent of faculty in engineering programs, up from 15.2 percent in 2014 (and up from 11.3 percent in 2006). In an era of growing engineering enrollments, these data represent relatively important

increases in the numbers of female engineering graduates. Still, women continue to be a minority in engineering, and the progress, while real, has been extremely slow.

Importantly, women are *not* evenly distributed across engineering fields and institutions. For example, women earned almost half (49.7 percent) of bachelor's degrees in environmental engineering and 40.9 percent of bachelor's degrees in biomedical engineering, while they earned only 12.5 percent of bachelor's degrees in electrical engineering and 10.9 percent of bachelor's degrees in computer engineering. Some schools have been more successful in graduating female engineering students and/or in recruiting female engineering faculty. Thus, schools such as the Olin College of Engineering and the Massachusetts Institute of Technology (MIT) grant almost half of their undergraduate engineering degrees to women; at Yale, 43 percent of master's degrees in engineering went to women; and at Northeastern, 43.4 percent of doctoral degrees in engineering were earned by women. Women are significantly more than 15.7 percent of the engineering faculty at a number of

Engineering Bachelor's Degrees by Discipline and Gender, 2015



institutions (including Seattle Pacific University, where they make up two-thirds of the faculty, and Smith College, where they are 62.5 percent). Unfortunately, many of the schools with higher female faculty representation are not among the large, prestigious universities that grant the largest numbers of engineering degrees, so their impact on overall numbers is modest. Nevertheless, cases such as these indicate that women's underrepresentation need not be permanent, and that it is possible to achieve something resembling gender balance in the field.

Women in engineering and STEM also tend not to be as well compensated as their male counterparts. Two studies we reviewed this year provided some insights into why. Tao (2016) analyzed data from the 2008 National Science Foundation Survey of Doctorate Recipients, finding that women with engineering doctorates are more likely than men to be in academic research, teaching, government research, and other government positions, while comparable men are more likely to be employed in industry. Buffington et al. (2016) used data from the Umetrics™ files — which include all individuals employed on federal research awards — and linked them to data from the 2010 census. They isolated a sample of 1,237 students who had Ph.D.s and were employed on grants. The men in their sample were much more likely than the women to have done dissertations in engineering, math, physics, or computer science and, for all fields, were more likely to be employed in industry. This study confirmed that women are more concentrated in academic and government positions. Buffington et al. argue that this pattern partially explains women's lower wages in engineering and other STEM fields, as industrial positions tend to be more lucrative.

THE PRIMARY QUESTION

We know that women continue to be underrepresented in engineering. The question remains: Why? This has been and continues to be the issue that dominates the literature on women in engineering. There continue to be multiple answers to this question, but they tend to cluster around two broad concepts:

- Women are underrepresented in engineering because women are less likely than men to

pursue an educational pathway that leads to an engineering degree; and/or

- Women who are attracted to engineering as a field and start down the road toward an engineering career are more likely than their male counterparts to leave.

A substantial amount of research, including a number of studies we reviewed this year, argue that the low numbers of women in engineering are the result of the small numbers of women who are attracted to the field in the first place. School-age girls, when they are considering potential college majors and careers, are less likely than comparable boys to select engineering as an option. Because engineering is a field of study one needs to enter early — given the complex ladders of requirements one must complete and the need for advanced mathematical training prior to entering engineering coursework — the choices girls (and boys) make in high school, and even before, play an important role in limiting the numbers of women in the field.

WHY DO SO FEW WOMEN CHOOSE TO STUDY ENGINEERING?

The question thus becomes, why do relatively few women choose engineering and why is the field more attractive to young men? At least three answers emerged from this year's research literature, although there remains considerable debate about each:

- Engineering does not present itself as a field consistent with the values and goals of many young women.
- Young women in math and other courses that lead to engineering are more likely to experience self-doubt regarding their ability to persist as engineers.
- Engineering continues to be perceived as “masculine,” so young women don't see it as a viable option for themselves.

YOUNG WOMEN'S GOALS AND CAREER OBJECTIVES

Several studies we reviewed this year repeated a claim made in past research — that young women are not drawn to engineering because they don't

continued on page 12

2016 Outstanding Women in Engineering

By Micah Roediger

American Society for Engineering Education (ASEE) Awards

JAMES H. MCGRAW AWARD

Carol Richardson, Ph.D., Rochester Institute of Technology

NATIONAL OUTSTANDING TEACHING AWARD

Mary Verstraete, Ph.D., The University of Akron

SHARON KEILLOR AWARD FOR WOMEN IN ENGINEERING EDUCATION

Karen C. Davis, Ph.D., University of Cincinnati

WILLIAM ELGIN WICKENDEN AWARD

Debra M. Friedrichsen, Ph.D., CEO and Engineering Consultant, MJ Innovations

Edith S. Gummer, Ph.D., Education Research Director, Ewing Marion Kauffman Foundation

Audrey B. Champagne, Ph.D., University at Albany, The State University of New York

Women in Engineering ProActive Network (WEPAN) Awards

INCLUSIVE CULTURE AND EQUITY AWARD

Susan Coady Kemnitzer, National Science Foundation

LEADER IN ENGINEERING EDUCATION AWARD

Linda Vanasupa, Ph.D., California Polytechnic State University, San Luis Obispo

INDUSTRY TRAILBLAZER AWARD

Lisa Durham, Argonne National Laboratory

FOUNDERS AWARD

Beth Holloway, Ph.D., Purdue University

BEVLEE A. WATFORD INCLUSIVE EXCELLENCE AWARD

Bevlee Watford, Ph.D., Virginia Tech

BETTY VETTER AWARD FOR RESEARCH

Mary Besterfield-Sacre, Ph.D., University of Pittsburgh

WOMEN IN ENGINEERING INITIATIVE AWARD

University of Maryland – Flexus: The Dr. Marilyn Berman Pollans Women in Engineering Living & Learning Community

Halliburton and Colorado School of Mines: Making the Connection Program

PRESIDENT'S AWARD

Michigan Technological University, mechanical engineering department

The University of Oklahoma, mechanical engineering department
Oregon State University, mechanical engineering department

Purdue University, mechanical engineering department

Texas Tech University, mechanical engineering department

The National Academy of Engineering (NAE) Awards

BERNARD M. GORDON PRIZE FOR INNOVATION IN ENGINEERING AND TECHNOLOGY EDUCATION

Kristin K. Wobbe, Ph.D., Worcester Polytechnic Institute

SIMON RAMO FOUNDERS AWARD

Ruzena Bajcsy, Ph.D., University of California, Berkeley

NEW FEMALE MEMBERS

Zhenan Bao, Ph.D., Stanford University

Emily A. Carter, Ph.D., Princeton University

Fiona M. Doyle, Ph.D., University of California, Berkeley

M. Cynthia Hipwell, Ph.D., Buhler Inc.

Kristina M. Johnson, Ph.D., Cube Hydro Partners

Yilu Liu, Ph.D., Oak Ridge National Laboratory

Arati Prabhaker, Ph.D., Defense Advanced Research Projects Agency

Wanda K. Reder, S&C Electric Company

Ann Beal Salamone, Rochal Industries

Bridget R. Scanlon, Ph.D., The University of Texas at Austin

Kathryn D. Sullivan, Ph.D., U.S. Department of Commerce

Jennifer L. West, Ph.D., Duke University

Society of Women Engineers (SWE) Awards

ACHIEVEMENT AWARD

Stephanie Watts Butler, Ph.D., P.E., Texas Instruments

SUZANNE JENNICHES UPWARD MOBILITY AWARD

Endowed by Northrop Grumman Corp.

Jill M. Hruby, Sandia Corporation

ENTREPRENEUR AWARD

Michele S. Stuart, Efficiency Engineers

DISTINGUISHED ENGINEERING EDUCATOR

Pamela M. Norris, Ph.D., University of Virginia

ADVOCATING WOMEN IN ENGINEERING AWARD

Natalie Hagan, The Johns Hopkins University Applied Physics Laboratory

Nora C. Lin, F.SWE, Northrop Grumman Corporation

Beth A. Mitchell, General Dynamics Mission Systems

Marla Ann Peterson, Honeywell Aerospace Engineering and Technology

Shelly A.M. Wolff, P.E., F.SWE, HNTB Corporation

GLOBAL LEADERSHIP AWARD

Decie Autin, ExxonMobil

Louise Goetz, GE Oil & Gas

Barbara E. Rusinko, Bechtel Group

GLOBAL TEAM LEADERSHIP AWARD

Rockwell Automation Insider Risk Team
Team leader, Dawn Cappelli

PRISM AWARD

Christine A. Coverdale, Ph.D., Sandia National Laboratories

Lesley Anne Polka, Ph.D., Intel Corporation

Mindy Rapp, Caterpillar Inc.

Holly Rollins, Booz Allen Hamilton

Susan Stevenson, Praxair Inc.

SPARK AWARD

Rhonda L. Childress, IBM Corporation

Reates Curry, Ph.D., Ford Motor Company

Erica Messinger, Keysight Technologies

Carolyn Moore, ExxonMobil Chemical Company (Retired)

EMERGING LEADER

Lindsay M. Forsyth, Chevron Corporation
 Allison Goodman, Intel Corporation
 Christina Bishop Jackson, Ph.D., Honeywell
 Jaime Gray Nelson, Booz Allen Hamilton
 Siobvan Nyikos, The Boeing Company
 Kelly Griswold Schable, The Boeing Company
 Laura Schafer, Emerson Process Management
 Rashi Tiwari, Ph.D., The Dow Chemical Company
 Tracy Van Houten, Jet Propulsion Laboratory
 Janet Willett, John Deere

SWE DISTINGUISHED NEW ENGINEER

Rachel Borchers, Boston Scientific Corporation
 Gail Dyer, Corning Incorporated
 Lesley Farah, Starkey Hearing Technologies
 Stueti Gupta, John Deere India
 Sunita G. Lavin, Garmin International
 Jacquelyn K. Nagel, Ph.D., James Madison University
 Rebecca M. Reck, Ph.D., Kettering University
 Casey Griswold Waggy, Ball Aerospace and Technologies Corp.
 Amanda Weissman, Partner's Consulting
 Allison Wright, Spirit AeroSystems

FELLOW GRADE

Ellen Ferraro, Ph.D., Raytheon Company
 Nancy Manley, P.E., United States Air Force
 Cheryl Andrews Manning, The Johns Hopkins University Applied Physics Laboratory
 Diane L. Peters, Ph.D., P.E., Kettering University
 Holly J. Teig, Caterpillar Inc.
 Mary C. Verstraete, Ph.D., The University of Akron

DISTINGUISHED SERVICE AWARD

Janis L. Mantini, F.SWE, The Boeing Company (Retired)
 Frances Stuart, Stuart Technical Services/Alpha Testing Laboratory (Retired)

OUTSTANDING FACULTY ADVISOR

Terry Comerford, Colorado State University

OUTSTANDING COLLEGIATE MEMBER

Erica Brackman, The Ohio State University
 Alyssa Deardorff, Oregon Institute of Technology
 Elizabeth Dreyer, University of Michigan
 Katie Gonzagowski, University of Missouri-Kansas City
 Danielle Johnson, The University of Texas at Austin
 Rebecca Kandell, California Polytechnic State University, San Luis Obispo

Anna Lucrezia Oldani, University of Illinois at Urbana-Champaign
 Danielle Schroeder, Drexel University
 Rachel Unruh, Texas A&M University
 Elia Zanella, University of Minnesota Twin Cities

OUTSTANDING SWENEXTERS

Sarah Adebabay, Inglewood, California
 Alyson Chaney, Clinton, Indiana
 Alycia Lee, Lower Gwynedd, Pennsylvania
 Jordan Love, Overland Park, Kansas
 Sam Steinberg, New York, New York

The Anita Borg Institute for Women and Technology Awards

TECHNICAL LEADERSHIP ABIE AWARD
 Anna Patterson, Ph.D., Google

WOMEN OF VISION ABIE AWARD FOR LEADERSHIP

Michele D. Guel, Cisco Systems

ABIE AWARD FOR TECHNOLOGY ENTREPRENEURSHIP

Pooja Sankar, Piazza

SOCIAL IMPACT ABIE AWARD

Kathryn Finney, digitalundivided

DENICE DENTON EMERGING LEADER ABIE AWARD

Colleen Lewis, Ph.D., Harvey Mudd College

A. RICHARD NEWTON EDUCATOR ABIE AWARD

Bih Janet Shufor Fofang, Collège D'enseignement Technique Industriel et Commercial

CHANGE AGENT ABIE AWARDS

Amanda Gicharu, Tech Republic Africa

National Society of Black Engineers (NSBE) Golden Torch Awards**DR. JANICE A. LUMPKIN EDUCATOR OF THE YEAR**

Whitney Gaskins, Ph.D., University of Cincinnati

PRE-COLLEGE INITIATIVE STUDENT OF THE YEAR (FEMALE)

Olivia Martin, St. Louis

OUTSTANDING WOMAN IN TECHNOLOGY

Tracy Hamilton, Texas Instruments

Society of Hispanic Professional Engineers (SHPE) Awards**COMMUNITY SERVICE**

Lorena L. Loucel, Lockheed Martin

JUNIPERO SERRA AWARD

Rosa Linda Puga, Lockheed Martin

PROMISING ENGINEER

Mariana Verdi, Chevron

SHPE STAR OF TODAY AWARD

Adriana Sandoval, Chevron

continued from page 9

perceive it as a field in which they can pursue their desire to work with people and to solve social problems and make the world a better place. Young women are said to have different professional goals and objectives than men and feel that they may not “fit into” the field of engineering.

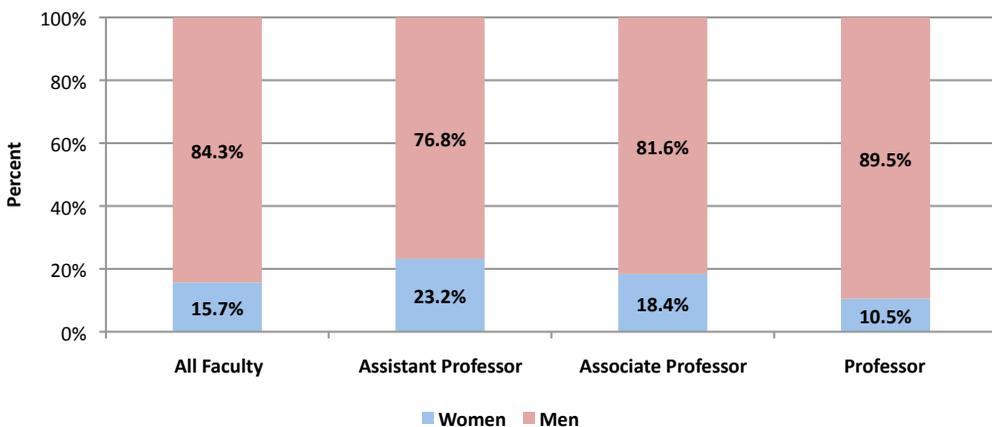
Stout, Grunberg, and Ito (2016) surveyed a group of 136 undergraduates (71 women, 65 men) early in their first year in university. They asked their respondents to evaluate whether a variety of scientific majors offered opportunities for communion (maintaining relationships/serving society) or agency (autonomy/self-promotion). Three years later, the researchers examined what courses these students had taken. They found that students perceived fields such as engineering, math, and physics to offer fewer communal opportunities and more agentic ones. Men took more courses in these fields; if women perceived these fields as offering communal opportunities, however, they were more likely to take such courses. Overall, the researchers concluded that the low numbers of women in fields such as engineering could be increased if the field were perceived as (and presented itself as) more communal.

Godwin et al. (2016) came to similar conclusions

based on their examination of data from “Sustainability and Gender in Engineering,” a 2011 survey of 6,772 first-year students from 50 colleges and universities across the United States. They found, unsurprisingly, that having a strong math/physics identity was an important predictor of students’ choosing engineering as a major and career choice. They found that this was less true for women than for men, however. For women, “agency” beliefs were found to be important — i.e., the belief that one could improve the world through engineering. Godwin et al. conclude that efforts to recruit women to engineering by focusing exclusively on building their math/physics identities are likely to fail; attention also must be directed to persuading young women that it is possible to change the world through engineering.

It is worth remembering that Wang and Degol (2013) made a very similar argument earlier when they observed that a young person who is good at math may not choose to enter engineering if they believe the costs of doing so are too high and that the choice is not consistent with their values and goals. They noted, in their meta-analysis of the literature, that while the gender gap in math achievement has declined significantly, math-competent women continue to opt out of fields such as engineering while men are drawn to them.

Engineering Faculty by Rank and Gender, 2015



Wang and Degol linked this to differences in values and goals, including women's desire to work with people and their perception that fields such as engineering are "object-oriented."

Miller (2016) presented results from implementation of a "culturally responsive" introductory computer science course at the University of California, Berkeley. It showed that women had a significantly stronger experience of belonging in the culturally responsive course than they did in the traditional introduction to computer science course, but that still only meant that 50 percent of the 388 women had a positive sense of belonging. Perhaps the largest takeaway from this study is that women's sense of belonging was highly correlated with the computer science self-efficacy, but men's was not.

Before one concludes that the key to making engineering more attractive to young women is emphasizing its potential as a field in which communal goals can be pursued, it is important to acknowledge research that suggests otherwise. Sax et al. (2016) utilized data from the Cooperative Institutional Research Program, a national longitudinal study of U.S. college students housed at the University of California, Los Angeles. This is a very large data set, with more than 8 million respondents between 1971 and 2011. Sax et al. were interested in understanding the changing dynamics of the gender gap in undergraduate engineering majors: Has the gender gap changed, what factors determine men's and women's decisions to enter engineering, and have those changed in nature or salience over time? They find a significant increase in women's interest in engineering since the 1970s, but that that interest remains quite low. Among the factors that predict contemporary women's interest in engineering, they find that a social activist orientation in engineering has actually *decreased* in salience, even as women's interest in the field has *increased*.

Smith-Doerr, Vardi, and Croissant (2016) conducted an exploratory study of 10 male and 10

female scientists and engineers in 2011 that may help us to understand what is happening. Among the goals of their study was to examine whether it was, in fact, the case that women focused on the social benefits of engineering. They found that neither the men nor the women in their sample were focused on these benefits and that there was no real gender difference on this point. The authors speculate that this may reflect the fact that the women had to adapt to the male norms of science and engineering and that efforts to recruit women to the field by focusing on altruism and social impacts may backfire if young women entering the field find that those aspects are not valued in the workplace.

Stoup and Pierrakos' (2016) survey of relationships between identity, personality, authenticity, and persistence differences among four groups of engineering students at James Madison University (29 first-year men, 12 first-year women, 27 senior men, and 14 senior

women) points to a similar conclusion. The most significant difference they found was between first-year female and senior female students, with senior women being more introverted. The authors conclude that introversion increases during an engineering program; this claim would need to be verified with a much larger dataset, however, before it could be generalizable, because this was not a longitudinal study but was rather based on data from different groups of women. Furthermore, in engineering environments, senior women felt the least authentic to their personalities of the four groups (i.e., they felt the most tension and pressure), which could suggest that as women progress through their engineering education programs, they conform to a dominant (male) personality type, even though that is inauthentic to their personalities.

CONFIDENCE AND SELF-DOUBT

Other researchers emphasized that the low numbers of women in engineering may be the result of personal doubts about one's ability to suc-

THE SELECTIVE, MISLEADING USE OF ACADEMIC RESEARCH BY PUBLIC FIGURES SUCH AS YIANNPOULOS ALSO POINTS TO THE IMPORTANCE OF ENGAGING DIRECTLY WITH WHAT THAT RESEARCH ACTUALLY SAYS.

ceed in the field. Of particular significance is the fact that these doubts appear *not* to be related to actual differences in ability or performance. Thus, overcoming them is not simply a matter of helping female students to strengthen their foundational skills in math and science (something that has already been happening for some time).

Seron et al. (2016) note that many entering engineering students (both male and female) have to confront the reality that they are no longer the top student in their cohort; however, women are more likely than men to react to this by doubting their abilities. Ro and Knight (2016) analyzed data from a 2009 survey of 4,901 sophomore, junior, and senior engineering students at 31 four-year institutions in the United States. They found that the women in their study felt that they had lower design skills, although this appeared more related to the pedagogical strategies of instructors than to the actual skills the women possessed. Robnett (2016) studied small samples of girls and women from two high schools, a college, and a graduate program in the western United States. She found that the majority (61 percent) of the respondents reported having experienced gender bias at least once in the previous year, and that this was particularly common in math-intensive fields such as engineering. Robnett also found that this experience of bias was linked to lower STEM self-concept among the women who encountered it, and that this is linked to weaker career aspirations in STEM.

Not everyone is equally convinced that these kinds of self-doubts are the reason for women's continued underrepresentation in engineering and other math-intensive STEM disciplines. Cheryan et al.'s (2016) meta-analysis of the literature on why some STEM fields are more gender balanced than others found that the existing research has mixed results on this question; they conclude that more research is needed.

continued on page 16

Female Deans and Directors of Engineering Programs in the U.S.

Cammy R. Abernathy, Ph.D., dean of engineering, University of Florida

Stephanie G. Adams, Ph.D., dean of engineering, Old Dominion University

Emily L. Allen, Ph.D., dean of engineering, California State University, Los Angeles

Nada Marie Anid, Ph.D., dean of engineering and computing sciences, New York Institute of Technology

Nadine N. Aubry, Ph.D., dean of engineering, Northeastern University

M. Katherine Banks, Ph.D., P.E., dean of engineering and vice chancellor, Texas A&M University

Gilda A. Barabino, Ph.D., dean, The Grove School of Engineering, City College of the City University of New York

Susamma Barua, Ph.D., interim dean, California State University, Fullerton

Gail Baura, Ph.D., director of engineering science, Loyola University Chicago

Stacy G. Birmingham, Ph.D., dean of engineering, Grove City College

Barbara D. Boyan, Ph.D., dean of engineering, Virginia Commonwealth University

Mary C. Boyce, Ph.D., dean of The Fu Foundation School of Engineering and Applied Science, Columbia University

JoAnn Browning, Ph.D., P.E., dean of engineering, The University of Texas at San Antonio

Jenna P. Carpenter, Ph.D., dean of engineering, Campbell University

Emily Carter, Ph.D., dean of engineering, Princeton University

Tina Choe, Ph.D., dean of the Frank R. Seaver College of Science and Engineering, Loyola Marymount University

Robin Cogger, Ph.D., dean of engineering, North Carolina A&T State University

Jennifer Sinclair Curtis, Ph.D., dean of engineering, University of California, Davis

Teresa A. Dahlberg, Ph.D., dean, College of Engineering and Computer Science, Syracuse University

Natacha DePaola, Ph.D., dean of engineering, Illinois Institute of Technology

Persis S. Drell, Ph.D., dean of engineering, Stanford University

Doreen D. Edwards, Ph.D., dean, Kate Gleason College of Engineering, Rochester Institute of Technology

Julie R. Ellis, Ph.D., P.E., department head, Western Kentucky University

Jacqueline A. El-Sayed, Ph.D., vice president for academic affairs, Marygrove College

Elizabeth A. Eschenbach, Ph.D., department chair, Humboldt State University

Liesl Folks, Dean of Engineering, Ph.D., University at Buffalo, The State University of New York

Molly M. Gribb, Ph.D., P.E., dean of engineering, University of Wisconsin–Platteville

Christine E. Hailey, Ph.D., dean of the College of Science and Engineering, Texas State University, San Marcos

Wendi Beth Heinzelman, Ph.D., dean of engineering, University of Rochester

Martha Hogan, Ph.D., dean of engineering, Richland College

Leah H. Jamieson, Ph.D., dean of engineering, Purdue University

Brig. Gen. Cindy Jebb, Ph.D., dean, Academic Board, U.S. Military Academy

Sharon A. Jones, Ph.D., P.E., dean of the Shiley School of Engineering, University of Portland

Ranu Jung, Ph.D., interim dean, Florida International University

Maria V. Kalevitch, Ph.D., dean of engineering, Robert Morris University

Anette M. Karlsson, Ph.D., dean of engineering, Cleveland State University

Bo-Kyoung Kim, Ph.D., dean of the School of Engineering and Computer Sciences, Daniel Webster College

Debra Larson, Ph.D., P.E., dean of engineering, California Polytechnic State University, San Luis Obispo

Elizabeth Loba, Ph.D., dean of engineering, University of Missouri

Denise Martinez, Ph.D., department head, Tarleton State University

Charla Miertschin, Ph.D., interim dean, Winona State University

Amy J. Moll, Ph.D., dean of engineering, Boise State University

Holly J. Moore, Ph.D., interim chair, Salt Lake Community College

Jayathi Y. Murthy, Ph.D., dean of the Henry Samueli School of Engineering and Applied Science, University of California, Los Angeles

Hallie Neupert, interim dean of the College of Engineering, Technology, and Management and department chair, Oregon Institute of Technology

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Courtesy of the American Society for Engineering Education, January 2017

continued from page 14

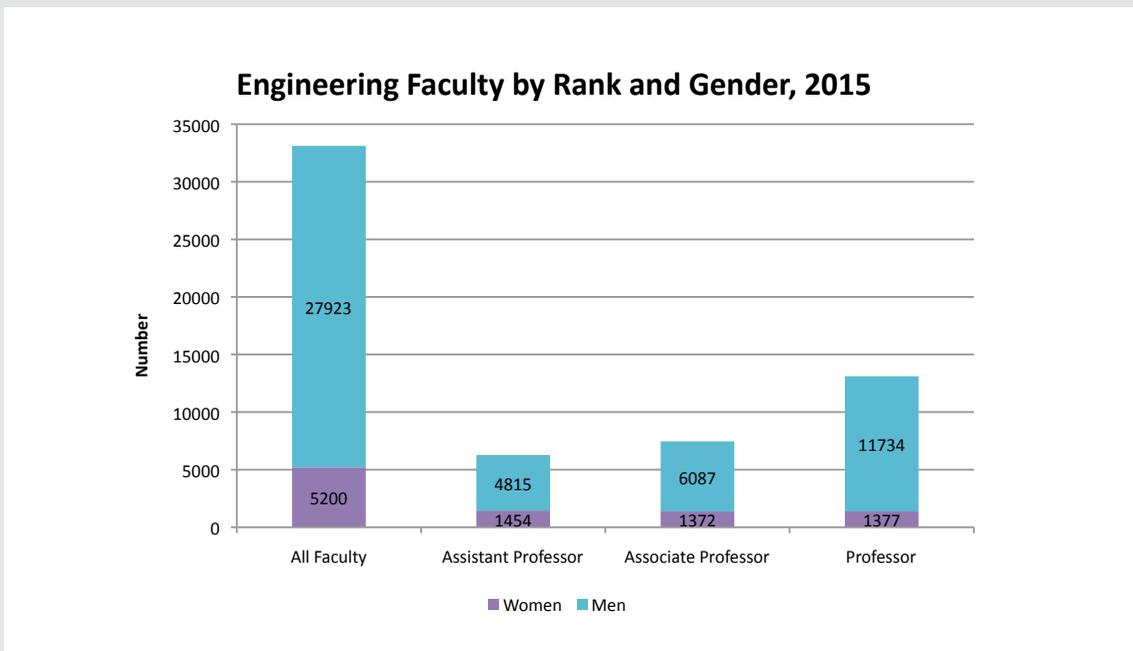
Sax et al.'s (2016) study of the changing dynamics of the gender gap in undergraduate engineering majors found that, although self-rating of mathematical ability remains a predictor of an interest in pursuing an engineering degree, it has become less salient for women over time. So, it may be that women's alleged lack of math confidence may turn out to be as temporary as their alleged lack of math ability.

ENGINEERING AS "MASCULINE"

A final explanation of the small numbers of women who are attracted to engineering as a major and career path focuses on the degree to which the field is stereotyped as masculine and/or has a masculine culture. Cheryan et al.'s review of the literature identifies three possible reasons that some STEM fields are more gender balanced than others: gender gaps in self-efficacy in certain fields, insufficient early exposure to certain fields, and the masculine culture of certain fields. As we have just seen, they find that the literature does not yield a consensus on whether women feel less self-efficacy in the fields in which they

are underrepresented (math-intensive fields). Cheryan et al. also note that lack of early exposure, *per se*, does not explain the underrepresentation of women, as there are other subjects in which women are well-represented where early exposure is uncommon (e.g., psychology and nursing). Thus, the masculine culture of engineering, including stereotypes of engineers as socially awkward males who possess innate abilities that women allegedly lack, the perception that women may face bias and discrimination, and the lack of role models in the field, is identified as a significant reason for the low probability that qualified women will select it.

Several studies we reviewed this year found that there continue to be gendered stereotypes of engineers and scientists. It remains the case that Americans perceive these fields as "masculine." Carli et al. (2016) conducted two small-scale studies of female undergraduates at a small, single-sex liberal arts college and students from a larger coeducational university. They found that respondents generally held stereotypical views of men and scientists as more similar than women and scientists (except for fields such as psychology, where women are well-represented). Female students at single-sex colleges saw more similarities between women and



scientists, but, even there, the tendency was to see men and scientists as more similar.

A similar finding emerged from Banchevsky et al.'s (2016) study of 51 U.S.-based workers. Respondents were shown 80 photos (40 of men, 40 of women) of actual tenured and tenure-track faculty in STEM departments at elite universities. They were asked to rate each photo along various dimensions and to indicate the likelihood that each was a scientist. Banchevsky et al. found that respondents used gendered appearance as a cue as to whether the pictured individuals were scientists — women who were rated as “feminine” were perceived as less likely to be scientists, while men’s gendered appearance was not related to the evaluation of their career likelihood.

Stearns et al. (2016) conducted research pointing to the importance of the gender stereotyping of STEM fields. They analyzed data on a sample of 16,300 students who attended any of the 16 colleges in the University of North Carolina system in 2004. Not surprisingly, they found that men were more likely to declare and complete a STEM major. However, they also found that girls who had attended a high school with larger numbers of female math and science teachers were more likely to major in STEM fields. This was true only for white girls; there was no comparable effect for African-Americans. And, the gender composition of the faculty had no measurable effect on boys’ likelihood of declaring and completing a STEM major. Nevertheless, this research suggests that a weakening of the stereotype of a field as masculine (due to the presence of female models) can increase the probability that women will enter fields such as engineering that are typically stereotyped as male.

It is encouraging to note that there has been some effort to combat the stereotypical views of science and engineering that young children have traditionally received. Previs (2016) conducted a content analysis of science stories, letters to the editor, and a feature called “the science corner”

published in the popular children’s magazine *Highlights* between 1967 and 2010. The study found that males were mentioned more than females in science stories, but the discrepancy diminished over time. The “science corner” feature actually tended to feature women more, and females wrote twice as many letters to the editor as males. Overall, the study concluded that *Highlights’* portrayal of women in science reflected or even exceeded the real percentages of women in science during the period in question. Previs is not able to determine whether this had any effect on children’s attitudes toward STEM and STEM careers, but it is at least encouraging that a widely read children’s publication did not simply reproduce gender stereotypes

of STEM.

It would be premature to conclude that we know, with certainty, why young women, even young women who are capable in math, continue not to be attracted to engineering. However, the research we

reviewed this year definitely confirms that engineering continues to struggle to attract young women and that the field remains stereotyped as male. As it has become increasingly clear that the low numbers of women entering engineering in the first place have little to do with ability, researchers have focused attention, increasingly, on the gendered perception of engineering, and on whether women are able to see themselves in the commonly available images of an engineer.

ARE WOMEN MORE LIKELY TO LEAVE?

Another possible explanation for the underrepresentation of women in engineering is that some women who begin down the path toward an engineering career change their minds and/or are pushed away from the field. The metaphor of the “leaky pipeline” has frequently been used to characterize what is happening and has been the basis for the argument that increasing the numbers of women in engineering requires attention not just to recruitment but to *retention*.

A YOUNG PERSON WHO IS GOOD AT MATH
MAY NOT CHOOSE TO ENTER ENGINEERING
IF THEY BELIEVE THE COSTS OF DOING SO
ARE TOO HIGH AND THAT THE CHOICE IS NOT
CONSISTENT WITH THEIR VALUES AND GOALS.

Although the leaky pipeline metaphor has been widely adopted, some scholars have questioned whether the evidence supports it. In previous reviews, we drew attention to this lack of consensus; as we noted a number of years ago, Lisa Frehill (2010) (among others) has pointed out that there is remarkably little comparative research on departures from engineering, so it is not entirely clear that women leave the field at higher rates than do men. Over the past several years, we have reviewed a number of studies analyzing women's departure from engineering and STEM more generally; the result has been to document further the apparent lack of consensus regarding what is happening.

If this year's literature on women in engineering is any indication, a bit of clarity may have begun to emerge. Although there remains some disagreement, several of the studies we reviewed this year

support the conclusion that women who enter college-level engineering programs do *not* leave the field during college at higher rates than men. However, the percentage of women who leave engineering subsequent to earning a degree is higher than the percentage of men who leave, offering support for the view that there is a "leak," although it appears to be located less in the educational pipeline and more at a stage subsequent to completion of professional training.

There had been some thought in the past that many women left engineering early on, while they were still students in undergraduate and graduate training programs. Most now reject the view that this departure was due to a lack of academic ability (see Wang and Degol 2013, especially pp 307-8, for a review of the literature on this question). The view, however, was that female engineering

Hidden Figures, Rise of the Rocket Girls, and The Glass Universe

The movie *Hidden Figures* received popular acclaim and three Oscar nominations this year for portraying the lives of African-American women who performed the calculations that sent Americans into orbit and to the moon in the 1960s. The book of the same name, by Margot Lee Shetterly (2016), joined Nathalia Holt's *Rise of the Rocket Girls* (2016) and Dava Sobel's *The Glass Universe* (2016) in describing the lives of women who worked as human computers in astronomy and the space program. Like the "Top Secret Rosies" of World War II (*SWE Magazine*, Conference 2013, <http://www.nxtbook.com/nxtbooks/swe/conference13/#/36>), who calculated ballistic trajectories and programmed the first ENIAC computer, women at the Harvard Observatory, the Langley Aeronautical Laboratory, and the Jet Propulsion Laboratory applied their mathematical skills to classify stars, optimize the designs of airplanes, and determine the orbits of the first spacecraft.

In the late 19th and early 20th centuries, the Harvard Observatory had an ambitious program to photograph and catalog the stars. The director of the laboratory hired a group of women to analyze the photographs, but they did much more than routine, behind-the-scenes analysis. Sobel's book reveals the existence of a group of mathematically talented, educated women in

the late 19th century who made a significant contribution to the field of astronomy, including developing a standardized star categorization scheme based on brightness and stellar spectra that is still in use, the discovery of a large number of novae and variable stars, and the revelation that stars are largely composed of hydrogen. *The Glass Universe* describes the complex experiences these women had at the Harvard Observatory. On the one hand, the director(s) of the laboratory actively recruited women, recognized their abilities and achievements, and even worked to ensure that they were recognized (e.g., by nominating them for awards, pressing them to use their full names rather than simply initials, etc.). At the same time, however, the women were poorly compensated (and requests for raises were resisted), and the Harvard administration was adamantly opposed to appointing a woman to the faculty of astronomy until well into the 20th century.

While the *Hidden Figures* film focuses on the 1960s, the book begins during World War II when women were recruited to support the war effort. Work at the Langley Memorial Aeronautical Laboratory in Hampton, Virginia, focused on increasing the efficiency of airplane flight, with calculations supporting the design and analysis of wind tunnel tests. A group of African-

students were an isolated minority who found few role models among the faculty; that they were likely to encounter a “chilly climate” and to receive less support from faculty and fellow students. The result, according to this argument, was that at least some capable female engineering students left engineering programs for other, more welcoming academic opportunities.

Some of the research we reviewed this year, however, called this argument into question. Two studies, in particular, presented evidence that women did not leave engineering schools at a higher rate than men. Riegler-Crumb, King, and Moore (2016) analyzed a sample of 3,702 graduates drawn from the 2004/2009 Beginning Postsecondary Students Longitudinal Study. The original study collected data from a larger sample of post-secondary students in 2003 and followed

up with them in 2006 and 2009. Riegler-Crumb, King, and Moore examined whether the members of their sample who were in gender-atypical majors were more likely to switch than those who were in gender-typical programs. They found that men in female-dominated fields were more likely to switch than their male counterparts in other majors. However, they found that this was *not* the case for women in male-dominated fields — they switched at rates similar to their female counterparts in other disciplines. This, of course, leaves open the question of whether women generally are more likely to switch majors than men, but it does suggest that, if women are leaving engineering, it is not because of something unusual about the field. Cheryan et al. (2016) con-

continued on page 20

American women, many of whom had been high school math teachers, were hired into a segregated computing department at Langley and continued to play critical roles as the lab’s work evolved with the establishment of NASA and the birth of the space program. The women faced racial as well as gender discrimination, but some managers at Langley recognized and valued the women’s contributions in spite of the legal resistance to integration in Virginia. Some of the women computers fought to earn engineering degrees and others adapted to the advent of electronic computers by learning how to program the new machines that replaced their jobs.

At the same time the Langley lab was playing a critical role in the development of aeronautics on the east coast, a group of rocket scientists established the Jet Propulsion Laboratory (JPL) in Pasadena, California, and also hired women to perform calculations for their rocket tests. *Rise of the Rocket Girls* describes the evolution of JPL from a small group of fanatics testing rockets in a remote canyon to the home of NASA’s planetary exploration program through the eyes of the female computers. Like *Hidden Figures*, it portrays the intensity of the space race in the 1960s through the perspective of individuals who lived it.

Both books are based on extensive personal interviews interwoven with the institutional history of NASA and the cultural evolution of racial and gender relations in the United States. Where *Hidden Figures* situates its story in the context of the civil rights movement of the 1960s, *Rise of the Rocket Girls* describes the efforts of JPL’s women computers to balance the work they loved with husbands and children at a time when women could be and were fired when they became pregnant. Some of the Rocket Girls went on to play leading roles in NASA’s planetary program, and Susan G. Finley, who started at JPL in 1958, was still on the job last summer as the Juno probe entered Jupiter’s orbit.

All three books document the mathematical abilities of women who lived at a time when the prevailing view was that women’s mathematical skills were inferior. They also reveal the powerful resistance to the inclusion of women as equals in scientific work, even when there was clear evidence that their contributions were invaluable. It is testimony to the remarkable persistence of these women that they achieved what they did; it is also remarkable that their contributions are only now gaining wider acknowledgement as a result of these books and the associated *Hidden Figures* movie.

continued from page 19

ducted a meta-analysis of the literature exploring the question of why certain STEM fields are more gender balanced than others. Their conclusion, based on their review, is unequivocal:

“... computer science, engineering, and physics do not have higher attrition of female students than male students between high school and the time they finish college. The current underrepresentation of women and overrepresentation of men in these fields appears to be more of a recruitment issue ... than a retention issue.” (p. 4)

At least one study continued to offer some support for the view that women leave engineering at higher rates than men, however. Ellis, Fosdick, and Rasmussen reported on data from a survey of a random sample of American calculus I students at two- and four-year colleges, conducted by the Mathematical Association of America in 2010. They found that some calculus I students lose their commitment to continue on to calculus II; standardized math test scores, career intentions (how committed to a STEM career was the student?), and instructor quality all predicted the decision

to “switch.” Most significantly, the authors found that women were 1.5 times more likely to “switch” than were comparable men. Although there was no evidence that women performed less well in calculus I, women were more likely to say that they did not understand the material in calculus I well enough to continue on to calculus II — hence their reluctance to persist. Ellis, Fosdick, and Rasmussen speculate that this lack of confidence may help to explain why women leave STEM disciplines at higher rates than men.

It should also be noted that there may be other explanations for women’s persistence (or failure to persist) in engineering programs. The paper that won the award for Best Diversity Paper at the American Society for Engineering Education (ASEE) Annual Conference was by Yang and Grauer (2016), in which the authors measured the effects of a loan repayment grant on persistence in engineering. They found that when a female student received a student loan repayment grant, it increased their graduation rates (compared with a control group) and increased graduation rates of female students with a wider range of GPAs.

While there continues to be some disagreement about whether female students leave engineer-

Engineering Bachelor's Degrees by Gender within Race/Ethnicity, 2015



ing programs at higher rates than their male counterparts, there is a higher level of agreement that female engineering graduates are more likely than men to leave the field. The fact that the percentage of working engineers who are female is smaller than the percentage of engineering graduates who are female has often been identified as evidence of this. Several studies we reviewed this year reported this difference as fact. Fouad et al. (2016) reported on their ongoing research on the differences between women who persist and women who leave engineering. In the article they published this year, they note that *half* of female engineering graduates leave engineering at some point along the way (a higher percentage than for men). Hunt (2016) analyzed data from the 2003 and 2010 National Survey of College Graduates — these are large data sets with more than 100,000 observations, so the survey provides a rich source of information on post-graduate experiences. She found that female graduates are more likely to leave engineering than men, a pattern she did *not* find for science more generally.

Several possible explanations for women's greater probability of leaving engineering were offered in the research reviewed this year. Seron et al. (2016) conducted a study of engineering students at four New England engineering schools (MIT, Olin, the University of Massachusetts Amherst, and Smith). They described the ways in which students' experiences in engineering school have the effect of weakening some women's commitment to a career in the field. Entering students, whether male or female, typically were top students in high school; now, as engineering students, they have to determine where they are in the pecking order. Seron et al. report that female students are more likely than comparable male students to experience self-doubt when they find out where they are in the hierarchy, which begins to undermine their commitment to the field.

Later in their university careers, students experience both teamwork and various kinds of internships and summer jobs. These turn out to be very different experiences for female and male students, according to Seron et al. Women in teams often find that they wind up managing the team, while men do most of the technical work. Women

continue to encounter this kind of gender stereotyping when they enter the engineering workplace as interns or temporary workers. The result is that some women begin to question whether an engineering career will lead to satisfying work. In Seron et al.'s words:

“The findings reported here suggest that subtle and cumulative encounters with the values and norms of professional culture compromise women's affiliation with the profession and raise the prospect of departure.” (pp. 30-31)

Seron et al.'s analysis builds on earlier work done by one of her co-authors, Erin Cech (2015), who has argued that female engineers sometimes find that their values and self-concept are not fully consistent with the professional identity of an engineer. Other researchers, however, point to different explanations for female engineering graduates' leaving engineering. Fouad et al. (2016) reported, with surprise, that they *did not* find differences between women engineers who persist and those who depart in either self-confidence or outcome expectations. Rather, they found that the differences between the two groups centered on their experience of workplace support — were they given advancement opportunities and did their managers demonstrate understanding of work/family balance issues. Although Fouad et al.'s analysis does not share Seron et al.'s and Cech's emphasis on self-concept and confidence, both arguments point to the importance of negative workplace experiences and lack of support as factors in female engineers' decision to leave.

SWE undertook a study of why women leave engineering, the results of which were published in the Spring 2016 issue of *SWE Magazine* (Holmes, 2016). The study found that women's leaving engineering wasn't primarily the result of work/family balance issues. Instead, women left because they found that they were working in environments that tolerated persistent obstacles to attaining their company and career goals. It was not that women's values were different from men's. Rather, women, more than men, reported finding that highly ranked values were not being met in their workplaces. They noted a lack of “accountability” and were more likely than men to not accept “values breaches,” and to become frustrated

when they aren't given clear, consistent goals and a level playing field. Like Fouad et al., the SWE study draws attention to the role support, opportunity, and positive workplace experiences (or their absence) may be playing in leading some women to leave engineering.

Other researchers *do* point to work/family conflict as a possible explanation for attrition among female engineering graduates. As we have just seen, Fouad et al. pointed to this as an issue for the engineers they studied. Ecklund and Lincoln (2016) (see sidebar for a summary of this book) made this issue the centerpiece of their analysis of academic science. Although male scientists also experience conflict between their work as academic scientists and their desire to be parents, Ecklund and Lincoln found that this conflict is more intense for female scientists and that they are more likely to consider leaving academic science (or leaving science altogether) as a result. Their analysis focused on biologists and physicists, but it is reasonable to assume that something similar occurs among female engineers in academic settings.

Hunt (2016), however, questioned whether work/family issues are as important as these analyses indicate. Her study of the reasons for women's departure from science and engineering found that it is not related to the presence of children or to family-related issues. Rather, women are more likely than men to leave engineering for reasons similar to those that explain why women are more likely than men to leave other male-dominated fields, such as economics or financial management. As in those fields, female departures were related to pay and promotion opportunities. Hunt's conclusion is that "a lack of mentoring and networks, or discrimination by managers and co-workers, are the more promising of the existing explanations for excess female exits ..." (p. 221).

If Hunt turns out to be right that work/family issues are not the key to female departures from engineering, research by Barth, Dunlap, and Chappetta (2016) may suggest a possible reason. They surveyed more than 1,000 undergraduate STEM majors at a public university in the Southeast and another in the Midwest. They found that women were *both* more likely than their male partners to prioritize their student/work roles over

their romantic roles *and* to anticipate taking on more parenting responsibilities than their partners. Although these may seem to be partly in contradiction, the authors conclude that the women in their study may be finding a way to resolve the contradiction, at least in part: "rather than choosing between STEM careers and romantic relationships, female STEM majors may select partners who are supportive of their career paths." (p. 122). This may help them find the support at home they need to manage work/family conflicts later in life, after they have entered the workforce.

Clearly there is room for further research on how experiences at work affect female engineers' commitment to the field. The literature we reviewed this year provides interesting potential answers to the question of why women leave engineering, but does not answer it definitively. Nevertheless, it may be worth observing, at this point, that the existing research suggests that we may not be quite as far from the world occupied by the "computers" at the Harvard Observatory and 60s-era NASA as it initially appears. The research we reviewed argues that women are leaving engineering, at least in part, because they encounter a lack of opportunity, negative experiences at the hands of managers and co-workers, and a lack of support. While one cannot argue that nothing has changed, it is striking that these are problems that would be very familiar to those early computers.

OTHER THEMES

The low numbers of women in engineering were not the only focus on the literature we reviewed this year. Indeed, at the 2016 American Society for Engineering Education (ASEE) Annual Conference, many papers focused on themes we highlighted in last year's SWE literature review.

Two such papers were new additions to a growing set of work from a group of researchers primarily at The University of Oklahoma who have been studying student engineering competition teams (Pan, Shehab, Trytten, Foor, and Walden, 2016; Walden, Foor, Pan, Shehab, and Trytten, 2016). In this year's paper, Walden et al. presented findings from interviews with 17 faculty members who served as advisors for engineering competition teams (ECTs) for Formula SAE competitions and a

Human Powered Vehicle Challenge. The findings from these interviews echo findings presented in 2015, namely that advisors are hands-off and that exclusionary practices related to the teams are not being addressed. Walden and colleagues identified 11 belief categories related to team culture that were grouped into four themes: recruiting, integration, ethos of commitment, and lack of diversity. They found that most advisors:

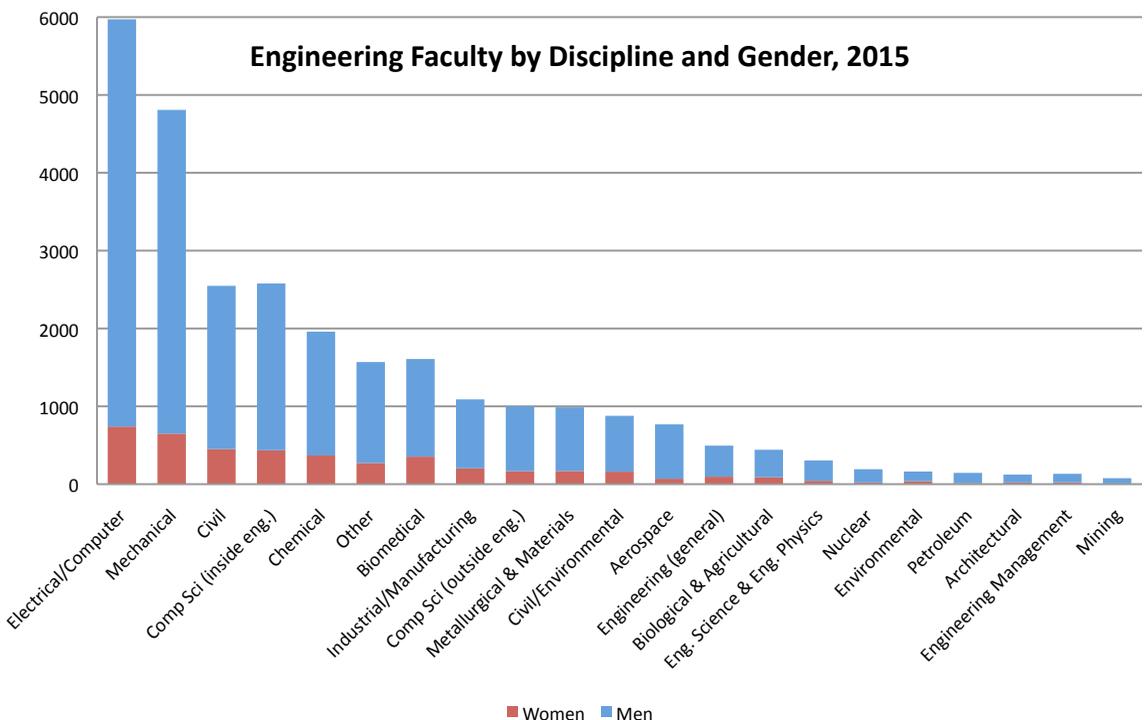
- describe themselves as hands-off and do not actively help new members gain skills or knowledge necessary to be successful on teams
- say that teams are open and welcoming to all but indicate that most participants join because a friend is participating, and new members have to take significant responsibility for finding their own place in the team and “sticking with it”
- believe that if a student deserves to be on the team, they will persevere
- recognize that an “extreme ethos of commitment” is required to participate on teams

- did not discuss race/ethnicity or gender without being prompted, but when prompted, admit that ECTs are “white man’s world”
- demonstrated belief in gender schemas by saying that women don’t like cars and are better at nontechnical leadership positions on teams

No advisors connected the lack of diversity to current recruiting and integration practices, and none described any active efforts to change the demographics of ECTs. Each of these findings supports data from students reported last year. They conclude that advisors do not have the skills or knowledge to promote more inclusive ECTs.

In the second paper by this group, Pan et al. presented findings from a nationwide survey of 116 students from 82 different institutions in the U.S. who had participated in an ECT. The findings supported those presented in 2015 from a survey at one institution, namely that the primary barriers to participation on ECTs are related to:

- Entry (recruitment and integration practices. Individuals are expected to overcome entry



barriers themselves)

- Persistence (structural obstacles such as ineffective processes for enabling new members to contribute, and expectation of extraordinary personal sacrifices, such as high time commitment each week)
- Legacy networks (subordinate members encounter obstacles to participation based on the lack of strong interpersonal relationships with more experienced team members, which becomes an issue when leaders are selected, for example)
- Lack of advisor engagement

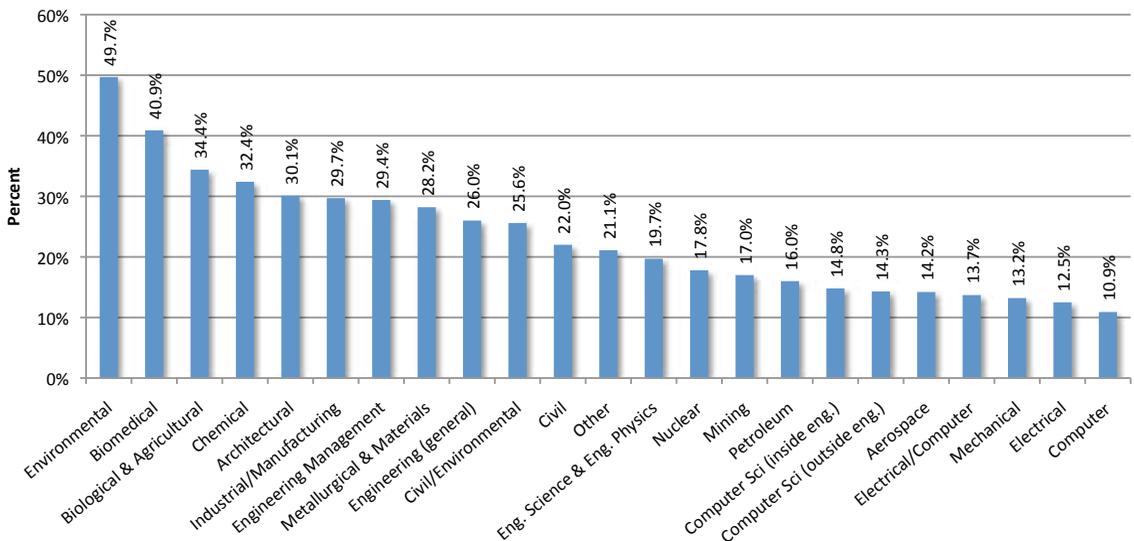
Also extending the teamwork theme we first discussed last year was a mixed-methods paper by Wolfe, Powell, Schlisserman, and Kirshon (2016) that examined the problems undergraduate students experienced during teamwork. The survey of 677 students from three different institutions and interviews with 63 students from seven different institutions revealed that women and underrepresented minority (URM) students were significantly more likely than men and non-URM populations to report two problems: domineering teammates and being excluded from the “main work” of the project.

Underrepresented minority females in particular

experienced more of every type of problem as compared with white or Asian females. Many women and URM students believe that their ideas are given less weight than majority students’/men’s and that their exclusion from important parts of the project negatively affected their grades and caused them to leave volunteer teams. The study also asked about how students responded to such problems and found that attempts to discuss the problems with teammates and faculty were often not helpful, and sometimes made the situation worse, resulting in an environment in which students simply decide not to bother informing instructors about problem teammates. They conclude that neither student nor faculty seem to have the resources and knowledge to effectively solve team problems around race and gender.

In addition to the papers on teamwork, there were papers that pressed into the world of intersectional analyses. For example, a work-in-progress paper examined written narratives and discussion of those narratives by eight black women in STEM (Thomas, Watt, Cross, Magruder, Easley, Mone-reau, Phillips, and Benjamin, 2016). This paper identified common experiences of isolation, a lack of support and encouragement, lack of faculty role

Percent of Bachelor's Degrees Awarded to Women by Discipline, 2015



models, and feelings of obligation to help others or serve as a role model. The authors frame their study through the theory of “womanism” and contend that womanism should be utilized more frequently to theorize the experiences of black women in STEM. Fleming (2016) broke down her data from a questionnaire about success factors for underrepresented minority students to highlight where African-American and Hispanic women differed from other populations in terms of why they chose engineering, the experiences of engineering programs, and their advice for others.

Yet, we also found a notable increase of intersectional papers on topics other than race or ethnicity at ASEE this year. Cech, Waidzunus, and Farrell (2016) explored “Engineering Deans’ Support for LGBTQ Inclusion” through a survey of 47 engineering deans and program directors and found that participants said they were somewhat or very supportive of many LGBTQ inclusion measures. They were not necessarily willing to commit resources to those measures, however, and were generally unsupportive of the most resource-intensive measures, such as hiring initiatives for openly LGBTQ engineering faculty. Participants also believed that their own support for inclusion measures was greater than that of most of their faculty members, which led the authors to conclude that deans may resist inclusion measures because of their perceptions of faculty beliefs rather than their own beliefs. Statistics reported in the paper also led the authors to conclude that deans greatly underestimated the extent of heteronormativity and heterosexism in engineering departments. This is an ongoing project, and the next phase will focus on students’ and faculty members’ experiences and attitudes.

Four other ASEE papers are worth mentioning here in the context of growing interest in LGBTQ issues, non-normative identities, and intersectionality. The first is a literature review of the use of Wendy Faulkner’s technical/social dualism, which aims to advance critiques of binary gender schemes in order to allow for greater expression of multiple intersections of gender and sexuality with other social identities (Leyva, Massa, and Battey, 2016).

The second is a literature review on identity literature, in which one of several problems identi-

fied was that intersectionality is underutilized and undertheorized in the identity literature (Patrick and Borrego, 2016). This literature review also nicely summarizes what is known, and what is not known, about gender and STEM identities, including, importantly, the relationship between identity and persistence, and should be a go-to starting place for researchers wanting to delve into identity research on women in engineering.

Third, recognizing that improved theorizing about non-normative identities requires new data-collection methods, specifically around collection of demographic data, Fernandez et al. (2016) discuss the complexities of collecting demographic data on all types of minority populations and suggest specific strategies and advice for researchers who want to better account for complexities of nuanced identities, including sexual orientation, gender identity, family arrangements, and race/ethnicity, in their data collection.

Lastly, in a fourth paper that is part of an ongoing, mixed-methods project, that same group of researchers demonstrates how they are utilizing new data collection and data analysis techniques to advance understandings of non-normative identities in engineering (Kirn et al., 2016). It is worth noting that while they did not specifically set out to study teamwork, the qualitative data presented in this paper relates back to the teamwork theme discussed above by highlighting that problems women encounter often occurred in the context of teamwork.

Aside from these ASEE papers, however, we found only one journal article on LGBTQ issues. In 2013, Yoder and Mattheis (2016) surveyed 1,427 LGBTQ individuals who were working in STEM fields in both academia and industry (21 percent were from engineering). The research found that respondents were more open in their personal than in their professional lives, but that there was a positive correlation between the percentage of women in the field and levels of openness in professional life. Those who reported a high degree of openness in the workplace also were more likely to describe their workplace as safe and welcoming and to have positive things to say about their employers’ support for LGBTQ needs. The study found more positive experiences

than previous research on these issues; the authors note, however, that they may be missing negative experiences among those who chose to leave the STEM pipeline.

Several ASEE papers also contributed new data to last year's discussion of sexual harassment and also broke down data by underrepresented minority (URM) students (Fitzpatrick, Romero, and Sheridan, 2016). Items on harassment and stereotyping were added to a climate survey of one college of engineering that included 733 men and 237 women, of which 45 were URM, in 2008; and 714 men and 287 women, of which 70 were URM, in 2015. In 2008, women reported significantly higher rates of stereotyping and harassment (such as being singled out in class, faculty expressing stereotypes, and sexual harassment from other students) than men reported, and URM students reported higher rates of racial stereotyping and harassment than majority students reported. In 2015, more than 38 percent of students reported hearing other students express gender stereotypes, 37 percent of students reported hearing other students express racial stereotypes, 58 percent of women reported hearing other students express gender stereotypes, and 55 percent of URM students reported hearing other students express racial stereotypes.

Further, two troubling findings related to changes over time were that in 2015 professors, student interactions, and engineering self-efficacy were all rated significantly lower than they were in 2008, and that of the six stereotyping/harassment items included in both years, four items were endorsed at higher levels in 2015 than in 2008. Those items were: singled out because of race, faculty express race stereotypes, singled out because of gender, faculty express gender stereotypes. However, two items (sexually harassed by faculty, and sexually harassed by other students) were endorsed at lower rates in 2015. These findings raise questions about whether some problems are occurring at higher rates, or whether they are being "seen" and reported at higher rates. If the former, this study would undermine the oft-heard assertion that gender biases are slowly going away and will continue to decrease as the older generations of men retire.

Furthermore, evidence of harassment was found in a study about workplaces climates. Yonemura and Wilson (2016) also concluded that men do not experience negative work environments in the same ways as women do, or evaluate negative work experiences by the same criteria as women (based on interviews with 16 male and 29 female computer science graduates). Sixty-nine percent of women discussed some aspect of a hostile work culture, including discrimination and harassment. And, in a related survey of female STEM faculty intended to measure subtle gender biases and microaggressions (Yang and Carroll, 2016), 25 percent of the participants had experienced stereotypes of women or were objectified on their physical appearance, 40 percent had been either ignored in a professional setting or had been challenged regarding their authority, 25 percent had been told women's work would be inferior to men's work, or told they were "too assertive or sassy." Differences were found based on rank, position, age, and ethnicity, and the authors conclude that further research is needed to sort out differences among departments and other contexts.

WHAT CAN BE DONE?

As we indicated at the outset of this review, popular books and films such as *The Glass Universe* (2016) and *Hidden Figures* (2016) remind us that women played an important role in engineering and science even when they were more or less invisible participants in the STEM workforce. They also put contemporary engineering and science in context — it is obvious that things have indeed changed, at least to a degree. The scholarly literature we reviewed, however, reminds us that the amount of progress toward the full gender integration of engineering and science has been limited. It also reveals the multiple forces that make this integration so difficult and draws attention to the many things that need to happen if gender equality in these fields is to be achieved.

Although scholarly researchers have revealed significant obstacles to the gender integration of engineering and science, they also have described things that have worked, or have the potential to work. Readers of this literature learn that some of the factors that have been identified as

obstacles to increasing the numbers of women in engineering can be overcome, with appropriate effort, resources, and commitment. A review of the literature is, thus, simultaneously an experience of frustration at the limited progress and optimism that change is at least possible.

As noted earlier, some researchers have found that women are not attracted to engineering, or leave the field after entering it, because they have doubts about their ability to succeed. However, Ro and Knight (2016) present evidence that pedagogical choices can have a positive influence on women's evaluation of their own abilities and potential. While women in their study typically reported that they had lower design skills than men — whether or not this was actually the case — women who described having instructors who used more student-centered teaching methods and who experienced a stronger emphasis on professional skills in their coursework reported higher design skills. Thus, simple changes in pedagogical approach can increase the chances that women will enter and/or stay in the field. However, these findings must be considered in light of other research reported last year and below that shows how teamwork is often a site for the manifestation of gender biases, and any pedagogical choice should be made with an effort to ensure equality, not an assumption that it exists.

Ro and Knight also found that women who participated in nonengineering co-curricular activities reported having greater fundamental skills, contextual competence, and communication skills. They conclude that this likely reflects the benefits of having found support from other women in those activities (something that was harder to find in male-dominated engineering). If they are correct, this points to the potential for change in providing female engineering students and practicing engineers with support from female peers.

Work/family conflict has been identified as a factor contributing to women's departure from engineering careers. Ecklund and Lincoln (2016), in their study of academic science, emphasize that this can (indeed *must*) be addressed by policies that move society away from the idea that a scientist (or engineer) must be an "ideal worker" who puts work before everything and is willing and able to

delegate their family responsibilities to a partner at home. In academic science, this means providing on-site day care, providing better child care benefits, and making leaves and tenure clock stoppages automatic, not something that requires special permission. While the policies needed outside the academy might take different forms, one of Ecklund and Lincoln's central arguments would appear to apply to a wide range of employment contexts: The policies cannot be available only to women. They argue that such policies must apply universally both because increasing numbers of men are dissatisfied with (and sometimes leave) scientific careers because they prevent them from devoting the time they would like to family and because, if the opportunities are only for women, they will not gain the broad, cultural acceptance that is needed to allow individuals to take advantage of them.

The progress of women in academic engineering has been greatly aided by the efforts of the various ADVANCE programs funded by the National Science Foundation. Two articles we reviewed this year reported on what has been accomplished at individual universities that participated in the program.

Stepan-Norris and Kerrissey (2016) reported on the effects of the ADVANCE program at the University of California, Irvine, the first such program in the California system and one of the earlier programs funded by NSF. They note that the university opted to support the program beyond STEM fields, indicating a high level of institutional commitment. They found that the program had resulted in a significant increase in the percentage of female faculty, an increase that was greater than those at other comparable public institutions in the state. However, they found that the effect of the program had primarily been on hiring, not retention (where Irvine actually had below average results for the state system). They concluded that this was largely because the focus of the program was on the recruitment process; in that sense, Irvine's program successfully achieved what it had set out to do.

Stewart, Malley, and Herzog (2016) described the results of another early ADVANCE program, this one at the University of Michigan. They found that the effects of the program varied by

department: Some departments experienced substantial change, others some change, and several experienced little or no change at all. What accounted for the different outcomes? The authors found that change was enabled when there was strong leadership supporting the change, when the disciplinary context was favorable, and when the department had a negative past experience or experiences that could be used to mobilize support for positive change. In departments where issues besides diversity were viewed as more important and/or where the context was unfavorable, efforts to change were more likely to fail.

These experiences from the academic world demonstrate that it is possible to move the gender “needle” if an organized, well-funded effort to do so is put in place. Nothing is guaranteed, of course, as the unsuccessful aspects of these programs demonstrate. With strong leadership and a willingness to make change a priority, however, much has been and can be accomplished. It would be interesting indeed to see what would be the results of a program like ADVANCE *outside* the context of academic engineering and science.

Researchers who focus on the issue of creating gender integration in engineering continue to emphasize the importance of moving beyond an approach that involves “fixing the women,” of requiring them to adapt to institutional arrangements designed for a largely male workforce. They contend that increasing the numbers of women in engineering requires engineering to change — to become less obviously gendered in all sorts of ways. At the same time, one of the more interesting findings in the research we reviewed this year is that women’s departure from engineering careers is linked not just to the differences between women and men but also to their similarities. As the SWE study of why women leave engineering found, women, like men, want to be given opportunities, to be supported, and to find that they are able to pursue the goals and objectives their workplaces say they are supposed to pursue.

A review of this year’s scholarly literature on women in engineering, therefore, leaves one with a sense that there is a dual project to be completed. On the one hand, engineering needs to become less gendered and to move in directions that make

it both more consistent with women’s goals and objectives and more accommodating of their needs and concerns. On the other hand, whether or not it becomes less gendered, engineering must treat men and women the same — provide all with opportunities for advancement and support. Progress on either of these fronts would certainly improve matters. But, it is likely that full gender integration of engineering requires progress on both.

Finally, as we reflect on the competing and sometimes contradictory findings from this year’s literature, we wish to reiterate one of our suggestions for future research from last year: meta-analyses that look across disciplines to make sense of conflicting findings and provide grounds for moving forward to advance research. Given the wide range of methods, populations, sampling, and analysis techniques in the literature, critical meta-analyses, or systematic reviews, could help make sense of the lack of consensus we continue to see around key questions that arise year after year. The lack of consensus is also a good reminder to be cautious of making claims about “women” in engineering as a homogeneous group who all share the same values, goals, and beliefs.

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