International Journal of Gender, Science and Technology
http://genderandset.open.ac.uk

Gender and Career Outcomes of U.S. Engineers

Lisa M. Frehill

Energetics Technology Center, USA

ABSTRACT
Why are women more likely than men to leave the U.S. engineering workforce? This article analyses existing, nationally-representative data about engineers in the United States to answer this question. Two types of factors are considered: factors associated with balancing work/family; and those associated with the relative success of moving into managerial work away from technical tracks, a common engineering career path. The data are the U.S. National Science Foundation's Science and Engineering Statistical Data System for 2006 and provide the most comprehensive data about the U.S. science and engineering workforce. While U.S. engineering women are more likely than their male peers to indicate that family-related reasons were part of the reason for not being in the field, this reason was less important than were "changes in career or professional interests." Consistent with previous research, men are more likely than women to move into managerial careers and to indicate that they have left engineering for "pay or promotion opportunities."

KEYWORDS
careers; gender; engineering; work-life balance; SESTAT

This journal uses Open Journal Systems 2.2.2.0, which is open source journal management and publishing software developed, supported, and freely distributed by the Public Knowledge Project under the GNU General Public License.

The Open University

Gender and Career Outcomes of U.S. Engineers

INTRODUCTION AND CONTEXT

Despite the recent economic downturn, U.S. demand for engineers remains robust: the Bureau of Labor Statistics projects a need for 178,300 more engineers in the next decade with the fastest growth in biomedical, civil, environmental, industrial, and petroleum engineering. Only chemical engineering, which traditionally attracts a high proportion of women, is projected to decline. Further, new engineering bachelor's degree graduates continue to earn relatively high starting salaries and the engineering unemployment rate of 7.7% is lower than the 9.6% for all workers (Izzo, 2011). This robust demand has been underscored in reports by the U.S. National Academies (2006 and 2011), indicating a broad-based, strong national-level interest in increasing recruitment to engineering.

However, retention is another way to increase the supply of engineers. Work by Regets (2006 and 2010) using the U.S. National Science Foundation's (NSF's) SESTAT[1] database system shows that many individuals who have earned bachelor's degrees in the sciences and engineering are employed in non-science and engineering fields, yet report that their work draws upon science or engineering knowledge. In addition, Regets' work documents that the movement into management or sales by those with science or engineering training is not viewed by these occupants as out of field even though it is often lamented as such by policy analysts.

The larger U.S. labor market in which engineers find themselves after completing a bachelor's degree has been undergoing rapid and accelerating changes, most notably associated with globalization as a broad trend. On the one hand, a technical education in science and engineering (S/E) has become even more important (National Academies, 2006). On the other hand, many young people are concerned about the "outsourcing" of S/E jobs and employers are increasingly concerned about the quality of the labor force (National Academies, 2006) and whether the U.S. labor force will be able to remain competitive in a global environment. Recent reports, such as the update to "Rising above the gathering storm" (National Academies, 2011) refer to a potential shortage of U.S. engineers and other science-trained workers as posing a threat to economic security and the innovative capacity of U.S. corporations.

LITERATURE REVIEW

Past research has described attrition of women from college engineering programs (Wolffram, Derboven and Winker 2009; Seymour and Hewitt 1996; and Frehill-Rowe 1993) but to date there has been little systematic research on career outcomes for women in engineering after they earn their bachelor's degrees. In the United States, McIlwee and Robinson's 1992 volume included data from a survey and interviews with women working in engineering jobs in California and concluded that most women experienced sexism. A national survey by the Society of Women Engineers (SWE) in 1991-1992 revealed that women were more likely than men to

indicate that they felt that women had been overlooked for promotional opportunities (Eng, 1993; and Frehill, 1997) but the sampling methodology – members of professional engineering societies – meant that few respondents had left engineering. A more recently commissioned study by SWE in 2005 was designed to capture the views of those who had left the field in comparison to those who had stayed. This study found that women were, indeed, more likely than men to exit engineering (Frehill, 2007).

In her more general study of occupational exit from scientific careers, Preston (2004) cites similar reasons using data from the National Science Foundation as well as her own survey of science and engineering college alumni and a paired-samples interview strategy. Preston's interviews of men and women followed a pairing method in which interviewees were matched within gender, education level and field, age, and family situation so that the principal difference between the matched interviewees was that one had left and the other had persisted in a scientific (or engineering) career. Preston's results about the role of sexism and the double standard were more nuanced than those of McIlwee and Robinson or SWE, emphasizing a stronger impact of the lack of mentoring for women's retention, while for men, the higher prestige and salary and greater responsibility associated with managerial careers were critical in men's decisions to move away from science. According to Preston: "sex discrimination and double standards were only secondary factors in exit decisions as they contributed to low levels of mentoring, a mismatch of interests, and difficulties in shouldering the double burdens of family and career." (Preston 2004, p.35). It is important to note, though, that entry into U.S. science and engineering differ: while scientists are generally trained at the graduate (and usually the doctoral) level, engineers enter their fields directly after completing undergraduate degrees. Hence, the aggregation of scientists and engineers can make it more difficult to understand important gender lifecycle implications that can impact engineers' career outcomes differently than those of scientists in such studies.

Some have argued that there has been a recent revolution of professional women "opting out" of the workforce for more rewarding roles as mothers (Belkin, 2003). Contrary to the journalistic account in a highly-publicized *New York Times Sunday Magazine* article, Cheeseman Day and Downs (2009) found no support for such a revolution. Indeed, Cheeseman Day and Downs used more valid and reliable U.S. American Community Survey data to show that women in occupations that were both low-paying and had relatively low educational requirements were the most likely group to leave the workforce after the birth of a child, possibly due to the lack of economic resources for childcare. Further, women who had children over a year old at home were no less likely than women without children to be employed full time.

Salary and advancement are also important in engineering retention/attrition. While much has been made about salary differentials, analyses of engineering salaries reveal parity between women and men (Frehill 2011 and Eng 1993). Eng noted that the pay of engineers reported in the SWE survey was near parity until about age 30, at which time, a gap between women and men grew and widened with age, a

finding that she posited might disappear as more women entered engineering. Morgan's (1998) analysis of these data suggested that cohort effects were responsible for the gap in earnings, which means that women and men in more recent cohorts are closer in salary than their predecessors. Engineering salaries tend to be high relative to other occupations (Frehill, 2011; and Beede et al., 2011), which provides women engineers with more economic resources to manage family responsibilities.

Advancement can also be an important reason why those who have college-level training in engineering may leave the field. Among U.S. engineers, for example, just under 6 percent of the 2.6 million workers employed in engineering occupations are in engineering management positions (Frehill 2010b), which are counted separately from three other engineering job titles (the other three are "engineering," "engineering technician," and "sales engineer"). In addition, engineering is a feeder field for upper level positions in U.S. corporations with engineering the most common undergraduate major of U.S. corporate CEOs. The most recent analysis of CEO educational backgrounds found that 22 percent of Fortune 500 CEOs had undergraduate engineering degrees (SpencerStuart, 2011).

Outside the United States there has been interest in understanding how gender affects engineers' careers. The Women in Engineering Committee of Engineers Australia has studied women's retention in engineering via two studies. The first, with data collected in 1999 (Roberts and Ayre, 2002) documented the many interpersonal and structural problems that women engineers encountered working as engineers in Australia. Like their sisters in other English-speaking advanced economies such as the United States, Australian women engineers often were the only woman within their organization or in their geographic area and were less satisfied with their careers than their male counterparts. Work organizations were not very responsive to women's needs. According to Roberts and Ayre:

> *Many engineering organisations have underlying values that are unfriendly, and even hostile, to women because they are based on male defined priorities, values and life choices. Hostile corporate practices include an assumption that commitment is demonstrated by working long hours, sacrificing family and personal time, and exhibiting high levels of aggression and competitiveness.* (Roberts and Ayre 2002, p.7)

A recent update of these results, however, documents that the work climate for women engineers in Australia, like that for women in the United States (Frehill 2009) appears to be improving. Although women are significantly more likely than men to be less satisfied with their chances for advancement, with attention to their suggestions and with industrial relations between management and workers, these were the only three sex differences in the updated study. On 15 other key indicators of satisfaction (including the overall measure) there were no sex differences. Indeed, both women and men were more satisfied in 2007 with their jobs as engineers than in 1999 and the sex gap in satisfaction had fundamentally disappeared (Mills et al., 2008).

A more recent mixed methods study of engineers in Australia (Gill et al., 2008) built upon the earlier work by Roberts and Ayre. Key findings from this study suggest that women's retention in engineering is associated with systemic issues in Australian engineering culture that is shaped by hegemonic masculinity (Connell, 2001), creating an unwelcoming work environment for women. Early findings by Fouad and Singh (2011) suggest this may also be the case for women in engineering careers in the United States.

In Europe, two cross-national collaborative projects focused attention on women in engineering using mixed methods approaches. The Womeng Project (2002-2005) explored how to increase the number of women studying engineering in college and how to retain women in engineering careers in the labor force (Pourrat 2005). A similar project, with many of the same collaborators, was started on the heels of Womeng in 2005 and completed in 2008. The second project, PROMETEA, focused on women engineers in industrial and academic research, which meant a stronger emphasis on women with advanced degrees rather than merely first or second tertiary credentials[2] (ENSC/CEDIS, 2008).

Using interviews with women engineers, the Womeng team focused on the various practices within workplaces that disadvantaged women engineers. For example, a lack of transparency in internal advancement processes was problematic as was "presenteeism," which was defined as a belief that part-time workers were not as committed to their careers as were full-time workers. While all seven nations had laws associated with parental leave, when a woman returned from such leave, it was not guaranteed that she could return to her same job, just to the same company (Pourrat, 2005).

Findings in this study about women in engineering workplaces in seven European nations did not differ markedly from the more recent ones by Fouad and Singh (2011) in the U.S. context. Without comparisons to men though, (both studies involved interviews with women only), the complaints of the women who were interviewed may reflect deeper problems in engineering workplaces rather than issues associated with gender. Such qualitative studies nevertheless provide useful complements to the quantitative work presented in the present article.

DATA AND METHODS

In this paper, I drill further down into the same data that Regets used to describe career outcomes of engineers and, in particular, women engineers. These nationally-representative data will show that there are some important similarities between women and men engineers once they are in the labor market. Significantly, though, these data provide some evidence for what many have known anecdotally all along: women are more likely to leave engineering post-graduation than are men.

Research Questions

Q1: Are women less likely to stay in engineering because of work/family issues?

Q2: Are women more successful than men in moving to engineering managerial work?

Data

The data are from the National Science Foundation's (NSF) public use SESTAT 2006 data, which includes data from three surveys:

- National Survey of College Graduates (NSCG)
- National Survey of Recent College Graduates (NSRCG)
- Survey of Doctorate Recipients (SDR).

The data were collected in 2006 with all cases assigned appropriate statistical weights by the data provider. Sampling was complex and drew from three separate populations associated with each survey. All were stratified random samples and are considered representative of the U.S. science and engineering workforce. For more details, visit http://www.nsf.gov/statistics/sestat/ and Kang (2007). All analyses in this paper were weighted, as recommended by the NSF.

Defining Engineers

There are many ways that one can define engineers using these data. Information is available about respondents' highest degree, first bachelor's degree, and most recent degree as well as their current job. For this paper, I selected for analysis those individuals who reported that their first bachelor's degree, most recent degree, and highest degree were all in engineering. This seemed like the "cleanest" –and most conservative—way to define engineers so that the complications associated with possessing degrees in various fields would not be present in the analyses that will be presented herein.

A further restriction on the sample was made to those who had earned their highest degree in 1971 or later, when women began entering engineering programs of study in increasing numbers. While there was a cohort of women who completed engineering programs during the Second World War (e.g., see Meiskins et al 2011), up until 1972, U.S. engineering schools were legally permitted to deny women entry and, in many cases, schools did bar women. In 1972 Title IX prohibited this discrimination and laid the groundwork for employers and universities to rectify past discriminatory practices (U.S. Department of Labor 2012). After 1972, women's participation in engineering grew quite rapidly: in 1977 women accounted for 4 percent of U.S. engineering school graduates at the first tertiary level and peaked at 20 percent in 2002 with current (the most recent available data are for 2009) representation at 18 percent (Frehill 2011). With the degree and the degree year restrictions, together, there were 17,004 unweighted cases available for analysis representing a little over 2.1 million U.S. engineers.

Dependent Variable

Retention in engineering was the primary dependent variable. As with defining engineers, so too multiple definitions of retention are possible. For this paper, I

used a definition that entailed both subjective and objective elements. The SESTAT data include respondents' answers to the following item: *To what extent was your work on your principal job related to your highest degree?* To which three response categories were available: "Closely related," "Somewhat related," and "Not related." Those who answered "Not related" to this item were coded as having "left" engineering. Second, the SESTAT data include individuals' current labor force status, coded as "Employed," "Unemployed" and "Not in the labor force." Those who responded that they were "Not in the labor force" were also considered to have "left" engineering. Unemployed people, within the U.S. government definition of the term, are active job seekers. Therefore, even though these individuals are not employed, it is not clear whether they have "left" engineering.

The retention rate was computed as follows:

$$Retention = 1 - \frac{(\#\, job\ not\ related\ to\ eng.)_S + (\#\, not\ in\ labor\ force)_S}{respondents_S}$$

where S = Sex (female, male) and retention is represented as a percentage of individuals who are still in engineering.

Independent Variables

Sex was the chief independent variable but there were a number of others used to answer the research questions. The analyses of retention rate also controlled for the year the respondent graduated with his/her highest engineering degree in five-year increments. Other independent variables were derived from the survey items described in Table 1.

Table 1: Independent Variables Associated with Research Questions

Research Question	Survey Items and Variables
Q1: Work /family issues	• Not working because of family-related reasons. • Not in field because of family-related reasons[3]. • First or second reason for not working in field is because of family-related reasons (originally two survey items, combined into one).
Q2: Movement into management.	• Current job is in management or administration. • Primary work activity is management or administration. • Supervise employees.

The hypotheses associated with the research questions were:

H_1: Women are more likely than men to leave engineering due to family-related responsibilities.

H_2: Women are more likely than men to leave engineering due to movement into managerial positions[4].

Methods

Analyses were performed using SPSS for Windows. Because most variables were nominal-level indicators, the predominant technique was cross-tabulation with the likelihood ratio chi-square the chief inferential statistic and alpha set at 0.05 but statistical significance reported for $p \leq 0.05$ and $p \leq 0.01$. Control was exercised via multi-layer crosstabs and sample restrictions to produce readily interpretable multivariate outcome measurements.

Results

The overall retention rate for women was 70 percent while for men it was 86 percent. Figure 1 shows retention by sex and the year of the individuals' highest degree: all of these gaps were statistically significant using the standard test of proportions. The widest gap between women's and men's retention was for the cohort that had graduated with their highest engineering degree in 1976-1980 with 34 percent more men than women retained in engineering. This gap was also large for those who graduated in 1991-1995 with 24 percent more men than women still in engineering in 2006 who had graduated with their highest engineering degree during this period.

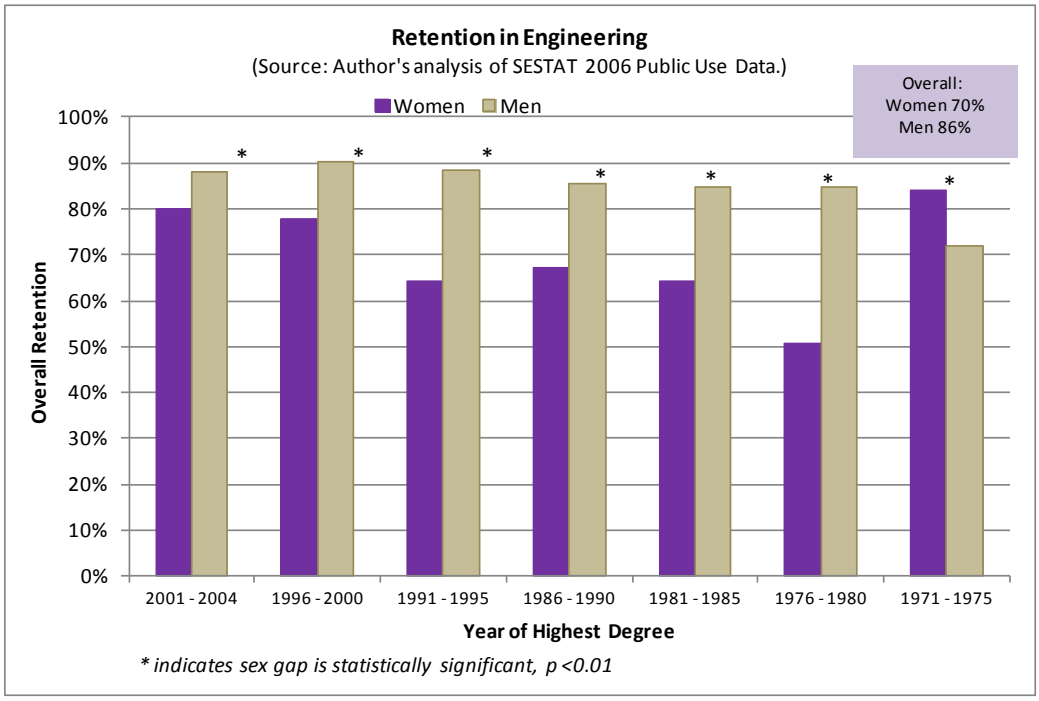


Figure 1: Retention in Engineering by Sex and Year of Highest Degree

As shown in Figure 1 women are slightly less likely than men upon receipt of their degrees to be employed in engineering with a similar gap up until about ten years after they receive their degrees. Both men and women leave engineering within the first ten years of earning a degree, but women do so at a more rapid rate than do men. But as the percentage of men who no longer report working in engineering levels out, women in older age cohorts have left the field at higher

rates except for those who had received their highest degrees between 1971-1975, a cohort in which women were more likely than men to still be in engineering.

Table 2 shows the basic descriptive variables used in the analyses including the two variables used to compute the retention rate (labor force status and relationship of job to degree field) and year of highest degree by sex. Women engineers were more likely than men engineers to be both unemployed and not in the labor force (χ^2 = 232.3, 2 d.f., p = 0.000). Not surprisingly, whereas men engineers in SESTAT2006 were nearly evenly distributed across the seven five-year degree cohorts, women were increasingly present in the more recent degree cohorts (χ^2 = 875.4, 7 d.f., p = 0.000). Finally women were less likely than men to indicate that they were in a job that was closely related to engineering (47 percent of women versus 55 percent of men) and were more likely than men to report that their job was "not related" to engineering (χ^2 = 58.0, 2 d.f., p = 0.000).

Table 2: Basic Descriptive Variables

	Women	Men	Total
Labor force status			
Employed	82.2%	94.7%	92.9%
Unemployed	3.3%	1.6%	1.9%
Not In Labor Force	14.5%	3.7%	5.3%
Year of highest degree			
1971 - 1975	1.1%	9.3%	8.1%
1976 - 1980	6.6%	10.9%	10.3%
1981 - 1985	13.6%	15.9%	15.5%
1986 - 1990	17.4%	16.6%	16.7%
1991 - 1995	18.5%	17.0%	17.2%
1996 - 2000	19.0%	14.9%	15.5%
2001 - 2004	23.8%	15.5%	16.7%
Total	315,530	1,819,786	2,135,316
Relationship of job to degree			
1: Closely related	47.1%	55.1%	54.1%
2: Somewhat related	34.5%	33.7%	33.8%
3: Not related	18.4%	11.2%	12.2%
Total	259,220	1,723,643	1,982,863

Note: Author's weighted analyses of SESTAT2006 public use datafile.

Question 1: Family-Related Impact on Engineering Retention

Results of a comparison of women's and men's responses to four survey items that asked respondents about reasons for either working outside their field (three items) or for being outside the labor force (i.e., not working in paid employment) are shown in Table 3.

Women are more than twice as likely than men to report that family-related reasons were associated both with not being in the labor force (χ^2 = 264.8, 2 d.f., p = 0.000) and with not working in their highest degree field (χ^2 = 23.2, 2 d.f., p = 0.000). Overall, 46 percent of women but just 20 percent of men indicated that "family related reasons" were one reason for not working in the field of their highest degree. But, as shown in Table 3, "family-related reasons" were not the

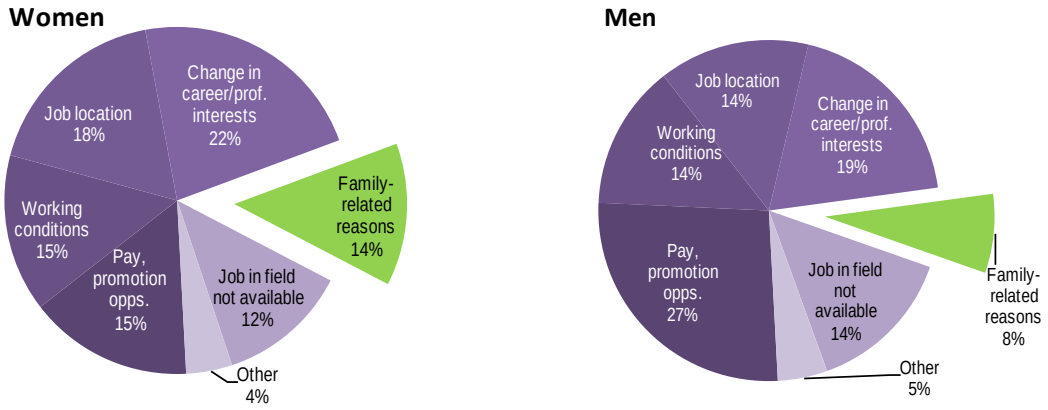
primary ones. The reasons that men and women cited when asked about the most important and second most important reasons for not working in their highest degree field were significantly different (χ^2 = 59.8, 6 d.f., p = 0.000) for most important and (χ^2 = 14.9, 7 d.f., p = 0.038) for the second most important reason. For women, the most important reason cited was “change in career or professional interests (26 percent), while for men it was “pay, promotion opportunities” (31 percent), with women half as likely to report this reason.

Table 3. Question 1 - Family-Related Impact on Engineering Retention

	Women	Men	Sex Gap*	Total
Percent indicating "Yes" to "Family-related" reasons for not working in field of highest degree.	45.8%	20.4%	25.4%	25.5%
Most important reason for not working in field related to highest degree.				
Change in career or professional interests	25.9%	19.8%	6.2%	21.0%
Family-related reasons (e.g., children, spouse's job moved)	18.5%	5.6%	12.9%	8.2%
Job in highest degree field not available	16.0%	17.7%	-1.7%	17.4%
Pay, promotion opportunities	15.4%	30.8%	-15.4%	27.8%
Job location	10.0%	9.0%	1.0%	9.2%
Working conditions (hours, equip., working envir.)	7.8%	9.8%	-2.0%	9.4%
Other reason for not working	6.4%	7.2%	-0.8%	7.0%
Second most important reason for not working in field related to highest degree				
Job location	22.7%	16.4%	6.2%	17.7%
Working conditions (hours, equip., working envir.)	19.2%	14.6%	4.6%	15.5%
Pay, promotion opportunities	12.6%	16.6%	-4.0%	15.8%
Family-related reasons (e.g., children, spouse's job moved)	5.9%	7.8%	-1.9%	7.4%
Job in highest degree field not available	6.4%	7.5%	-1.1%	7.2%
Change in career or professional interests	14.9%	14.4%	0.5%	14.5%
Other reason for not working	1.5%	1.2%	0.3%	1.2%
No second most important reason	16.9%	21.5%	-4.6%	20.6%
Total	47,701	193,393		241,094
Percent indicating "Yes" to "Family-related" reasons for being out of the labor force.	63.2%	9.7%	53.5%	29.5%
Total	56,310	96,143		152,453

**Note: Sex Gap = Women - Men*

Figure 2 shows pie charts for the combined responses on the most and second most important reasons respondents gave for working outside of their highest degree field. Women (14 percent) were twice as likely as men (7 percent) to indicate that family-related reasons were one of the top two most important reasons for not working in a field related to their highest degree. While 27 percent of men overall cited “pay, promotion opportunities” just 15 percent of women did so. Finally, “working conditions” were about as likely to be cited by men (14 percent) as women (15 percent).



Note: numbers may not sum to 100 due to rounding.

Figure 2: Important Reasons for Not Working in Highest Degree Field.

Question 2: Movement into Management

There were several ways in which engineers' movement into management could be captured within the SESTAT 2006 data. Table 4 shows results associated with three of these variables. In all cases, women are significantly less likely than men to report that they were involved in managerial occupations. In this case, though, the focus is not on line management jobs, such as contracts and accounting, but on management jobs that are in the chain-of-command to the top of many organizations. Table 4 shows that women engineers are less likely than men to supervise employees, to report that "management and administration" was their primary work activity and to report working in top or middle level management.

Table 4: Question 2 - Management Variables

	Women	Men	Total	Chi-Square	d.f.	p
Percent who:						
Supervise employees	33.4%	48.8%	46.8%	192.4	1	0.000
Primary work activity is management and administration	20.1%	26.4%	25.6%	194.2	13	0.000
Reported occupation as "top and middle-level managers, executives and administrators"	4.0%	6.4%	6.1%	461.0	25	0.000
Total	259,221	1,723,642	1,982,863			

Simultaneous Impacts of Degree Cohort and Sex

Figures 3 and 4 provide evidence that even when cohort is controlled, there are substantial (and statistically significant) differences between women and men in

terms of engineering retention. Figure 3 shows that within every age group, women are much more likely than men to indicate that family-related reasons such as children or their spouse's job move were why they were not currently employed in a field consistent with that of their highest degree (i.e., engineering). Family issues are often popularly framed to emphasize the additional responsibilities women take on with child-bearing/rearing (see, for example, Belkin, 2003). But this is a limited view of "family issues," which have come to include elder care responsibilities. Women are also more likely than men to be responsible for care of elder relatives in what the U.S. Bureau of Labor Statistics has termed the "sandwich generation" (Pierret, 2006).

The likelihood of serving as a supervisor tends to increase over the career course. Younger employees are less likely to supervise the work of others than are older employees. So, given that women are more highly represented in the younger degree cohorts while men are fairly evenly distributed across the degree cohort groups, it is possible that the net effect, shown in Table 4, that just 33 percent of women but 49 of men overall supervised employees, could be an artifact of the different degree cohort distribution of women and men. However, Figure 4 shows that this is not the case: that within each degree cohort, women are significantly less likely than men to supervise the work of others, reflecting a possible glass ceiling effect.

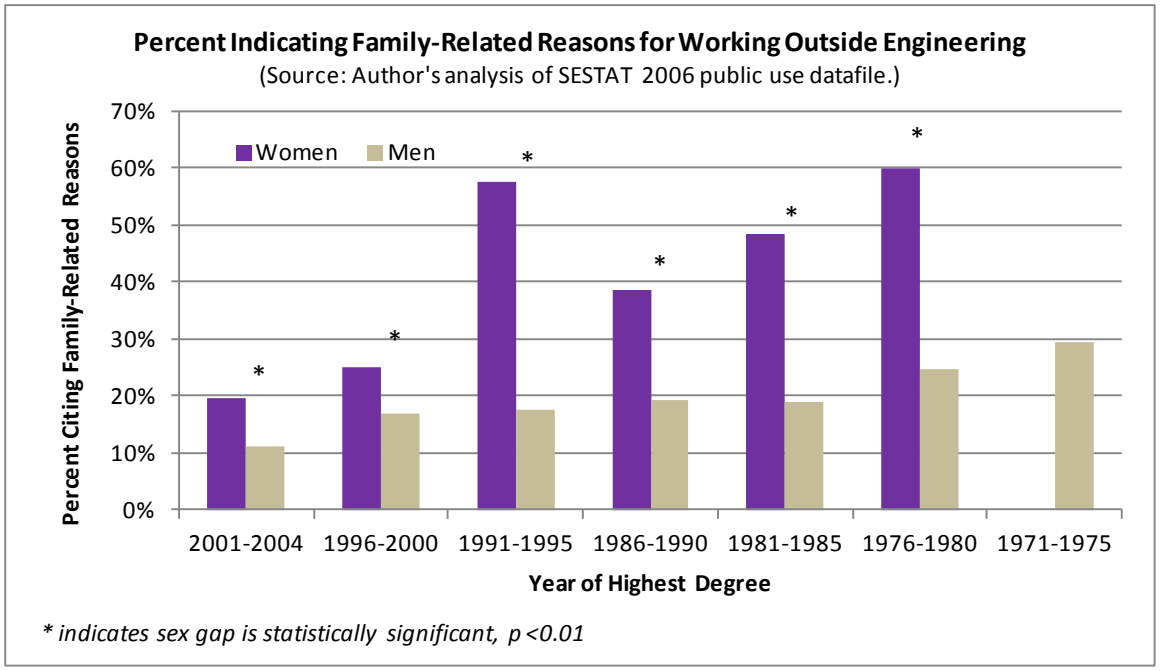


Figure 3: Family-Related Reasons for Attrition from Engineering by Degree Cohort and Sex

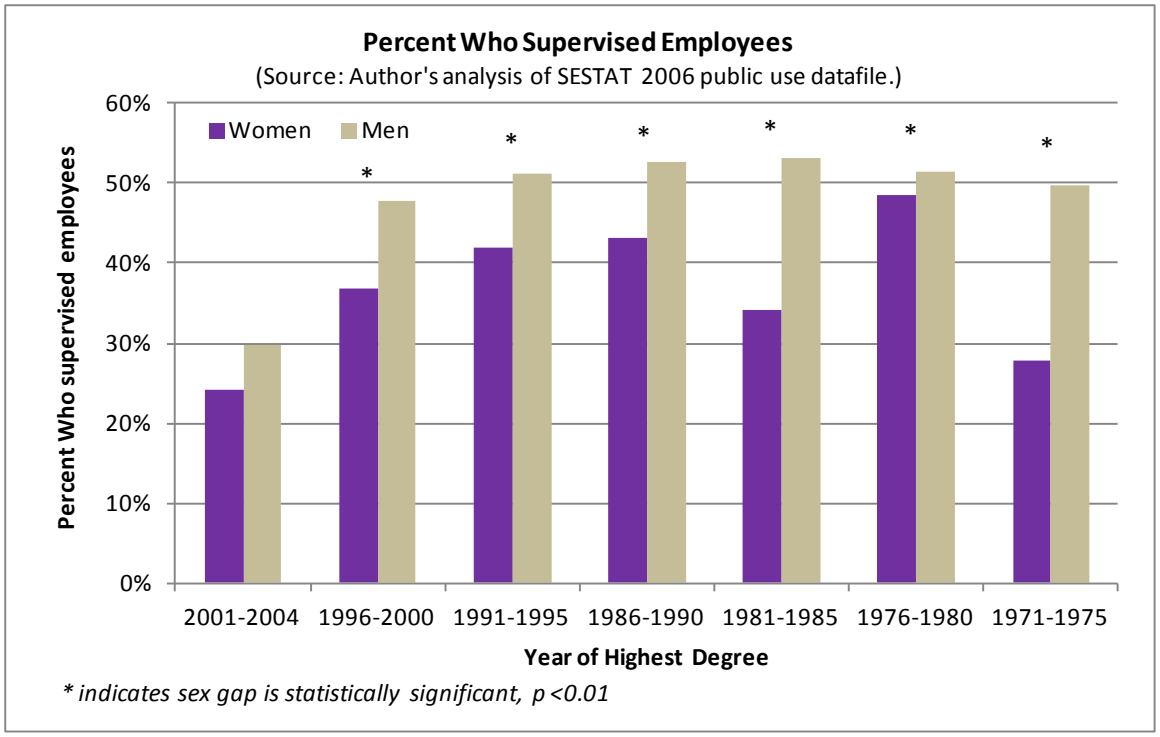


Figure 4: Percent Who Supervise Other Employees by Degree Cohort and Sex

CONCLUSIONS

The results indicate that women are less likely than their male peers with bachelor's degrees in engineering to be working in engineering after receiving their bachelor's degree and that the sex gap increases with older cohorts. The one exception to this pattern was among those who had received degrees between 1971-1976. It is unclear why women in this cohort would be more likely than their male counterparts to still be in engineering. It was also noteworthy that this cohort of women was least likely to report being in managerial positions – and the gap in women's and men's likelihood of being in management was largest for this cohort – so, there may be a historical effect for this group of women who may have been even more likely than more recent graduates to have been denied advancement opportunities. Women in this cohort completed their engineering studies in advance of the women who entered engineering schools after Title IX (1972), so perhaps they had a stronger attachment to the field associated with being pioneers. It could also be that the changes brought about by Title IX and Equal Employment Opportunity (EEO) enabled these women to retain engineering positions. Finally, men in this cohort may have had greater opportunities outside of engineering, consistent with the findings shown here, men are more likely to leave engineering to pursue positions of higher prestige, authority and pay (U.S. Department of Labor, 2012).

The results also indicate that women are more likely than men to cite family-related reasons (such as children, a spouse's job move, etc.) as important for why they were not employed in engineering or were out of the labor force. While nearly half of women cited family-related reasons compared to just 20 percent of men, these

reasons were not indicated as the top one or two reasons. Instead, the most important reason cited by women was “Change in career or professional interests” (cited as most important by one-in-four women and one-in-five men who had left the field) and for men “Pay, promotion opportunities” (31 percent of men but just 15 percent of women cited this reason).

Were women more likely than men to move away from technical work and towards managerial work? The results here indicate that this is not the case. Indeed, men were more likely than women, to report that they supervised employees, to report a job as a “top or middle-level manager, executive or administrator” and to indicate that management and administration were their top work activity. Even when controlling for degree cohort, women were far less likely than men within every degree cohort group to report that they supervised employees. This finding is consistent with those of Mills et al (2008) and those cited above: engineers often need to leave the technical career path and move onto the managerial one in order to take advantage of better pay and/or promotion opportunities.

There are a number of other explanations for differential attrition of women and men from engineering. For example, Preston’s (2004) study found that a mentoring gap was a critical reason that women left science. Mentoring to better understand career paths and opportunities might have been lacking for women who indicated that they were no longer in engineering because their career or professional interests had changed.

This paper was unable to fully address the extent to which negative work climate issues may have played a role in women’s greater attrition from engineering. Past research that used a special dataset commissioned by SWE indicated that 14 percent of women and 5 of men who had left engineering reported that they did so because of “negative work climate issues” (Frehill 2009). Research on Australian engineers found that 42 percent of women who had responded to a survey about work experiences reported that they had experienced discrimination. In addition, 28 percent of women and 19 percent of men who responded had experienced bullying, a particular form of negative work climate (Mills et al., 2008).

Engineering labor market issues may also be important in understanding the different rates of retention of women and men, which were not explored here. Another study using the recent (2005) SWE data showed that engineering attrition varied across engineering disciplines and that in some fields there was no sex gap (Frehill 2010a). Such findings suggest that there are larger, economic issues related to the structure of engineering careers, patterned by disciplinary differences, which affect retention in the field.

Methodological considerations are important to bear in mind with these various studies. The data used herein were from the NSF SESTAT data, the three constituent surveys of which deal broadly with post-graduation employment, earnings, and subsequent educational outcomes. Surveys by Engineers Australia (Mills et al 2008), the Womeng team in Europe (Pourrat 2005) and SWE (Eng 1993 and Frehill 2009) and the work by Preston (2004) and Fouad and Singh (2011) had

a more explicit focus on the issues associated with leaving the field. As such, respondents' frame of reference when completing surveys or interviews was likely different than when completing the more general surveys such as those associated with SESTAT.

Further research funded by the National Science Foundation, Research on Gender in Science and Engineering is now in progress. The most recent SESTAT data (2008) are expected to be available soon so that comparative analyses of engineers' career outcomes reflected in this article, along with findings from earlier SESTAT datasets (i.e., 1993, 1995, 1997, 1999, and 2003) can be completed. Such analyses will permit a more robust examination of the ways in which the structure of engineering labor markets affect retention in the field, with special attention to the impact of gender on career paths. These analyses will be supplemented with data from two national surveys sponsored by the Society of Women Engineers (one in 1991-1992 and another in 2005) as well as panel data from the U.S. National Center for Education Statistics known as "Bachelors and Beyond." Each of these datasets provides another piece to the puzzle to explain the gap in engineering retention for women and men.

ACKNOWLEDGEMENT

A first draft of this paper was supported by the National Science Foundation, Research on Gender in Science and Engineering under HRD#0827361/#1137641. Any opinion, findings, and conclusions or recommendations expressed in this article are those of the authors and do not necessarily reflect the views of the National Science Foundation.

ENDNOTES

[1] SESTAT is the Scientists and Engineers Statistical Data System. The use of NSF data does not imply NSF endorsement of the research, research methods, or conclusions contained in this paper. For more information about SESTAT see National Science Foundation (2011).

[2] The WOMENG project team found that in four of the seven countries (Slovakia, France, the United Kingdom and Germany), a master's degree was necessary to be recognized as an engineer. Often a period of professional practice in most of the seven countries was an important step towards recognition as an engineer. This is different than the situation in the United States, where most engineers hold a bachelor's degree as the entry credential. Licensure as a professional engineer starts with a bachelor's degree but then necessitates a period of professional employment, which varies across the states in which engineering licensure is performed.

[3] On the original survey, the item that asked why the respondent was not working in the field of their degree, one of the reasons was: "Family-related reasons (e.g., children, spouse's job moved)."

[4] "Managerial positions" includes engineering management.

REFERENCES

Beede, D., et al. (2011) 'Women in STEM: A Gender Gap to Innovation' ESA Issue Brief #04-11, U.S. Department of Commerce, Economics and Statistics Administration. Available from: http://www.esa.doc.gov/reports [Accessed 2/12/11].

Belkin, L. (2003) 'The Opt-Out Revolution', *New York Times Magazine*, (October 26).

Cheeseman Day, J., and Downs, B. (2009) 'Opting-Out: An Exploration of Labor Force Participation of New Mothers', Washington, DC: U.S. Census Bureau.

Connell, R.W. (2001) *The Men and the Boys.* Berkeley, CA: University of California.

Eng, P. (1993) *A National Survey of Women and Men Engineers: A Study of the Members of 22 Engineering Societies*. Chicago, IL: Society of Women Engineers.

ENSC/CEDIS. (2008) Deliverable No 20: Periodic Progress Report on WP7 results Transversal integrating analysis and interpretation, PROMETEA: Empowering Women Engineers in Industrial and Academic Research. Available from: http://www.prometea.info/ [Accessed 2/11/11].

Fouad, N. A. and Singh, R. (2011) *Stemming the Tide: Why Women Leave Engineering*. Report, University of Wisconsin-Milwaukee.

Frehill, L.M. (2011) Salaries of Engineers *NACME Technical Report*, (April). Available from: http://www.aauw.org/learn/research/upload/NewVoicesPayEquity_LisaFrehill.pdf. [Accessed 9/18/11].

Frehill, L.M. (2010a)' Why do people give up engineering? Surveys of men and women engineers tell an unexpected story' *Mechanical Engineering: The Magazine of ASME*.

Frehill, L.M. (2010b) Fact Sheet: U.S. Engineering Workforce *NACME Research and Policy Brief 1*(3). Available from: http://www.nacme.org/user/docs/Res_Brief_V1_no3.pdf [Accessed 9/18/11].

Frehill, L.M. (2009) 'SWE Retention study and work/life balance.' *SWE Magazine*, (Fall), pp. 34-40.

Frehill, L.M. (2007). 'Are women more or less likely than men to be retained in engineering after college?' *SWE Magazine*, (Fall), pp. 22-25.

Frehill, L.M. (1997) 'Subtle Sexism in Engineering.' In: Benokraitis, N. (ed.) *Subtle Sexism: Current Practices and Prospects for Change.* Newbury Park, CA: Sage, pp. 117-135.

Frehill-Rowe, L.M. (1993)' Education and Occupational Sex Segregation: The Case of Women in Engineering.' Unpublished dissertation (PhD), University of Arizona.

Gill, J., et al. (2008) 'I still wanna be an engineer!: Women, education and the engineering profession' *European Journal of Engineering Education 33*(4): 391-402.

Izzo, P. (2011) 'What's the unemployment rate in your profession?' *Wall Street Journal* (January 11, 2011). Available from: http://online.wsj.com/article/SB10001424052748703667904576072193861249106.html#project%3DUNEMP_BY_OCCUPATION_IPAD_1101%26articleTabs%3Dinteractive [Accessed 2/17/11].

Kang, K. (2007) National Survey of College Graduates, Technical documentation. Available from: http://www.nsf.gov/statistics/showsrvy.cfm?srvy_CatID=3&srvy_Seri=7 [Accessed 2/22/2007].

Mcilwee, J. and Robinson, J.G. (1992) *Women in Engineering: Gender, Power and Workplace Culture.* Albany, NY: SUNY Press.

Meiskins, P., Perusek, A., and Zanish-Belcher, T. (2011) 'Curtiss-Wright engineering Cadettes: 21st century questions and issues.' *Journal of the Society of Women Engineers 5*, pp. 18-31.

Mills, J., et al. (2008) *An update on women's progress in the Australian engineering workforce*. Barton ACT: Engineers Australia. Available from: http://www.engineersaustralia.org.au/shadomx/apps/fms/fmsdownload.cfm?file_uuid=7DA323DA-E3CC-A6FB-8DB3-4D97EFFBBEEF&siteName=ieaust [Accessed 3/12/12].

Morgan, L. A. (1998) 'Glass-Ceiling Effect or Cohort Effect? A Longitudinal Study of the Gender Earnings Gap for Engineers, 1982 to 1989' *American Sociological Review 63* (4), pp. 479-493.

National Academies. (2011). *Rising Above the Gathering Storm: Rapidly Approaching Category 5*. Committee on Science, Engineering, and Public Policy. Washington, DC: National Academies Press.

National Academies (2006) *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. Committee on Science, Engineering, and Public Policy. Washington, DC: National Academies Press.

National Science Foundation. (2011) About SESTAT. Available from: http://www.nsf.gov/statistics/sestat/sestatfaq.cfm [Accessed 2/18/11].

Pierret, C. R. 2006. 'The 'sandwich generation': Women caring for parents and children.' *Monthly Labor Review* (September), pp. 3-9.

Pourrat, Y. (project coordinator) (2005) *Womeng: Creating Cultures of Success for Women Engineers: Synthesis Report*. Available from: http://www.womeng.net/intro.htm [Accessed 2/16/12].

Preston, A. E. (2004) *Leaving Science: Occupational Exit from Scientific Careers.* New York, NY: Russell Sage Foundation.

Regets, M. C. (2006) 'What do people do after earning a science and engineering bachelor's degree?' National Science Foundation, Science Resource Statistics, InfoBrief NSF 06-324, (July).

Regets, M. C. (2010) Employment in Science and Engineering Occupations Reached 5.8 Million in 2008, National Science Foundation, Science Resource Statistics, InfoBrief NSF 10-315, (April).

Roberts, P. and Ayre, M. (2002) *Counting the Losses . . . The Careers Review of Engineering Women: An Investigation of Women's Retention in the Australian Engineering Workforce*. National Women in Engineering Committee, Engineers Australia. Available from: http://www.engineersaustralia.org.au/shadomx/apps/fms/fmsdownload.cfm?file_uuid=992886E3-F73D-ADD8-0125-77596762BD1A&siteName=ieaust [Accessed 5/21/11].

Seymour, E. and Hewitt, N. (1997) *Talking About Leaving: Why Undergraduates Leave the Sciences.* Boulder, CO: Westview.

SpencerStuart. 'Leading CEOs: A Statistical Snapshot of SandP 500 Leaders.' (December 2008). Available from: www.spencerstuart.com/research/articles/975 [Accessed 8/8/11].

U.S. Department of Labor. (2012) Title IX, Education Amendments of 1972, Available from: http://www.dol.gov/oasam/regs/statutes/titleix.htm, [Accessed 7/4/2012].

Wolffram, A., Derboven, W. and Winker, G. (2009) 'Women withdrawers in engineering studies: Identity formation and learning culture as gendered barriers for persistence?' *Equal Opportunities International 28(1),* pp. 36-49.