Career Choices of Female Engineers: A Summary of a Workshop

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CAREER CHOICES OF FEMALE ENGINEERS

A Summary of a Workshop

Sara Frueh, Rapporteur

Committee on Career Outcomes of Female Engineering Bachelor's Degree Recipients
Committee on Women in Science, Engineering, and Medicine

Policy and Global Affairs

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PREFACE AND ACKNOWLEDGMENTS

An ad hoc planning committee, under the auspices of the standing Committee on Women in Science, Engineering, and Medicine (CWSEM), convened a public workshop to examine the career outcomes of women recipients of bachelor's degrees in engineering. The importance of educating and training a technical workforce has received significant public interest lately, but there has been much less on the subject of retaining scientific and technical employees in the workforce. The retention of workers in these areas is particularly challenging for women and underrepresented minorities. The workshop that is the focus of this report was organized to address career pathways and advancement, areas of priority for the CWSEM. The committee is interested in (1) understanding gender differences in the recruitment, retention, and advancement of women at critical transition points and (2) investigating and disseminating the best practices to facilitate career transitions and advancement for all.

The workshop was scheduled to coincide with the 2013 National Academy of Engineering (NAE) and American Association of Engineering Societies (AAES) Engineering Convocation, an annual event that draws leaders of many engineering societies and associations. This provided an opportunity for both the participation of these leaders in the workshop and the discussion and dissemination of the research results conducted through this project.

The committee commissioned research by independent experts to analyze relevant data for the workshop; the resulting papers are included in the appendices to this report. Gail Greenfield's research used nationally representative data on baccalaureate-trained engineers—from the National Center for Education Statistics (NCES) Baccalaureate and Beyond Longitudinal Study (B&B)—to answer research questions about gender differences in postbachelor's retention in engineering careers. This work was complemented by the research of Nadya Fouad and Romila Singh in their surveys of women trained as engineers and their retention in the workforce. In addition, a group of graduate students from Carnegie Mellon University conducted a literature search and a survey of small and medium businesses and the composition of their information technology workforce, which included many fields of engineering. This work was commissioned in an effort to address the following questions:

- What are the similarities and differences in career outcomes for women and men with bachelor's degrees in engineering?
- Why are there differences in women's and men's retention in engineering?

There were challenges in accessing data that could be disaggregated by specific field (e.g., electrical engineering) and ensuring robust cell sizes that could include demographic information. Professional societies may well be a resource for collecting recent field-specific data that can inform future research.

The workshop discussions uncovered interesting, puzzling, and even alarming trends. For instance, the B&B data showed that the retention rates for all cohorts of men in engineering remained fairly steady one year after graduation, whereas there was dramatic variation in the retention rates for women, depending on the cohort population (defined by the year of graduation): female retention rates one year after graduation were 67.8 percent for Cohort 1 in 1994, 51.6 percent in 2001 (Cohort 2), and a comparatively dismal 36.4 percent in 2009 (Cohort 3). The survey data for Cohort 3 indicate that for these women it was harder to find jobs they wanted in locations they desired in comparison to men. In addition, more women in Cohort 3 cited poor working conditions as a factor for leaving engineering (8.5 percent) compared to men (only 0.5 percent), indicating that climate and work opportunities remain important problems to be addressed to reduce gender differences in retention in engineering.

It may also be useful to follow retention rates for women in the different disciplines, given the wide range of representation in various fields—low in electrical and mechanical engineering, for example, and high in environmental and bioengineering.

I am grateful to my colleagues who served on the workshop planning committee; to Sara Frueh, who ably captured and summarized the workshop presentations and discussion; and to all the speakers and participants in the conference. I also thank Joanne Cohoon, Ruthe Farmer, Allan Fisher, and Lilian Wu, advisors to the Carnegie Mellon University graduate students' project, "Women in IT: Recruit Them & Retain Them."

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Academies' Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for quality and objectivity. The review comments and draft manuscript remain confidential to protect the integrity of the process. We thank the following individuals for their review of this report:

Erin Cadwalader, Association for Women in Science
Melissa Carl, American Society of Mechanical Engineering
Donna Ginther, University of Kansas
Robert Green, National Society of Professional Engineers
Julie Martin, Clemson University

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the content of the report, nor did they see the final draft before its release. The review of this report was overseen by Marigold Linton, University of Kansas. Appointed by the National Academies, she was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the rapporteur and the institution.

This material is based on work supported by the National Science Foundation under Award # HRD-1137641. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Alice Agogino, Chair

Contents

1

Introduction

Despite decades of government, university, and employer efforts to close the gender gap in engineering, women make up only 11 percent of practicing engineers in the United States.[1] What factors influence women graduates' decisions to enter the engineering workforce and to either stay in or leave the field as their careers progress? Researchers are studying existing data and fielding new surveys to help answer these questions.

On April 24, 2013, the National Research Council Committee on Women in Science, Engineering, and Medicine (CWSEM) held a workshop to explore emerging research and to discuss career pathways and outcomes for women who have received bachelor's degrees in engineering. Participants included academic researchers and representatives from the US Department of Labor, National Science Foundation, Census Bureau, and several engineering professional societies.

Lilian Wu, program executive for IBM's Global University Program and former CWSEM chair, opened the workshop. She proclaimed it an exciting time to be an engineer or computer scientist as the world is becoming increasingly computerized, interconnected, and instrumented with sensors, developments that have made it possible to capture massive amounts of data on natural systems, manufactured structures, and social systems. This information can in turn be used to improve the delivery of public services, such as education, public safety, and health care, as well as the way cities operate.

She observed that another important development is that people and systems are much more interconnected and there is an emerging capacity to look at systems in much greater depth. The healthcare system is not improved in isolation, for example, and the new data and interconnected technologies are changing the nature of physical manufacturing as well.

Engineers and computer scientists are at the center of this new world, and women and minority groups must fully participate in the design and building of it, Wu said. Efforts at this workshop to examine women's career paths and obstacles can point the way to ensuring that this new world has a system in which women and minority groups can fully participate.

After Wu's introductory remarks, attendees heard presentations on the research commissioned for the workshop. Gail Greenfield, principal with Mercer Consulting, reviewed her findings on "Career Outcomes of Women Engineering Bachelor's Degree Recipients," followed by Nadya Fouad and Romila Singh of the University of Wisconsin–Milwaukee, who detailed the results of their study investigating why women leave engineering. Tom Perry then led a discussion of data needs, critical transitions, and career pathways for women in engineering that yielded numerous insights and ideas for further research. A special feature of the workshop was the presentations by graduate students in public policy and management at Carnegie Mellon University's H. John Heinz College who surveyed small and medium-sized businesses about women on their technical staff. The workshop closed with a general discussion of the issues presented and of other areas that warrant further exploration as well as a call to the attendees to incorporate the workshop observations and lessons in their actions going forward.

[1] Fouad, N., and R. Singh. 2012. "Stemming the tide: Why women leave engineering." University of Wisconsin–Milwaukee.

2

Career Outcomes of Women Engineering Bachelor's Degree Recipients

Gail Greenfield, principal at Mercer LLC, presented the results of her study of career outcomes of women who received bachelor's degrees in engineering.[1] Her analysis was based on data from the Department of Education's Baccalaureate and Beyond (B&B) Longitudinal Study, which gathers information on the postgraduation experiences—education, employment, and family experiences—of people who have graduated with a bachelor's degree. The B&B study also collects information on degree recipients' undergraduate experiences (e.g., major field of study, how they paid for college) and demographic information such as gender, ethnicity, and age. It follows multiple cohorts of students over time, drawing its initial cohorts from the National Postsecondary Student Aid Study (NPSAS).

The B&B study follows three cohorts of a representative sample of graduating seniors in all majors over time:

- Cohort 1, about 11,000 students who graduated with a bachelor's degree during the 1992–1993 academic year. These students were surveyed in their last year of college and then one year, four years, and ten years after graduation (in 1994, 1997, and 2003, respectively).
- Cohort 2, a similarly sized group of students who graduated with a bachelor's degree during the 1999–2000 academic year. For this cohort only one follow-up survey was conducted, one year after graduation (2001).
- Cohort 3, a larger sample (nearly19,000 students) who graduated with a bachelor's degree during the 2007–2008 academic year. A follow-up survey was conducted one year after graduation (2009), and another is in progress.

Greenfield focused her presentation on her analysis of Cohort 1, the group for which 10 years of data are available, and used the other two cohorts primarily for comparisons. She used the B&B data to address three questions:

- What are the career outcomes of women who receive bachelor's degrees in engineering?
- How do these outcomes compare to men who receive bachelor's degrees in engineering and to women who receive bachelor's degrees in other "career-oriented" majors (e.g., business and management, education, and nursing)?
- What factors help explain these observed career outcomes?

LIMITATIONS OF THE B&B DATA

The primary limitation of the B&B data are the small number of engineers represented in each survey, noted Greenfield. Of the approximately 8,000 people (out of 11,000) in Cohort 1 who responded to all four surveys, fewer than 7 percent (520 people) graduated with a degree in engineering, and only about 80 of those were women (Table 2-1). In addition, the online tool that provides access to the data does not permit the pooling of cohorts and limits the ways in which variables can be used and created. Last, the survey does not distinguish managers and supervisors who oversee engineering-related work as opposed to work of any other type. This limitation is most problematic for Cohort 1 as one might expect a sizable number of these graduates to have progressed to manager or supervisor by ten years after graduation.

ANALYTICAL METHODS

Greenfield examined two key career outcomes: (1) the percentage of graduates in the labor force ("labor force

[1]The slides of Greenfield's presentation are in Appendix F.

TABLE 2-1 Number of engineering graduates responding to each survey, by cohort and survey year

		Engineering graduates responding to the survey		
Cohort	Survey Year	All	Male	Female
1	1994	640	550	90
	1997	625	535	90
	2003	575	490	85
	All surveys	520	440	80
2	2001	580	480	100
3	2009	930	750	180

*Includes the base-year survey in 1993.
SOURCE: National Center for Education Statistics

participation")[2] and (2) the percentage of employed graduates working in the field of their major ("retention"), using the following two types of analysis:

- Descriptive comparisons: To the extent that the B&B surveys are representative, descriptive comparisons depict the population of individuals who received undergraduate degrees in engineering in the graduation year under consideration (e.g., 1992–1993). Such statistics are useful for understanding gender similarities and differences in career outcomes for those with bachelor's degrees in engineering.
- Multiple regression: Regression analysis can yield insights into the reasons for observed differences in career outcomes. It is used to examine the relationship between an outcome of interest (e.g., labor force participation) and a variable hypothesized to be related to this outcome (e.g., gender), holding constant other factors that may also be related to the outcome (e.g., age, marital status, undergraduate debt).

DESCRIPTIVE COMPARISONS: LABOR FORCE PARTICIPATION

Greenfield found that for engineering bachelor's degree recipients in Cohort 1, the labor force participation rate is quite high for both men and women (Figure 2-1), although women's participation is consistently lower than men's in the three survey years. This difference in labor force participation is not statistically significant until 10 years after graduation, when the men's participation rate is more than 10 percentage points higher.[3]

Greenfield's analysis revealed that labor force participation for women with undergraduate engineering degrees is quite similar to that of women in other career-oriented majors. One year after graduation, the participation for women engineering graduates in Cohort 1 was 88.6 percent—similar to, though a little lower than, the rate for other career-oriented majors (specifically, education, business and management, and health). Four years later, that rate increased to 92 percent, again almost indistinguishable from the other fields. But ten years after graduation, labor

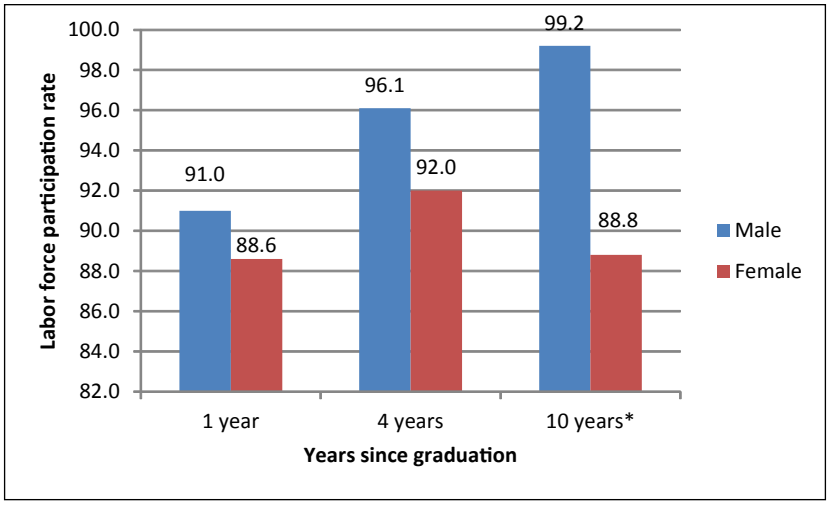

FIGURE 2-1 Labor force participation rate by gender for engineering bachelor's degree recipients, Cohort 1 of the National Center for Education Statistics Baccalaureate and Beyond Longitudinal Study. * Difference between men's and women's rates is statistically significant at the 5 percent level. SOURCE: National Center for Education Statistics.

[2] *Labor force participation* rate is the percentage of working-age persons in an economy who are (1) employed or (2) unemployed but looking for a job.

[3] Greenfield also compared labor force participation across all three cohorts of women engineering graduates one year after their graduation. For Cohort 1, labor force participation was 88.6 percent (1994); for Cohort 2, 93 percent (2001); and for Cohort 3, 87.7 percent (2009). The pattern—lower for Cohort 1, higher for Cohort 2, lower for Cohort 3—was the same for men in those years.

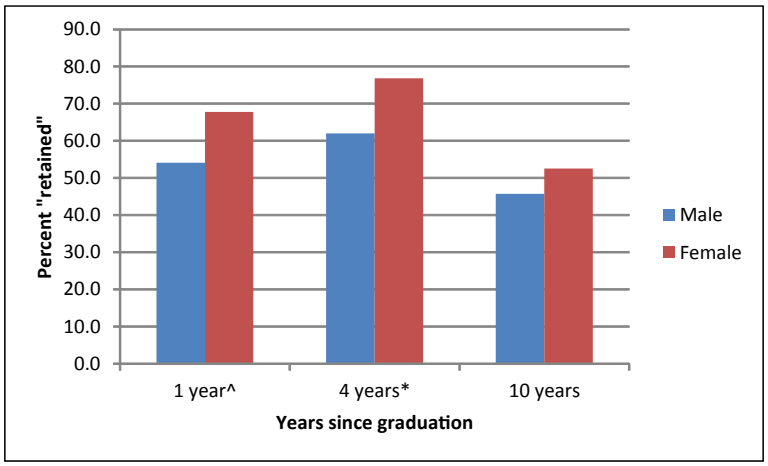

FIGURE 2-2 Percentage of employed engineering bachelor's degree recipients in an engineering/architecture occupation, Cohort 1 of the National Center for Education Statistics Baccalaureate and Beyond Longitudinal Study. ^ Difference between numbers for women and men is statistically significant at the 10 percent level. * Difference between numbers for women and men is statistically significant at the 5 percent level. The decline in the percent retained from four to ten years after graduation is statistically significant at the 5 percent level for both men and women. SOURCE: National Center for Education Statistics.

force participation had declined for women in all four fields, most notably for those in education, where participation had dropped to 78.7 percent; for those with degrees in business and management, engineering, and health-related fields, the percentages participating in the labor force were in the high 80s.

DESCRIPTIVE COMPARISONS: RETENTION IN ENGINEERING

Greenfield analyzed the B&B data to determine the rates at which labor force participants with bachelor's degrees in engineering remain in engineering or leave for other types of jobs, and whether women are staying in engineering at the same rates as men.[4] She compared the retention rates of employed men and women who were engineering bachelor's degree recipients in Cohort 1 at various points after graduation (Figure 2-2).

> Female engineers have higher retention rates in engineering careers than male engineers in engineering careers one year, four years, and ten years after graduation
> ~Gail Greenfield

Surprisingly, Greenfield said, retention rates in engineering careers 1, 4, and 10 years after graduation were actually higher for women engineering graduates than for men, although by the 10th year the rate had dropped substantially for both sexes. This does not take into consideration the substantial migration of male engineers into engineering management career paths, where female engineers are less well represented.

When comparing the retention rates of women engineering graduates one year after graduation to those of women graduates in other career-oriented majors, the former remain in their field at a rate (67.8 percent) similar to that of their peers in education (69.7 percent) and health (75.3 percent), and significantly higher than for those in business and management (52.2 percent). Four years after graduation, the pattern is similar. Ten years after graduation, however, women's retention in engineering has dropped to 52.5 percent, lower (although not significantly) than that of the women graduates in business and management (58.6 percent), and significantly lower than that of health professions (72.2 percent) and education (72.5 percent).

Next, Greenfield looked at retention rates 1 year after graduation for women across all three cohorts and found a significant drop between Cohort 1 and Cohort 3 (Figure 2-3). Specifically, retention in engineering was 36.4 percent for Cohort 3 in 2009, as compared to 67.8 percent for Cohort 1 in 1994.

> Ten years after graduation, women's retention in engineering careers is significantly lower than women with degrees in other career-oriented fields such as health, business, and education.
> ~Gail Greenfield

The pattern was not the same for the men, whose retention rates across cohorts held steady between 50 percent and 60 percent (Figure 2-4).

Why did those who left engineering for another field decide to leave? When the B&B researchers asked the engineering graduates in Cohort 3 who were working outside of engineering their primary reason for doing so, the most frequently given answer was the same for both men and women: A job was not available in their field (Table 2-2). However, while that was the primary reason for nearly half the women, it was the primary reason for only one-third of the men. The second most frequently given reason for men (32 percent) was pay/promotion opportunities; in other words, there were more lucrative opportunities

[4] In the B&B study, engineers and architects are grouped in a single occupation category.

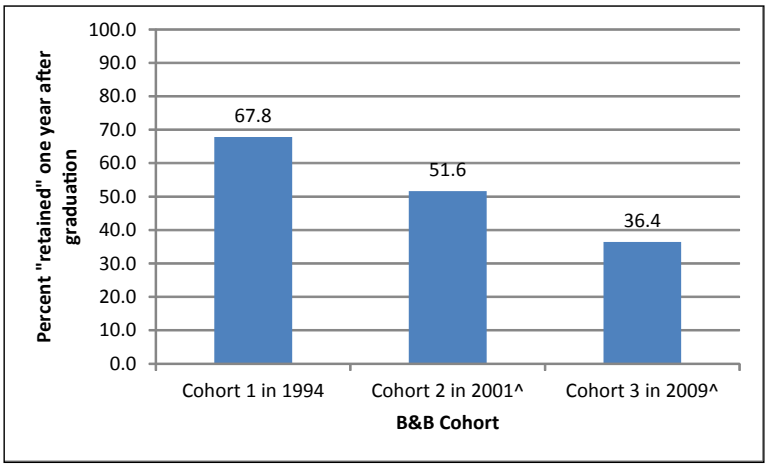

FIGURE 2-3 Percentage of employed women with a bachelor's degree working in the field of their major (engineering) one year after graduation, by cohort of the National Center for Education Statistics Baccalaureate and Beyond Longitudinal Study (B&B).
^ Difference between this and prior cohort is statistically significant at the 10 percent level. SOURCE: National Center for Education Statistics.

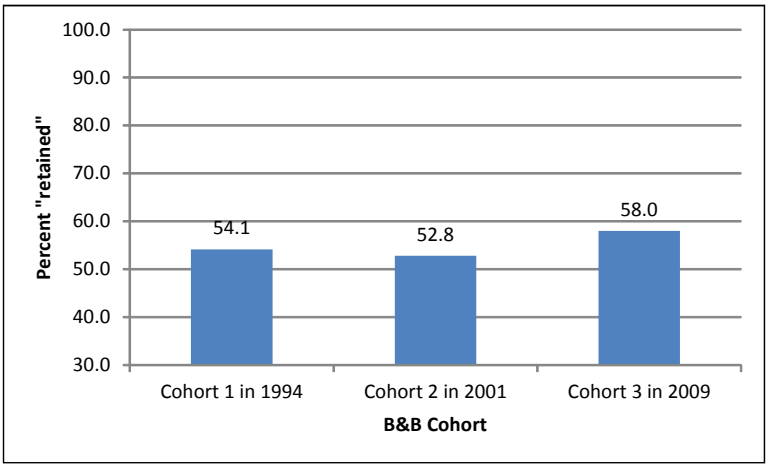

FIGURE 2-4 Percentage of employed men with a bachelor's degree working in the field of their major one year after graduation, by cohort of the National Center for Education Statistics Baccalaureate and Beyond Longitudinal Study (B&B). SOURCE: National Center for Education Statistics.

elsewhere. In contrast, only 11 percent of women cited this as their primary reason. For women the second most frequent reason was a change in career interests; although only about 16 percent of the women respondents cited this reason, this was still almost four times the percentage of men who selected this answer.

MULTIPLE REGRESSION RESULTS

To interpret the B&B data and shed light on the reasons for observed differences in career outcomes, Greenfield conducted logistic regression analyses. Specifically, she modeled the following two outcomes for Cohort 1:

- Likelihood that graduates are participating in the labor force ("participation")
- Likelihood that graduates are working in the field of their major ("retention")

The 15 predictors considered included gender, ethnicity, and undergraduate GPA, among other factors (see list below). The regression models revealed that changing one predictor (when all others are held constant) changes the odds of a graduate either participating or being retained in the labor force.

The participation regression model was used to determine the factors or characteristics related to whether women graduates with a degree in either engineering or another "career-oriented" major are participating in the labor force. The model revealed that women engineering graduates in Cohort 1 are generally no more or less likely to be participating in the labor force than their peers in other career-oriented majors. The model also showed that both groups of women graduates:

- are less likely to be in the labor force if they have children;
- are less likely to be in the labor force one and ten

TABLE 2-2 Primary Reasons for Working Outside Degree Field, Engineering Bachelor's Degree Recipients in Cohort 3

Women	Men
Job in field not available (47.6%)	Job in field not available (33.8%)
Change in career interests (16.6%)	Pay / promotion opportunities (32%)
Job location (12.4%)	Other factors (25.1%)
Pay / promotion opportunities (11%)	Change in career interests (4.6%)
Working conditions (8.5%)	Job location (4.0%)
Other factors (4.0%)	Working conditions (0.5%)
Family-related reasons (0%)	Family-related reasons (0%)

years after graduation if their spouse's income is relatively high;

- are more likely to be in the labor force one and four years after graduation if they incurred debt in college;
- are less likely to be in the labor force one year after graduation if they are enrolled in school, but are more likely ten years after graduation; and
- are more likely to be in the labor force ten years after graduation if they have a graduate degree.

The focus of the retention regression model was on factors or characteristics related to engineering graduates' retention in the field of engineering. According to the results, women with undergraduate engineering degrees are not retained at lower rates than men with undergraduate engineering degrees; in fact, they are more likely than men to be working in engineering four years after graduation. The regression model also found that both men and women were more likely to be working in engineering one year and ten years after graduation if their undergraduate GPA was 3.5 or above.

In terms of the findings' implications, Greenfield clarified that participation in the labor force is not a concern: women are participating in the labor force at high rates for all three cohorts. It is retention in engineering that appears to be a challenge for both men and women: ten years after graduation, only about 50 percent of men and women in Cohort 1 were working in engineering jobs. In Cohort 3 both men and women cited a lack of jobs in their field as their primary reason for working outside engineering. Moreover, the retention rate appears to be worsening for women, since the one-year retention rate fell more than 30 percentage points between Cohort 1 in 1994 and Cohort 3 in 2009 (Figure 2-3).

DISCUSSION

Erin Cadwalader from the Association for Women in Science (AWIS) commented on Greenfield's finding that a higher number of women than men said there were no jobs available: could this be because there are more women in certain subfields of engineering? Greenfield explained that the data did not capture that information, but acknowledged the possibility that more women might have a degree in an engineering subfield that is not in demand in the marketplace. Given what she had heard anecdotally, she said she was shocked to see that almost half the women said there was not a job available; she assumed that what they meant was "there was not a job that fit my skills or requirements."

Thomas Perry from the American Society of Mechanical Engineers (ASME) pointed out that, in looking at the difference in the reasons men and women gave for working outside their degree field, the variations between the men's and women's answers tend to have a magnitude between 0 and 3 to 4 times; the number who cited "working conditions," in contrast, has a variation of 16 times. Greenfield replied that she had tried to find the survey to see what was meant by "working conditions" but was unable to. For men, she noted, the reasons given for working outside the field were more dispersed; for example, the number who cited "pay and promotion opportunities" is not much lower than those who cited "jobs not available." For women, on the other hand, the reasons were concentrated in "jobs not available" and "changes in career interests."

Andy Richman from Carnegie Mellon University asked whether Greenfield had looked at the possible influence of the economy on retention rates—for example, when Cohort 1 graduated in 1992 unemployment rates were quite high. Greenfield responded that she had looked at recessions (there was not a recession in 1992) but not unemployment rates. Richman explained that some research shows that for those who graduate during a recession, their career earnings never recover. Follow-up data for Cohort 3, who graduated

Fifteen Predictors Considered in the Regression Model		
Gender	Undergraduate debt	Citizenship Status
Age at graduation	Undergraduate institution (Carnegie Classification)	Spousal employment
Ethnicity	Parental education	Spousal income
Undergraduate GPA	Marital status	Graduate degree
Undergraduate degree specialty/subfield	Parental status	Employment status

Note: Not all predictors were included in the final set of models.

during the latest recession, may reveal its impacts on their careers over time.

Jennifer Hunt, chief economist at the Department of Labor, suggested comparing the rates at which men and women leave engineering with the rates for other fields. Her research found that women were exiting at higher rates than men in all fields, but maybe that has flipped and is now the opposite, she said. It could be that women are leaving engineering less and also leaving other fields less as well—that women are now staying longer with careers in general. Pursuing this question is a good idea, said Greenfield, noting that she has the data to do so.

Echoing Richman's question about the economy's effects on retention, Patricia Taboada-Serrano from the Rochester Institute of Technology asked whether Greenfield could speculate about the reason for the dramatic drop in women's retention rates between Cohort 1 in 1994 (67.8 percent) and Cohort 3 in 2009 (36.4 percent). Was it mostly a response to job market conditions, or were there other reasons behind it? Greenfield did not have this information and hoped some of those at the workshop would do the research to find an answer.

Joanne Cohoon of the University of Virginia wondered whether the decline in retention could be related to the increasing representation of women with engineering degrees. Women have been successfully recruited into the line of study, she explained, but their educational experience may have been such that they concluded, "I'm going to finish this degree, but I'm getting out of the field." This information will have to be captured in future surveys.

3

Career Outcomes of Women Engineering Bachelor's Degree Recipients

Why do women decide to either stay in the engineering field or leave it, and what can employers do to make it more appealing for them to stay? Nadya Fouad, distinguished professor and chair of the Department of Educational Psychology at the University of Wisconsin at Milwaukee, and Romila Singh, associate professor of business at the University of Wisconsin's Sheldon B. Lubar School of Business, presented findings from their research on these questions.[1]

Fouad reported that women's underrepresentation in engineering has been a concern for three decades, with many calls to do a better job getting women into the engineering pipeline and into college. The President's Committee on STEM Education found that in fiscal year 2010, federal agencies' spending to support STEM education totaled $3.4 billion, of which 31 percent was targeted to underrepresented minorities, and $13 million was targeted specifically to women. These efforts have been relatively successful for the past two decades, about 20 percent of graduating engineers have been women, and this percentage has held relatively steady. This is an increase from 15 percent in the 1980s.

Among practicing engineers, about 11 percent are women, a share that has also been consistent over the past two decades. That percentage varies by discipline—electrical engineering and electronics engineering have the lowest percentage of women, while chemical engineering has a higher percentage, and biomedical engineering the highest of all, at 50 percent women. However, engineering has the highest turnover rate among skilled professions such as accounting, law, medicine, and higher education, so the return on investment in STEM careers is not optimally realized, given the substantial amount of money spent preparing and training engineers, said Fouad. When women leave the profession, it is a loss to organizations, a loss to the women themselves if that is not their preferred choice, a loss to the United States' competitive edge, and a loss to society.

CHARACTERIZATION OF SURVEY RESPONDENTS

Fouad and Singh undertook their study to learn what women do after they graduate with an engineering bachelor's degree—specifically, whether they go into engineering and how long they stay. "We were interested in the differences between women who stay in engineering and those who leave," said Fouad. Funded by a three-year National Science Foundation grant, the researchers formally partnered with the 30 US universities with the highest number of women engineering graduates, reaching out to women engineering alumnae through email and postcards. The recipients in turn passed on the link to colleagues and friends, and the researchers received 5,300 usable responses—many times more than their target number of 800. The survey also included text boxes that allowed the researchers to collect some rich qualitative data.

The study included women who had majored in engineering and who self-identified as an engineer (whether they were in an engineering occupation or not). The researchers identified four groups: those who graduated with a bachelor's degree in engineering and never entered the field (11 percent), those who left engineering more than 5 years ago (21 percent), those who left within the past 5 years (6 percent), and those currently working in engineering (62 percent). The researchers summarized the findings for each group of graduates.

- **Women who had an engineering bachelor's degree and never entered the engineering profession.** When the women were asked why they did not enter the field, respondents said they were not interested in engineering (24 percent), they wanted

[1] The report of this study is reproduced in Appendix D.

to start their own business (18 percent), they did not like engineering culture (17 percent), they had planned from the beginning to go into another field (15 percent), or the salary was low (7 percent). Among their comments were "I went to an interview, and there were no women other than secretaries in the firm" and "I'd have to go to the third floor to go to a women's bathroom." Others wrote "At the time I graduated, no one was hiring" or "The only job was in another city and my husband/boyfriend is here and I didn't want to move." Most of these women now work in a nonengineering field; only 8 percent are in full-time family caregivers. A number of women in this category said they valued the skills and analytical training they got from studying engineering but intended to use them for something else.

- **Women who worked in engineering and then left more than 5 years ago.** Some left to spend time with family (17 percent), but some also talked about not having opportunities for advancement (12 percent) and having lost interest in engineering (12 percent). Two-thirds of them now work in other fields. Some described what it felt like to be one of only a few women. Many commented on their perceptions of opportunities for advancement; for example, "To advance you need to work more than 50 hours a week and be on call" and "[There is] no opportunity for advancement in a male-dominated field. The culture of engineering is very male-centric with high expectations for travel and little personal time."
- **Women who worked in engineering and left less than 5 years ago.** In this group—the smallest of the four—two-thirds of the women who left did so to pursue opportunities in other fields, while one-third left to take care of children. Fouad noted that, as a vocational psychologist, she values the idea of people having choices; the comments, however, revealed that many women left to take care of children because the working conditions were uncomfortable and did not accommodate work-life balance.
- **Women currently working in engineering.** Women in this group work on average over 40 hours a week, have been with their organization for eight years, and are decently paid (earning salaries ranging from $76,000 to $125,000); about one-third are in project management positions, and 15 percent are in executive roles. Singh noted that these women love their jobs and careers. They reported working at places with supportive bosses and coworkers, support that was made obvious to them in myriad ways: They had training and development opportunities, the organization invested in their growth and provided opportunities for advancement, and the culture was supportive of balance with the other parts of their lives.

CHARACTERIZATION OF DECISION FACTORS

The researchers asked women whether they were considering leaving the job and engineering generally, noting that those who had left typically did so at about the 10-year mark with an organization. Survey respondents who were considering leaving their organization reported experiencing an excessive workload without enough resources, conflicting work demands, and unclear expectations about work goals and standards. They felt stalled in their careers and said that a variety of climate-related behaviors hampered their growth.

Singh and Fouad wanted to know the actual behaviors that fed the chilly climate, rather than just the perception. In their survey, they asked, "In the last six months, to what extent did your supervisors/coworkers engage in" a list of behaviors such as being insulted or belittled, talked about behind one's back, or pulled back when trying to succeed. This is self-reported, Singh cautioned, so it is perceptual and grounded in individual realities; nevertheless, they tried to capture the behaviors that prompt women to leave—"naming the beast" rather than simply calling it a chilly climate.

The other factor in women's decision to leave their place of employment was a lack of support for work-life balance. The companies where these women worked emphasized face time and working more than 50 hours a week, and employees were expected to put work before family. It is not enough to do add-on programs like child care, said Singh; it is important to look at the underlying beliefs that drive corporate decisions to determine whether they support people throughout their working lives.

What are the differences between women who are currently working as engineers and those who left less than 5 years ago? Singh and Fouad found no differences in the women's vocational interests, self-confidence to perform engineering tasks, manage multiple life roles, or navigate organizational politics. The differences appeared in a cluster of factors called *supports and barriers*. Women who left were more likely to report greater undermining behaviors by supervisors and a lack of managerial support and sensitivity for their family responsibilities. In contrast, women currently working in engineering experience a greater degree of support; their organizations are investing in their careers and providing them with the skills they need to climb career ladders.

> Racial/ethnic minority women were more likely to report a greater incidence of supervisory undermining than Caucasian women.
> ~ Singh and Fouad

Singh and Fouad also found that, among women currently working in engineering, racial/ethnic minorities were more likely to

report a greater incidence of supervisory undermining than Caucasian women. They also reported experiencing a lot of role-related stress, including overload and conflicting demands in terms of deadlines and priorities. However, there were no differences between underrepresented minorities and Caucasian women in terms of support from supervisors and coworkers or opportunities for advancement and professional development.

The researchers considered the possibility of differences by industry (government was excluded)—aerospace, transportation and utilities, construction, computer services/software, and biotech—in terms of experiences and opportunities for women in engineering, and did not find any differences in women's rates of departure or opportunities for advancement. Singh found this result heartening, because it means that factors that contribute to women leaving or staying are the responsibility of each individual organization. What then can organizations do to create more proactive, responsive environments that harness people's energy?

One concern expressed by many respondents, whether they had left engineering or were currently working in the field, was role-related stress—lack of clarity regarding goals, deadlines, and expectations; excessive workload; and incompatible work demands, such as multiple projects with the same deadline but separate leaders. Fortunately, there may be an easy fix: management approaches that call for specificity about project objectives, resources, timeline, and deliverables to reduce or remove ambiguities and roadblocks. These are relatively simple ways to address issues that otherwise lead to dissatisfaction, work environments that prevent workers from doing their best (and may even cause them to fail), and lack of opportunities for worker training and development. Even in resource-strapped times, meaningful changes such as these can help to address women engineers' satisfaction and turnover intentions, said Singh.

CONCLUDING OBSERVATIONS

The issue of retention in and departure from engineering is not a women's issue, and it does not concern women wanting to spend time with their children or take time off for care giving, said Singh. Women are leaving engineering careers because of a lack of advancement opportunities and because the climate does not support work-life balance. She believes that change has to start at the top. Commonly, she said, when presented with this type of data, senior leadership has a conversation about it and hands it off to Human Resources (HR), telling them to "go fix it." Rather than casting it as a "women's issue" or delegating it to HR to try to "fix" it, top leadership needs start with a hard-edged approach: zero tolerance for incivility and undermining behaviors in the workplace. Real engagement is needed up and down the organizational spectrum—and women need to be part of the solution, said Singh.

Corporate leaders should also think about work-life balance in a broad sense—not just helping women at a single point in life when they have small children or eldercare responsibilities, but supporting work-life balance for both women *and men* throughout their careers. Systematic change should include performance monitoring, "stretch" assignments and opportunities to advance, and adequate resources to ensure that employees have what they need to succeed in the workplace.

Fouad concluded by describing the role of professional societies in helping retain women engineers and advance their careers. In a webinar sponsored by the American Society of Civil Engineers (ASCE) and other societies, she and Singh discussed creating meaningful leadership opportunities for women and underrepresented minorities at varying levels; targeting women and minorities for association nominations at the fellow level; creating fellowship and leadership programs affiliated with the professional societies; and supporting formal and informal mentoring. As widely talked about as mentoring programs are, only 25 percent of the women in their survey had participated in one, revealing an opportunity for more programs.

DISCUSSION

Joanne Cohoon from the University of Virginia asked whether Fouad and Singh found that mentoring made a difference in terms of the women who stayed in engineering and those who left. Fouad reported that there was no difference, based on questions about whether the respondents' employers offered mentoring programs, whether the mentoring was formal or informal, and whether the women used the mentoring programs. Mentoring was not a contributor to the women's decision to stay, said Singh; she and Fouad had expected to see evidence pointing to the role of mentoring but came up empty.

Does this imply that mentoring is ineffective in terms of retaining women? asked Cohoon. Fouad did not think their data could be used to draw that conclusion; rather, she and Singh believe that mentoring is not widespread enough—and is an opportunity that professional societies could pursue. Informal mentoring, where the chemistry and connection is there, is particularly effective, and formal mentoring can be a catalyst for good mentoring.

> Women who considered leaving their organizations also strongly consider leaving the profession of engineering, much more so than in any other professions.
> ~ Fouad and Singh

Fouad reiterated that retention is not a women's issue but rather a function of workplace climate and lack of advancement opportunities, factors that concern men as well, though probably differentially. However, the survey showed a disproportionately high correlation for women in engineering compared with other professions between women's responses to two questions: (1) Are you thinking

about leaving the organization? (2) Are you thinking about leaving the profession of engineering? Women who considered leaving their organization also strongly considered leaving the profession of engineering, much more so than women in any other professions. This result clearly speaks to the need for interventions to improve workplace conditions for women engineers.

When asked whether the study did any cohort analysis, Singh replied that for the most part their findings mirror Greenfield's very closely, but they did not find any cohort differences in terms of entering the field, staying in the field, or leaving it. Fouad added that they found a departure timeframe similar to Greenfield's, with women leaving engineering after working in the profession for about 9 to 10 years.

Fouad went on to explain that their study is longitudinal and she and Singh are starting to recruit for the second phase, to learn whether the women who left engineering want to return to it and to determine the effects of the recession. With funding for two additional studies, they are also returning to the original partner universities to recruit male alumni, who will be asked many of the questions asked of the women—for example, if they graduated with a degree in engineering and did not enter the engineering workforce, why not? In their second study, Fouad and Singh want to flip the question of engagement, so that it does not address "Why do people leave engineering?" but rather "Why do people stay in engineering?" What is it about a profession or organization that helps people want to stay? Fouad and Singh invited those attending the workshop to assist them in recruiting participants and suggesting survey questions.

Nancy Conrad of the Conrad Foundation asked whether anyone is looking at how to get high school students interested in engineering and how to retain them through college and into careers. Fouad replied that while their own study looked only at people after they graduated from college, a number of studies have looked at earlier stages, and these have been put together in an American Association of University Women report called *Why So Few?*,[2] a resource she recommended.

Nimmi Kannankutty from the National Science Foundation asked whether the researchers knew where the women who leave engineering go: Did they move to higher-level positions in a management capacity? Did they move to related occupations where they would need their technical expertise? Singh explained that most (60–80 percent) of the women who left engineering are working in various capacities and doing well financially. Many are in executive positions; a few had started their own business. Based on their comments, she added, many of them are happy with their choices. Importantly, many said that they would "always be an engineer at heart," and that their engineering training and experience had prepared them well for their careers. Kannankutty observed that this pattern is not unlike what the NSF data show for other women in science fields.

Jennifer Hunt, chief economist at the Department of Labor, noted that just as the researchers had concluded that retention is not a women's issue, her own research showed that it's not an engineering issue or even a science issue: women tend to leave fields that are heavily male.[3] She suggested that it might be helpful to look at fields that are completely different and yet heavily male (e.g., finance or economics). Fouad responded that she and Singh had thought about looking at information technology (IT) but concluded that the variety of college majors going into IT would make it difficult to capture at an undergraduate level. Commenting on this issue in a later discussion, Greenfield said that she had looked at retention for Cohort 1 in education and health care—fields often dominated by women—and business and management, which is more of an equal mix. The 10-year retention rates for men in the women-dominated fields are much lower than those for women in these fields.

Hunt added that one reason for the concern about people leaving engineering is the investment in their training, which they don't use. It may be useful to ask whether these graduates are using the skills acquired through their engineering education even if they are not working in engineering?

Christie Corbett from the American Association of University Women inquired whether the study had investigated whether women leave engineering because it doesn't seem socially relevant: Did they find their jobs unsatisfying because they didn't feel like they were contributing in a meaningful way? Singh replied that this option was included in the study's list of choices but did not come up as one of the key reasons women left. In the anecdotal comments, some respondents (not a large number) felt their work was not contributing to what they thought was engineering's mission and that they were tired of making widgets. Some said the organization they were working for was making things that destroy people's lives rather than contribute to them. Singh also thought that a lack of connection to a meaningful mission could be inferred from responses such as "I'm not really clear what my work is all about" and "I'm getting too many conflicting demands."

The respondents could choose more than one response when asked why they left. Of the 1,100 who had left engineering:

- 136 (12.4 percent) said they lost interest
- 135 (12.3 percent) said there were no opportunities for advancement
- 113 (10.3 percent) wanted more time with family
- 112 (10.2 percent) didn't like the daily tasks
- 80 (7.3 percent) didn't like the culture
- 74 (6.7 percent) didn't like their boss

[2]American Association of University Women (AAUW). 2010. *Why So Few? Women in Science, Technology, Engineering, and Mathematics.* Available at www.aauw.org/research/why-so-few/.

[3]Hunt, Jennifer. 2010. "Why Do Women Leave Science and Engineering?" NBER Working Paper 15853. Cambridge, MA: National Bureau of Economic Research. Available at www.nber.org/papers/w15853.

American Society of Mechanical Engineers President-elect Madiha Kotb related her own experience of joining the workforce in the 1980s and her decision to stay in engineering. It wasn't always easy, she said; at the time the government was encouraging the hiring of women, and there was a stigma that every other engineer and technical person in the building said, "Oh, they hired her because she's a woman." When she and her female colleagues went out to represent the organization, others didn't know how to deal with women engineers, let alone women mechanical engineers. The pressure is greater than what an organization itself can address, she said. One resource that helped her was informal mentoring from both her professional and personal environments, including some who did not know they were providing mentoring. She urged women to use every resource available to them and not be ashamed of it.

Tamiko Mioshia Youngblood Reynolds, associate professor of engineering at Robert Morris University, was interested in learning how faculty can encourage engineering students to stay in the profession, especially African American students. Singh advised faculty to read recent research, including her and Fouad's study, for insights into what works and what doesn't work in organizations. Faculty should be more cognizant of the types of organizations that are recruiting students and encourage students to see what the organizations' cultures are like; some are more progressive and proactive at using the talents of their employees. Students can take advantage of job-shadowing opportunities to get a feel for an organization's culture and be better informed about what jobs there will be like. Such options are clearly helpful, as some of the survey respondents revealed that they felt totally unprepared when they entered the workplace because their educational experiences were not mirrored in their jobs.

4

Retaining Technical Talent: Data Needs, Critical Transitions, and Career Pathways

Are more data needed to understand why women enter engineering and why they stay or leave? If so, what types of data are needed? Tom Perry, director of education for the American Society of Mechanical Engineers (ASME), led this discussion, starting with a review of ASME's work in this area. As a point of reference, he presented data from the American Society for Engineering Education (ASEE) that he and his colleagues found particularly disturbing: Figure 4-1 shows that despite seven years of continual enrollment growth in mechanical engineering, the enrollment of women remained stuck at 11–12 percent.

But then they looked at the chart differently and realized that, for the total numbers to increase and the percentage of women to stay the same, there had to be more women. They saw that since 2005 the number of undergraduate women studying mechanical engineering has risen more than 10 percent faster than the number of men—an increase in women of over 55 percent, compared to a 40 percent increase in men (Table 4-1). ASME has begun a study of these women undergraduates to understand the meaning of this increase for mechanical engineering education, precollege education work, and so on.

ASME is also interested in finding the right mentoring networks and how to structure them. For example, is it better to be more prescriptive—offering women's networks and women's events—or to pay attention to the kinds of things women are interested in and do that kind of programming? A combination of both may be needed, he said.

Perry and his colleagues also realized that the fact that most women engineers are in civil engineering, followed

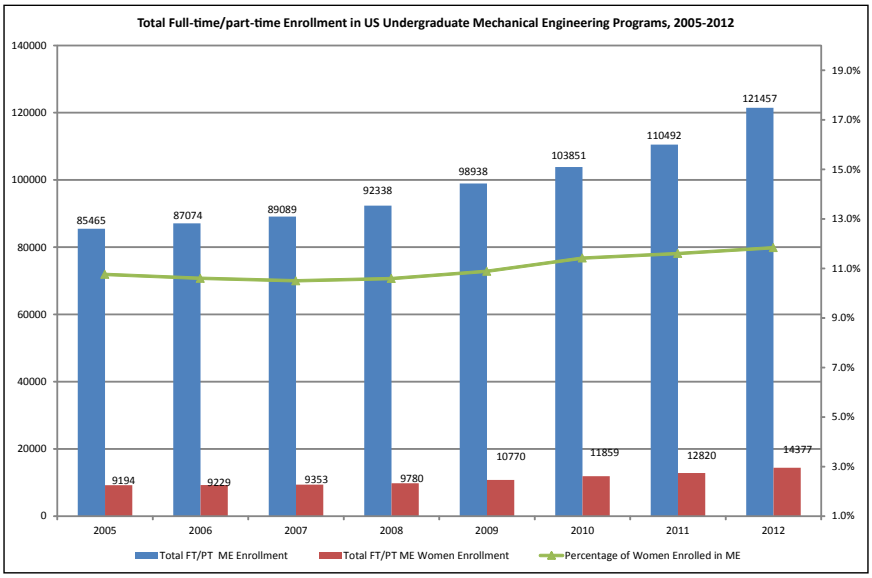

FIGURE 4-1 Enrollment in Full-time (FT) and Part-time (PT) Undergraduate Mechanical Engineering (ME) Programs, 2005–2012. Source: ASEE Data Mining Site. SOURCE: www.asee.org

TABLE 4-1 The number of undergraduate women studying mechanical engineering (ME) is increasing at a higher rate than the number of men, 2005–2012 and 2007–2012.

	2005	2012	Change in number	Percent increase
Female ME undergraduate education	9,194	14,377	5,183	**56.4%**
Male ME undergraduate education	76,271	107,080	30,809	40.4%
	2007	**2012**	**Change in number**	**Percent increase**
Female ME undergraduate education	9,353	14,377	5,024	**53.7%**
Male ME undergraduate education	79,736	107,080	27,344	34.3%

SOURCE: ASEE Data Mining Site, www.asee.org.

closely by mechanical engineering, is important information for ASME. What draws women to mechanical engineering? They survived the front-end filter by getting a degree in the field; next is the other filter—entry into the profession—and then the issue becomes retention again.

When research results and surveys showed that the answer to questions about retention problems was "It's climate, stupid," Perry said he started wondering, Who controls climate? Who has the "thermostat"? Middle managers have control over what happens in the daily lives of people; do they determine the climate? Climate may change because more women are getting into management, but that will take time, Perry noted. It would be helpful for research surveys to track female engineers—and male—into middle management and ask, for example, who taught them to tweak the thermostat?

Catherine Didion opened the general discussion with some questions for the participants to consider: Looking at the climate issues, are there data that would enhance understanding of these questions? Are there issues that should be raised that haven't been considered at the workshop?

Noting the limitations posed by the small sample sizes in the B&B survey, Jennifer Hunt from the Department of Labor wondered about appealing to the B&B surveyors to either oversample in science and engineering or increase the sample size, although she acknowledged that in these austere times that might not be likely. Perry suggested that ASME (and other engineering societies) could help with sample size, given the society's 100,000 members. ASME could do a certain amount of database selection and then the survey instrument itself could filter further.

Joanne Cohoon commented that in her work with the Computing Research Association Committee on the Status of Women (CRAW), they have consistently run into the problem of not being able to learn what they need to learn, such as how many students—men and women, of different ethnic groups—switch from computing to another major. To address the lack of data, CRAW recently launched the creation of a massive dataset based on surveys of students at critical points in their education and on department-level data on outcomes; the surveys cover retention in and attrition from the major, entry into graduate school, and faculty status, among other outcomes. About 70 institutions are participating, and CRAW's goal is to make the data publicly accessible while protecting confidentiality.

Engineering as a whole has the same sort of problem, Cohoon continued, and urged collaboration among those concerned about these issues to collect data and make it accessible. A single survey, for example, might present certain questions one year and different questions in other years, consistently collecting the same basic information for shared use among researchers.

CRAW sponsors undergraduate research experiences for students, and the data show that CRAW programs have a statistically significant effect on participants' likelihood of going into a graduate program in computing. These data are very valuable for determining outcomes for different intervention programs, said Cohoon.

Tamiko Youngblood from Robert Morris University suggested that sample size concerns can also be addressed by engaging the National Society of Black Engineers and other societies whose member demographics are of particular interest to ensure the inclusion of populations that aren't as well represented in the national datasets.

Victoria Rockwell, past president of ASME, wondered whether, in talking about datasets and how to retain women and minorities in engineering, other cultures have been benchmarked. She had recently learned from Kuwaiti women that women there make up over 50 percent of the engineering population, even though as undergraduates they cannot account for the same percentage in the classroom. Yet in a culture that is challenging for women, women constitute the majority in this profession and are very successful. This anecdote illustrates the need to benchmark datasets, conduct comparisons, and examine why women are better retained in some cultures, disciplines, and professions and why they drop out in others.

In response, Cohoon cited studies of engineering in 32 countries[1] and of computing,[2] and a 34-country study showing that interest in math-based fields or careers at the 8th grade level predicts women's participation in fields such as

[1]Charles, Maria, and Karen Bradley. 2002. "Equal but Separate: A Cross-national Study of Sex Segregation in Higher Education." *American Sociological Review* 67:573–599.

[2]Charles, Maria, and Karen Bradley. 2006. "A Matter of Degrees: Female Underrepresentation in Computer Science Programs Cross-nationally." Pp. 183–203 in *Women and Information Technology: Research on the Reasons for Underrepresentation*, ed. Joanne McGrath Cohoon and Bill Aspray. Cambridge, MA: MIT Press.

engineering or computing in those countries.[3] Rockwell too had heard that the odds of anyone going into science, technology, or engineering can be predicted based on how they perform in Algebra 1: if they do well, they'll typically be able to perform in one of the technical professions. Cohoon cautioned that although studies show the need to be able to perform well in math, most women who do extremely well in math choose to major in the humanities.

Constance Thompson, who is responsible for diversity programs at the American Society of Civil Engineers (ASCE), said that she struggles with partnering the Engineering Workforce Commission (EWC) and the Bureau of Labor Statistics (BLS) data. Civil engineering comprises construction, environmental and water resources, and transportation. Does it look like women are well represented in civil engineering careers because a lot of women are going into environmental and water resources areas? There is a need to cross-reference the data and learn how engineering students progress from their undergraduate and postgraduate degrees into the workforce. She recommends that universities, professional societies, the EWC, and the BLS collaborate to provide a clearer picture of the career outcomes of those who major in engineering disciplines. She also works to promote data sources that are less well known, such as the National Association for Minority Engineering Program Advocates (NAMEPA) and the Women in Engineering Programs and Advocates Network (WEPAN). Each has a data collection resource; why aren't they talking to one another, she asked, and why aren't we talking about those data?

Thompson also noted the need to seriously consider the number of foreign students in the United States who are graduating with BS, MS, and PhD degrees in engineering. According to the EWC,[4] in 2012 foreign students were

- the fourth largest population awarded bachelor's degrees in engineering,
- the largest population awarded MS degrees in engineering, and
- the largest population awarded PhD degrees in engineering.

Peggy Layne from Virginia Tech pointed out that researchers tend to approach the study of women in engineering from their own disciplinary perspective—whether psychology, sociology, economics, or another field—and often do not talk to one another or read each other's work, so they sometimes seem to be talking past one another as they attempt to understand the factors affecting women's persistence and success in engineering careers. She encouraged researchers to take a broader perspective on how to engage various disciplines that study women in engineering. The National Academies or another organization might take a role in bringing together scholars from different disciplines to look at these issues.

Nimmi Kannankutty from NSF said that the Foundation has been collecting extensive data on scientists and engineers in the workforce for almost 40 years. In the early 1990s the agency substantially redesigned its surveys to collect information on people with science or engineering degrees and/or in science or engineering occupations, an important change that made it possible to follow people once they got their degree as they entered the labor market and progressed in their careers. One striking finding was an unexpectedly loose relationship between degree and occupation: 70 percent of people with a science or engineering degree don't work in a science or engineering occupation. There is more of a connection in engineering, but it is still not as high as expected: even among those with a PhD in engineering, only about 60 percent work in occupations classified as engineering. Such data are collected through NSF's series of three surveys called the Scientists and Engineers Statistical Data System, which surveys about 100,000 people every two years. Though these surveys are not entirely longitudinal, it is possible to look at the cross-sectional patterns that many researchers have discussed.

The NSF data differ in important ways from those of the Bureau of Labor Statistics, Kannankutty continued. BLS asks employers to provide information about their employees, whereas NSF surveys employees: What do you do? What's your educational background? How do you spend your time? Are you satisfied with that? What kind of entrepreneurial activities do you engage in? How do you keep up your training? How do you stay relevant? Why did you change your job? Why did you leave the labor force? Moreover, once a decade NSF collects information on all college graduates—engineers, scientists, and those in nonscience fields—thus providing data that can provide broad national context.

Didion raised the question of critical transitions in the education and careers of women engineers. Are there certain transitions that seem to be of particular importance?

Hunt wondered why women seem to get onto a career path that leads to far fewer patents than men. Engineering is a major source of innovation, which is a driver of growth in the economy and in standard of living. So what engineers *do* is important, and one of the few tangible, measurable indicators of innovation is whether people patent. In her research Hunt has observed that men's patenting life cycle starts in their 20s, peaks in their 40s, and then drops off somewhat; in contrast, women's patenting life cycle remains at or near

[3] Nosek, B.A., Smyth, F.L., Sriram, N., Lindner, N.M., Devos, T., Ayala, A.,...and Greenwald, A.G. 2009. "National differences in gender–science stereotypes predict national sex differences in science and math achievement." *Proceedings of the National Academy of Sciences* 106(26):10593–10597.

[4] 2012 Engineering & Technology Degrees. Engineering Workforce Commission of the American Association of Engineering Societies. Available at http://ewc-online.org/publications/degrees.asp.

zero.[5] (She clarified, though, that a relatively small percentage of men patent, so it's important not to exaggerate the difference.) Aside from the fact that women are largely missing from mechanical and electrical engineering, which are the big engineering fields that do a lot of patenting, even in these fields women tend not to be in jobs that involve design and development, the tasks most associated with patenting. And that's true right from graduation. Why, right from the beginning, do women get onto a different path from men? Cohoon mentioned two reports from the National Center for Women in Information Technology on women's representation among IT patents,[6] which might shed some light on the issues raised by Hunt.

Echoing Perry's point about whether women will help change workplace climate once they reach greater numbers in middle management, Nadya Fouad raised the issue of women in leadership positions. When she presented her research to a large defense industry company that has a technical path, the attendees expressed concerned that women were not seeking those leadership positions. They wondered why: What's wrong with the women? Fouad reframed the question: What's wrong with the environment that isn't supporting women? In talking to the women, their perspective was, why would we want that opportunity? Patenting, she added, may be an opportunity for leadership.

Didion noted that the career pathways of many colleagues at the workshop may no longer exist for women who are getting their degrees now or did so in the recent past. Much has changed—for example, the assumption that a person may stay with one company for 30 years may no longer be true.

Rockwell questioned whether there has ever really been a career pathway. Each of us is responsible for our own career path, she said. When talking to women who are students or are in entry-level positions, she tells them to keep their eyes on their next position and to set their own career path. She urges them to think about where they want to be in one or two years and in five or ten years; that can change along the way, but they need to have that goal in mind.

Thompson described civil engineering as a highly entrepreneurial field—many women leave and start their own firms after 10 or 15 years. She also pointed out that engineering careers and the engineering curriculum are increasingly interdisciplinary, and that the discussion was not taking this into account. A person might start as a civil engineer and end up working in a field related to mechanical engineering. Current approaches to counting engineers and engineering careers may not capture these transitions.

Referring back to Hunt's observation about patenting, a student said she is about to graduate with a degree in mechanical engineering and that it has never entered her mind to pursue a patent. Instead, she plans to go into a leadership position in engineering soon after she graduates. Didion related this observation to the role of faculty: "To what extent do we help students think about careers, and is there a gulf between what we see as seminal markers of career pathways and whether, for example, students would even think about patenting?"

Hunt said she would ask why not, but she also thinks people should do what they're good at. She cited a friend at Pratt and Whitney who has five patents and believes that women go into management because that's what they're good at—they have better people skills compared to male engineers. If that's what your strength is, you should take advantage of that. On the other hand, if the problem is lack of information or ideas or examples, and that's why you haven't considered a more technical path, then that's a problem that warrants attention.

Cohoon observed that in computing, patenting varies tremendously by company. There is a company element that either encourages patenting as a valuable thing to do or doesn't mention it, and either assists with it or doesn't. That is one big variable in women's patenting. It might never have occurred to you as a student, she said, but if you're hired by a company that values patenting and values you, then you will be encouraged to patent and assisted with that process.

Why are we so concerned about long-term retention of women or men in strictly disciplinary occupations? asked Kannankutty. In engineering education, you learn quantitative skills and project management skills as well as how to conceptualize a problem and how to work in a team. On a macro level, if many people have this training and are out in the workforce, isn't that a good thing?

Gretchen Fougere from Boston University agreed that the point is for people to be productive and help society. Engineering is a great training ground for getting many necessary skills, and a lot of both men and women who get engineering degrees go on to do different things because they are driven by different factors. Students, young or old, need to be educated in how the world works and how to take care of themselves, and that includes advocating for themselves and asking the right questions, such as, What do I need to do next? She wondered about the flip side of the research discussed: What did women do to try to navigate the barriers and hostility? What approaches did and did not work?

Romila Singh commented that an important reason to care about people staying in engineering is innovation. Engineering skills can be applied in all walks of life and they help a person to be productive and innovative. And innovation should include diverse perspectives.

[5] Hunt, J., Garant J-P., Herman, H., Munroe, D.J. 2012. "Why Don't Women Patent?" NBER Working Paper 17888. Cambridge, MA: National Bureau of Economic Research. Available at www.nber.org/papers/w17888.

[6] Ashcraft, Catherine, and Anthony Breitzman. 2006. "Who Invents IT? An Analysis of Women's Participation in Information Technology Patenting." Available at www.ncwit.org/sites/default/files/legacy/pdf/PatentReport_wAppendix.pdf. Ashcraft, Catherine, and Anthony Breitzman. 2012. "Who Invents IT? An Analysis of Women's Participation in Information Technology Patenting: 2012 Update." Available at www.ncwit.org/sites/default/files/resources/2012whoinventsit_web_1.pdf.

Cohoon agreed that engineering skills are very valuable and can contribute to a productive and fulfilling career even if one does not remain in technical work. But when women are lost disproportionately as technical creators, they do not participate in creating the world we will all live in, she said. Engineering defines the built world, and the world should reflect the interests, perspectives, and needs of the world's diverse society.

5

Technical Women in Small and Medium Businesses

Graduate students in a Carnegie Mellon University capstone course presented their research on women working in information technology (IT) in small and medium-sized businesses.

Channing Martin, manager of the Carnegie Mellon University Heinz Graduate Systems Project, introduced the research project. She and her five colleagues attend Heinz College, where they are studying public policy and management in a 2-year program, the first year of which is on the Pittsburgh campus and the second in Washington, DC (with weekly meetings held at the National Academies). Students can work full time while continuing their studies in the evenings, applying lessons from the lecture-style classes to real-world problems. She explained that none of the six women have technical backgrounds, but "we all felt strongly about women in IT, and we wanted to use our policy backgrounds to effect change in that space."

BACKGROUND

Liz Schuelke said that at the beginning of the year, working with Catherine Didion, the students decided to focus on what has kept women's representation in IT jobs at 20 percent for the last decade. The group first conducted a literature review of research on barriers that deter women from entering and staying in the technical workforce; after reviewing 300 abstracts, they read 90 articles. "While there's a lot of research on what keeps women from entering the field and what's making them leave, all of it was geared toward big businesses and large IT firms," said Schuelke.

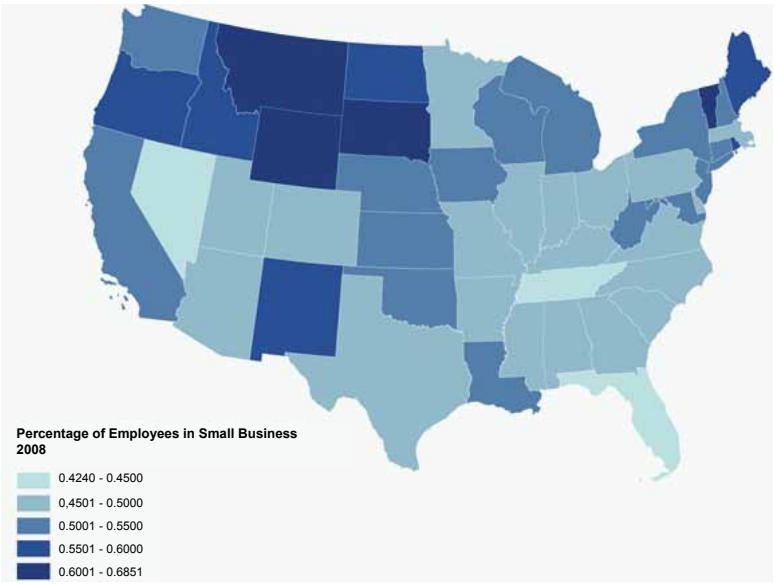

FIGURE 5-1 Percentage of employees in small businesses, by state, 2008. SOURCE: "Statistics of US Businesses: 2008: All Industries United States." US Census Bureau. Available at www.census.gov/epcd/susb/latest/us/US--.HTM.

FIGURE 5-2 Women control 80 percent of consumer decisions but design only 10 percent of IT products and services. SOURCE: Harris, K., and M. Raskino. 2007. *Women and Men in IT: Breaking Sexual Stereotypes*. Stamford, CT: Gartner.

Because most women actually work in small businesses, the group decided to see whether the barriers are the same in small businesses and whether change can be effected differently there.

The students also focused on small businesses because they control a large share of the economy, Schuelke explained: over 90 percent of companies in the United States employ fewer than 500 employees, and these companies account for half of the American payroll. In nearly every state, at least 45 percent of the working population works for a small business (Figure 5-1).

The students conducted a case study of eight companies across the country. They spoke to hiring managers and staff members to learn about the companies' hiring efforts and the training environment once employees have been hired. The students also surveyed 39 male and female IT employees in a variety of roles at these companies, ranging from Web development and software design to IT maintenance and database administration, to learn about their experiences: how they found their jobs, how comfortable they felt in the environment, and what training and/or mentoring programs were available to them.

Women make up about 45 percent of the small business workforce—but only 20 percent of the IT workforce. Why would a small business care about changing this statistic? Schuelke asked. Because women are consumers and make a lot of the decisions in purchases that impact small businesses (Figure 5-2).

One software development firm told the students that over half of its customers are women, but not a single one of its developers is. The firm's representative acknowledged that "Our developers can't talk to the mom, or the young professional woman, in the way that an IT woman could." He asked, "How do we better reach that consumer base?"

If small businesses owners are persuaded of the need to make changes, continued Schuelke, how will they make these changes? The students sought to identify interventions that would be feasible for small businesses to do in the near term. They looked at words that keep women away, and spaces that make them leave, and how to make the IT culture work for everyone. For example, the students determined that the language of job postings deters women from applying. When they surveyed the employees, the students found that, although the companies reported intensive use of websites (e.g., Monster, the company's website, CraigsList) for job postings, only 13 percent of the women found their jobs online, in contrast to 48 percent of the men surveyed.

The literature review turned up job posting language that is consistently associated with masculine occupations versus feminine occupations and may deter women from applying. The students developed a simple resource for use in job postings; for example, substitution of the word "understand" instead of "analyze," "establish" instead of "determine." The phrase "works well in a competitive environment" might deter a female applicant, who would respond more favorably to "knows how to cooperate in a supportive team environment." This is an intervention that doesn't have to go through a lengthy HR process, said Schuelke; it could be applied immediately and have a real impact on the number of women putting their names in the hat.

INFLUENCE OF THE PHYSICAL ENVIRONMENT

Angie Im described physical spaces that induce women to leave IT jobs. Images of videogames and Star Trek are considered stereotypical cues associated with computer science and computer engineering, she continued. A study at the University of Washington found that women demonstrated an aversion to these images in multiple scenarios, such as picking a team to work on or an environment they want to be in.[1] The study touches both on getting desirable candidates hired into a company's workspace and keeping them happy once they are hired.

> While over 90 percent of men reported feeling at least somewhat comfortable (with physical space), only 63 percent of women did.
> ~ Carnegie Mellon study group

With this information in hand, the students explored concerns associated with physical space. They asked

[1] Cheryan, S., Plaut, V.C., Davies, P.G., and Steele, C.M. 2009. "Ambient belonging: How stereotypical cues impact gender participation in computer science." *Journal of Personality and Social Psychology* 97(6):1045–1060.

employees how comfortable or out of place they felt in the company's common spaces, such as meeting rooms or lounges: while over 90 percent of men reported feeling at least somewhat comfortable, only 63 percent of women did.

The students also asked employers, "Do you think your physical space makes women feel comfortable?" One employer responded, "It's pretty dry, it's pretty technical. There's no flowers or other random things. We do have plans to liven up the environment." But he said that there is nothing that would make women feel uncomfortable, and that they have the same seating arrangements as other developers. "As an aside," Im noted, "there's a large oil painting of the Star Trek Enterprise at the entrance to this company, and the business is named after a work of science fiction." Many of the responses show that there's a disconnect between what employers think a diverse group of employees need and what the employees actually may want, she said.

Im then showed an image of the workspace at Mozilla in Toronto, which was voted #1 on Gawker's list of worst tech workspaces (Figure 5-3). Not all tech workspaces look like this, she said, but many do.

Furthermore, none of the eight companies in the study integrated their IT teams; all were separated from the rest of the office. This separation deprives the IT staff of the benefits of the larger corporate environment: the collaboration and dynamic culture often touted by HR employees. Employers need to create opportunities for IT staff and, in particular, women to engage with other members of the office and develop collegial bonds and relationships, said Im. The students are recommending that small businesses integrate IT employees across the rest of the company's offices rather than separating them, usually by walls in a windowless room. Seating IT employees where they are visible to the rest of the office could create a more inclusive environment, she said.

FIGURE 5-3 Example of separated IT workspace.

OPPORTUNITIES FOR SMALL BUSINESSES

Albery Melo observed that most of the studies reviewed focused on how women could assimilate into the dominant organization, instead of looking at how organizational environments could be adapted to accommodate diverse populations, including women. This is a missed opportunity, but small businesses usually are able to make changes to their physical space more quickly than large organizations.

The way women perceive the IT industry may also be a barrier, said Melo. Many see computer science and computer engineering as challenging to and incompatible with their communal goals—they do not see the IT fields as places where they can do work that benefits society, where they can make a difference in the way that, for example, a doctor is seen to do. Like the IT fields, medicine started out as an industry that was predominantly male, but women have been able to thrive in medicine.

It's not just women who have negative perceptions of the field, said Melo: those in the field have negative views of women. IT employers tend to place women in roles that are oriented toward administration, documentation, or training, because they are often perceived as being more detail-oriented and less technical.

To mitigate these barriers and encourage the recruitment and mentoring of women in IT, Melo and her colleagues propose that small businesses implement mentoring programs. These can be highly effective, especially if women are paired with female colleagues. A mentor can help a woman become socialized to the ways of the organization and guide her in her professional development. Of the employees surveyed, 83 percent said that mentoring had a positive impact on their decision to stay in their IT position; no respondent said that it had a negative effect. However, more than half of the respondents stated that no such programs were offered (or they didn't know about them)—another missed opportunity, but, again, one that small businesses can easily redress.

Because not all small businesses may have the resources or staff to implement mentoring programs, Melo and her colleagues suggested the promotion of membership in professional technical organizations. These organizations can be effective for employees and serve as platforms to share best practices. If internal networks are not feasible, external networks may be a great alternative for small businesses.

Melo reiterated that, unlike bigger businesses, small businesses have the flexibility to propose and implement these interventions rapidly, rather than going through a

potentially cumbersome process of approvals. For example, hiring managers could be quickly trained to write less biased job postings—just changing a few words could increase the company's ability to recruit women. Similarly, small businesses are not constrained by the dispersion of several thousand employees in several buildings; they can work directly with the space they are in, using desks and communal spaces to integrate their IT department with the rest of their personnel. And while they might not have the resources or staff for a formal mentoring program, they can draw on professional technical societies as a resource and source of support for their technical staff.

In closing, Martin urged workshop participants from professional societies to share the students' recommendations with their members who are employees or employers at small businesses. She also explained that, given more time, they would like to explore more questions: Where do women go when they leave their IT positions? Do they go to a different or larger firm, or do they leave the technical workforce altogether? To gain more insight into the small business experience, it might be useful to target employees who left large businesses to work in small businesses and see how the survey results differ from respondents who have experience only in small and medium businesses. Last, they would like to research changes in organizational culture over time: Would older men with children have priorities that align more with many women's priorities than younger men without families?

DISCUSSION

Nadya Fouad observed that one of the things she and Singh found in their study was that neither the women who stayed nor those who left identified their experience as sexist. She also agreed that smaller companies are more amenable to change: It might suffice to hire just one or two people to change the environment of a small business; the same would not be true at a company as large as IBM.

Another participant wondered whether the geeky pictures were something the students perceived as uncomfortable or if that perception was reported in the literature. She related her own experience working on the manufacturing floor of a high-tech company, when she and her colleagues had to worry about seeing far more offensive material in someone's toolbox. "I want you guys to understand that we've come a long way, baby," she said.

Carnegie Mellon student Emily Blakemore explained that she and her colleagues wanted to examine a couple of specific aspects to get at the impact of culture, and they selected the physical space and how it is decorated. The University of Washington study in question focused on smaller IT firms and the sense of "ambient belonging"—the idea that all employees want to feel that they belong in their environment—and found that physical environment and culture currently deter women from staying in IT. The study considered Star Wars posters, paint color on the wall, and books on the bookshelf, and reported that women felt less sense of belonging and less interest in the company when there were stereotypical Star Trek posters on the wall.

Given the discussion of words to use in job postings, Kristina Wagstrom from the University of Connecticut asked whether the students found anything in the literature on whether women applicants were looked upon more favorably when they used words like "analyze" instead of "understand" in their applications. Schuelke said they didn't find studies of cover letters, but thought the question deserved research. Erin Cadwalader from the Association for Women in Science commented that there is a fairly sizable body of research on the subject, and it pertains to letters of recommendation as well.

Romila Singh asked whether the students had had a chance to share their findings and recommendations with the companies they surveyed. Im explained that that was one of the incentives they offered the companies for participating: the employers would receive a summary of the findings in which it would not be possible to identify the other companies.

Kathleen O'Hara from Virginia Tech noted that when she worked in a small nonprofit company, the IT staff served as liaisons "between the technical world and the 'human' world" and they had a lot of interaction. They needed to have patience, for example, and the ability to articulate issues, but the management didn't appreciate this aspect of their work and evaluated the IT section entirely on the technical aspects.

She asked what types of businesses the students had surveyed. Sara Raju explained that of the eight companies six were small businesses, one was a medium-sized business (about 800 employees), and one was a small nonprofit. They were in a range of industries—an online clothing company, for example, a law firm, and one or two technology firms.

Im noted that when there are small teams with their own individual cultures, it is important to pay attention to the possibility that someone on the team might not connect with that culture. And there should be ways to help all team members feel valued and connected to the company and the mission of the work, even if they're part of the smaller culture.

Didion invited consideration of places where technology and engineering are done outside of larger entities. For example, there are a lot of women engineers at NASA, but that work is increasingly being contracted out—a trend that raises questions about the communities and cultures where engineering and technology will be done in the future.

6

Closing Discussion

Joanne Cohoon from the University of Virginia led the workshop's final discussion. Noting that people seem to shape their environment to suit them, she reiterated an earlier point that not only do women leave male-dominated fields at higher rates than men, men also leave women-dominated professions at higher rates than women do. What is needed to create environments where *all* people feel comfortable, rather than just one group? This is not just a STEM or engineering issue; nursing and teaching are not especially diverse either. What might be done to motivate employers to create environments suitable for more than one dominant group?

> What might be done that could motivate employers to create environments that are not just suitable for one dominant group?
> ~ Joanne Cohoon

Milan Yager from the American Institute for Medical and Biological Engineers posited that small businesses do not set out to create environments or job descriptions targeted to men rather than women. He believes the challenge is that most people do not understand the value that diversity brings to every field. In every environment diversity can bring value, and to the extent that diversity is a goal, companies and individuals have to do whatever is necessary to attract diverse people, whether by writing different job descriptions or creating different environments.

The easiest thing in the world is to be surrounded by people just like us, said Nadya Fouad: the small businesses probably simply hired people that were like them, and did not see any problem with that. The question is how to emphasize the true value of diversity—not just the "nice" value of diversity, but the bottom-line value of diversity—and encourage people to get out of their comfort zones.

Sara Raju found that many articles focus on gender neutrality rather than gender inclusiveness. She and her colleagues reported that, in addition to "feminine" and "masculine" words, there are neutral words. Similarly, in physical space there are two paradigms: the Star Trek paradigm and the one with blank white walls and white carpet (where no one is likely to be very comfortable). In a third paradigm both men and women would be comfortable. Cohoon remarked that although many employees and professors say they are gender neutral, "neutral" often means that an environment favors men. Failure to act is to allow the status quo to persist. Channing Martin seconded Cohoon's observation: she and her colleagues heard the word "neutral" over and over again from employers, but among employees "neutral" was "male."

She went on to report that in their company interviews, she and her colleagues asked employers whether they were using strategies to target women specifically: all said no, that they recruited everyone equally and did not do diversity initiatives. But many of them also understood that diverse environments are important in terms of return on investment and productivity, as the research shows. So there was a disconnect between having that knowledge and using it (though this may also have been a function of very little turnover in the companies surveyed, so there weren't many hiring opportunities).

Emily Blakemore pointed out that a growing body of research on recruitment is looking at cultural differences among women, and it's important to realize that women from different cultural backgrounds have different priorities and perspectives. It is important to approach employees as individuals—not treating them as men or women employees and not necessarily being gender neutral but recognizing differences in priorities and values that stem from cultural or generational differences. These differences need to be teased out and are an interesting area for future research, she said.

Melissa Carl of the Society of Women Engineers (SWE) and ASME noted that SWE just celebrated its 60th anniversary, with the theme "Success on our own terms." CEO Betty Shanahan wanted to encourage female engineers to find success on their own terms and not feel, as she had, that

they have to be "white men in high heels." We have come a long way, she added.

Referring to the earlier comments on gender neutrality, Romila Singh commented that when people talk about "gender neutral," it is really a code word for the modern form of sexism. People are now so politically correct that overt "-isms" aren't allowed to surface, she said. Thus when people say "I don't see a woman" or "I don't see a person in a wheelchair," it's a coded way to refer to something that makes them uncomfortable. Even if a company doesn't have a diversity outreach officer, it can help to simply have a conversation: "I don't know what you want, but let me know if there's something that can make you happier or more comfortable." Just talk on a personal basis, instead of putting on the "diversity" hat and saying, "Now I have to talk to a woman."

Constance Thompson of ASCE said that her role is really about leveraging diversity, which is inclusion. "Inclusion" appeals more to organizations than "diversity" and is more relevant because it leverages existing diversity. So the first thing is to "change our language and understand that what we are really talking about is inclusion." And professional societies need to acknowledge that they too struggle to engage underrepresented audiences. She suggested further investigation and maybe commissioned studies to look at why, for example, African Americans are leaving engineering.

Fouad pointed out that the definition of success in any company is determined by management, and often by how those managers themselves have been successful. She illustrated with the example of a proxy for a large technology company in Silicon Valley that was having trouble keeping women. Occupational analysts discovered that male employees were solving crises at 3 a.m. A closer look at when these crises were surfacing and whether it was necessary to solve them at 3 a.m. showed that it was not. When the analysts changed the definition for success in identifying and solving problems in a timely fashion, the metric revealed more successful women. This shift was the result of someone who stood back and asked who is defining success and whether there is a differential effect by gender.

Catherine Didion observed that the discussion showed the importance of language and ways to engage. It is necessary to avoid making assumptions about how we should engage and to "acknowledge that we are all part of the problem—and therefore that we all need to be part of the solution."

It's a big and complicated issue, and there's a lot that goes into understanding what creates the problem and how it is maintained, said Cohoon in closing the discussion. Even if people understand the problem, they do not necessarily know what to do about it. There was much talk at the workshop about valuing diversity and recognizing that it really contributes; but Cohoon acknowledged that probably every manager knows that diversity can create problems. So there is a management issue; people are not just going to swallow the "diversity is great" perspective. And because people already feel like they are overcommitted and overworked, it's important to think about changes they will actually be willing to make—changes that have both a low bar to implementation and an appreciable impact.

It is difficult to spur action, even when people know what the right behavior is, because everyone is part of this culture, and both men and women perpetuate stereotypes about who is good in technical roles. How can each individual and institution structure practices in ways that make it more difficult to act on those stereotypes? Those are the solutions to try to identify and propagate.

Appendix A

Workshop Agenda

April 24, 2013

Washington, DC

8:00 am – 9:00 am	**Breakfast and Registration**
9:00 am – 9:15 am	**Welcome** *Lilian Wu*, Member, Career Outcomes of Female Engineering, Bachelor's Degree Recipients, Chair Emeritus, CWSEM, and Program Executive, IBM Global University Program
9:15 am – 10:00 am	**The Career Outcomes of Female Engineering Bachelor's Degree Recipients: A Study Using the Baccalaureate & Beyond (B&B) Longitudinal Study** *Gail Greenfield*, Principal, Mercer Consulting
10:00 am – 11:00 am	**Stemming the Tide: Why Women Leave Engineering** *Nadya Fouad*, Distinguished Professor and Department Chair, Department of Educational Psychology, University of Wisconsin, Milwaukee *Romila Singh*, Associate Professor, Sheldon B. Lubar School of Business, University of Wisconsin, Milwaukee
11:00 am – 11:15 am	**Break**
11:15 am – 12:00 pm	**Retaining Technical Talent: Is There a Need for More Data? Are There Critical Transitions? How Are Career Pathways Changing for Everyone?**
12:00 pm – 1:00 pm	**Lunch Panel: Technical Women in Small & Medium Businesses** *Carnegie Mellon University Heinz College Graduate Capstone Project Team*
1:00 pm – 1:30 pm	**Closing Discussion** Moderator: *Joanne Cohoon*, Member, Career Outcomes of Female Engineering Bachelor's Degree Recipients, and Associate Professor, School of Engineering & Applied Science, University of Virginia
1:30 pm	**Adjournment**

Appendix B

List of Participants

Emily Blakemore
Carnegie Mellon University

Deborah Britt
National Science Foundation

Erin Cadwalader
Association for Women in Science

Melissa Carl
Society of Women Engineers, ASME

Joanne Cohoon
University of Virginia

Marie Coleman
Carnegie Mellon University

Nancy Conrad
Conrad Foundation

Christi Corbett
American Association of University Women

Nadya Fouad
University of Wisconsin-Milwaukee

Gretchen Fougere
Boston University, College of Engineering

Patrick Gouhin
International Society of Automation

Gail Greenfield
The National Academies

Angie Im
Carnegie Mellon University

Rachel Ivie
American Institute of Physics

Jolene Jesse
National Science Foundation (EHR/DRL)

Peggie Koon
International Society of Automation

Madiha Kotb
ASME

Peggy Layne
Virginia Tech

Channing Martin
Carnegie Mellon University

Julie Martin
Women in Engineering ProActive Network

Kaileh Mary
National Institutes of Health (NIA/LMBI)

Melissa May
Deloitte

Albery Melo
Department of Labor

Shari Miles-Cohen
American Psychological Association

Vilas Mujumdar
AAES and ASCE

Kathleen O'Hara
Virginia Tech

Thomas Perry
ASME

Golda Philip
National Institutes of Health

Sara Raju
Carnegie Mellon University

Andrew Richman
Carnegie Mellon University

Barbara Roberts

Victoria Rockwell
ASME

Elizabeth Schuelke
Carnegie Mellon University

Romila Singh
University of Wisconsin-Milwaukee

Patricia Taboada-Serrano
Rochester Institute of Technology

Constance Thompson
American Society of Civil Engineers

Sandra Trevino
Triangle Coalition (NSF/EHR/HRD)

Kristina Wagstrom
University Connecticut

Susan White
American Institute of Physics

Lilian Wu
IBM Global University Programs

Milan Yager
American Institute for Medical and Biological Engineering

National Academies Staff

Catherine Didion

Sara Frueh

Wei Jing

Appendix C

Biographies of Speakers

Joanne Cohoon
Associate Professor, School of Engineering and Applied Science, University of Virginia; and Senior Research Scientist, National Center for Women & Information Technology (NCWIT) Social Science Network

Cohoon is a sociologist who teaches about gender, technology, and education and supervises both graduate and undergraduate student research. She researches, publishes, and speaks on women's underrepresentation in IT and gender segregation in higher education, and has conducted nationwide studies of departmental factors that influence recruitment and retention at the undergraduate and graduate levels of computer science. She is a member of the Georgia Tech College of Computing Diversity Advisory Board, the PROACT Advisory Board, and the Working Committee on Women in Computing of ACM-W. She has a BA in philosophy from Ramapo College (New Jersey), an MA in student personnel administration in higher education from Columbia University, and a PhD in sociology (dissertation on Non-Parallel Processing: Gendered Attrition from Undergraduate Computer Science) from the University of Virginia.

Nadya A. Fouad
Distinguished Professor and Chair, Department of Educational Psychology, University of Wisconsin–Milwaukee

Fouad conducts research on the work-related decisions of women and ethnic minorities. She is editor of *Counseling Psychologist*, past president of the Society of Counseling Psychology of the American Psychological Association, past chair of the Council of Counseling Psychology Training Programs, and past chair of the Board of Educational Affairs of the American Psychological Association. She received her PhD in counseling psychology at the University of Minnesota.

Gail Greenfield
Principal, Mercer Consulting

Greenfield has been involved with studies of the US geospatial intelligence workforce; the science, technology, engineering, and mathematics (STEM) workforce in the US Department of Defense and defense industrial base; and the US energy and mining workforce. She is also a principal at Mercer, where she has more than 10 years of experience helping organizations improve the management of their human capital. Recent projects include diversity-related analyses of pay for a professional services organization and a hospital system to identify areas of these organizations with systemic pay disparities, and the generation of diversity benchmarks for four occupations in 18 countries for an international equipment manufacturer. Before joining Mercer, she was an assistant professor of economics at the College of Wooster. She received a PhD in economics from Claremont Graduate University and a BA in business economics from the University of California, Santa Barbara.

Romila Singh
Associate Professor, Lubar School of Business, and
Associate Research Director of the Center for the Study of the Workplace, University of Wisconsin–Milwaukee

Singh's research focuses on understanding career management issues related to career choices, work-life relationships, mentoring, retention, and turnover decisions of women and people of color. Her research has appeared in leading journals on management and vocational behavior, and she has also authored or coauthored several book chapters. She teaches courses in human resources management at undergraduate and graduate levels and has been awarded the School of Business teaching award every year since 2002. She is the faculty advisor for the student chapter of

the Society for Human Resource Management (SHRM) at UWM and helps this student-led organization win national awards and recognition for their professional programming and activities. She serves on the executive board for the Careers Division of the National Academy of Management. Singh received her doctorate in organizational sciences from Drexel University.

Lilian Wu
Program Executive, Global University Programs, IBM; and Past Chair, National Research Council Committee on Women in Science, Engineering, and Medicine

Wu manages a portfolio of major IBM-university-government research collaborations for IBM's Global University Programs. She has had a distinguished career at IBM mostly as a researcher in the mathematical sciences department, where her focus was on developing business planning methods and pricing of commodities and contracts, both under uncertainty. Her current interests are analysis of technology-enabled and people-intensive complex systems, particularly in the education and service sectors. She recently coauthored and published "Leadership hurdles" (*Nature* 493:125–126) and in 2012 contributed to *The Cost Disease: Why Computers Get Cheaper and Health Care Doesn't* (ed. W.J. Baumol; Yale University Press, 2012). She served on President Clinton's Committee of Advisors on Science and Technology (PCAST); NSF's Committee on Equal Opportunity in Science and Engineering, Engineering Directorate Advisory Committee, Committee on International Science and Engineering, and Corporate Alliance; the AAAS Committee on Public Understanding of Science and Technology; and the DOE Secretary's Laboratory Operations Advisory Board. She received her BS in mathematics from the University of Maryland, PhD in applied mathematics from Cornell University, and an Honorary Doctor of Humane Letters from Marymount College.

Carnegie Mellon University Heinz College Capstone Project Team

Members

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Born and raised in Southern California, **Angie Im**'s exposure to urban policy issues has shaped her experiences and interest in the intersection of business, environment, health, and technology. After receiving a BS in public health sciences from the University of California, Irvine, she worked at the California Department of Fish and Game on a unique, public-private partnership for developing marine protected areas along the California coast. As a result of her experience there and with a nonprofit organization conducting medical and humanitarian missions abroad, she was inspired to transition her focus from the sciences to public policy as an avenue for safeguarding the health and environment of future generations. She is honing her evaluative and technical skills as a program analyst trainee at the Department of Justice, and looks forward to working with IBM as a consultant in San Francisco in the fall.

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Appendix D

Stemming the Tide: Why Women Engineers Stay in, or Leave, the Engineering Profession

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INTRODUCTION

Consider this: millions of dollars in federal and private funding have focused on helping women enter and stay in STEM fields. In fact, in 2011, the President's Committee on STEM Education found that $3.4 billion dollars were spent by various federal agencies on STEM education, with about a third of that ($1,086 million) focused on increasing all underrepresented groups' participation in STEM careers and about 10 percent of that funding ($13.28 million) explicitly directed towards girls and women in STEM education (CoSTEM, 2011). Most of that funding has focused on intensive early education initiatives to help promote girls' interests in math and science and introducing them to engineering as a career. Juxtapose these investments with the almost steady and very low graduation rate for women engineers (11%) over the last two decades (NSF, 2011) and one can clearly see that despite numerous interventions, engineering remains one of the most sex-segregated occupations in the United States. This trend also echoes in the continued underrepresentation of women engineers in technical workplaces. What is even more concerning is that female engineers who do enter technical workplaces, end up leaving at a rate that's four times as much as their male counterparts (SWE, 2007). The loss of women engineers from technical workplaces has implications for the organizations, for the women who leave, and for our society as a whole. Against this backdrop, this article takes a critical look at the key differences between women engineers who left technical workplaces and those who are currently working in engineering. Using key vocational and management theories, we expose the points of convergence and divergence in the experiences of these two groups of women engineers from different racial and ethnic groups.

BACKGROUND AND PURPOSE

US leadership in technical innovation has been a vigorous force behind our nation's economic prosperity for at least the last 50 years. Recent concern about declining numbers of U.S. citizens choosing to enter technical careers and the increase in technological talent and jobs overseas led Congress to ask the National Academy of Sciences to analyze the U.S. technical talent pool and make policy recommendations to advance U.S. competitiveness in global research and development markets (Committee on Science, Engineering, and Public Policy, 2007). The report effectively argued for the increased importance of technology to the US economy, demonstrated global trends in research and development that favor other countries, and highlighted the need for concrete action to enhance U.S. competitiveness. In 2010, the National Academy of Sciences revisited the report and evaluated progress on the recommendations. The title of the 2010 report, *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5* is telling in the alarm the committee voiced about the lack of resources to implement the recommendations, the lack of preparation of K-12 students to enter science and engineering careers, the role of science and engineering in creating new jobs to help bolster the economy and, finally, the important finding that other nations are effectively competing with the US in technology and science.

We would add one more point to those made by the NAS (2005; 2010) reports: it is critical to keep current engineers and scientists in their organizations and the profession. Increased difficulty to secure visas to study and work in the United States combined with additional opportunities in other countries (especially India, China, and Brazil) have led to an increased reliance on US-born and -educated scientists and engineers. But at the same time, the Department of Labor predicts that domestic growth in engineering jobs is declining as manufacturing and design is done more globally

and a larger than average number of engineers are approaching retirement age (DOL, 2011). This issue acquires even greater urgency in light of a trend that shows that engineers leave the field at a rate four times that of doctors, three and a half times that of lawyers and judges, and 15-30 percent more than nurses or college teachers (Preston, 1994). Specific to women engineers, we already know that roughly half of the women who graduate from engineering leave the field (AAUW, 2010; NAS, 2011). A report released by the Society of Women Engineers (2007) suggests that women leave engineering careers in part because they encounter a chilly organizational climate when they reach childbearing age and desire to balance work and family roles. Of course, individuals leave all professions to pursue other occupations, but we argue that it is critical to U.S. technological competitiveness and to national security, to help understand factors that will help engineering organizations retain its highly trained female workforce and prevent avoidable turnover. Against this backdrop of disturbing trends in engineering as a whole, and specifically, among women engineers, we sought to understand factors related to women engineers' intentions to leave the organization and the profession and uncover key differences between women who left engineering and those who persisted in engineering careers.

FRAMEWORK FOR THE STUDY

We identified the top 50 universities that graduate women in engineering programs, as well as the top 20 universities that graduate Latino, African American and Asian engineers and used these lists to contact the deans of Colleges or Schools of Engineering and invite their engineering alumnae to participate in the study. Nearly half of the universities responded affirmatively, and in the end, thirty universities representing every region of the country, including large public and private institutions and universities known for their technology programs, agreed to participate.

In some instances, emails and postcards were used to contact female engineering alumnae whose addresses were provided to the team by the university. In other cases, the alumni offices sent the link to their alumnae themselves. Women interested in participating in this study were directed to a dedicated website and a link to the online survey. However, we realized that women were sending the link to their female engineering friends and co-workers. In the end, although we started with alumnae from 30 universities, women from an additional 200 universities participated in the survey after hearing about the study in the media and through colleagues.

Profile of Participants

A total of 5,562 women who graduated with a bachelor's degree in engineering participated and completed the study. Of this, 554 (10 percent) women obtained a degree but never worked as engineers, 1,365 (29 percent) women previously worked as engineers but had left the field since (279 of these left less than five years ago), and 3,324 (60 percent) women are currently working in engineering. This article is solely focused on those women who are currently working in engineering (labeled "persisters) and compares them with women who left engineering within the past five years (labeled "non-persisters"). These two groups received the entire survey; the other two groups filled out shorter versions of the survey. We chose five years as a cutoff point for comparison to ensure recall accuracy and minimize the potential for recollection biases.

A Comprehensive Portrait of Women Engineers: Those Who Stay and Those Who Leave

The top majors for women currently working in engineering were chemical, mechanical, civil, and electrical engineering. Forty three percent received additional degrees; most had a master's or MBA, and 2 percent had earned a PhD. The graduates represented over three decades of engineering education: 9 percent graduated prior to 1984, 10 percent in 1984–1989, 7 percent in 1990–1994, 11 percent in 1995–1999, 14 percent in 2000–2004, and 12 percent after 2005. Most women self-identified as Caucasian (84 percent), with 3 percent identifying themselves as Latina, 2 percent as African American, 3 percent as Multiracial, and 8 percent as Asian or Asian-American.

Similar to women currently working in engineering, the majority (79 percent) of those who had left engineering less than five years ago also self-identified themselves as Caucasian followed by Asian-Americans (8 percent), 3 percent each representing African-American, Latina, and multiracial groups, and 2 percent reported belonging to "other" category.

With regard to their marital status, 70 percent reported being married or in a committed relationship, while 23 percent reported never having married. Only a quarter reported being parents. Current women engineers in our sample were no less likely to be married as their counterparts who left engineering less than five years ago, but less likely to be parents.

Current engineers reported working on an average for 43.5 hours/week, being with their employer for 8 years, and earning a median income of between $76,000-$100,000 a year. Among this group, two-thirds reported that the gender composition of their work group was either mostly men or all men. About half (51 percent) reported working as individual contributors with no direct reports, while 30 percent worked as project managers, and 16 percent were in executive positions. The top industries represented were consulting (16 percent), aerospace (10 percent), electronics (6 percent), education (6 percent), construction (5 percent), computer engineering (4 percent) and utilities (4 percent).

There were no significant differences between women

who are currently working in engineering and those who left engineering less than five years ago in terms of the hours worked (39 hours/week), length of tenure with their company (10 years), average range of salary reported (between $51,000 and $75,000), and both groups were likewise most likely to have graduated with chemical, mechanical, civil, and electrical engineering degrees.

Unlike women who are currently working in engineering, women who left engineering were more likely to be in management and executive positions (53.8 percent) and project management roles (21.9 percent). The least common positions occupied by these engineers were nonmanagement roles (24.4 percent). Unlike women who are currently in engineering, the majority of women who left within the past 5 years were in an executive role. Finally, for those in management positions, the majority indicated that they had 1 to 4 direct reports and were most likely to work in groups that were predominantly male; however, a larger number who left engineering (26 percent) reported working in gender balanced groups.

In sum, current and former engineers do not differ in terms of race, marital status, or engineering major, salary level, or number of direct reports. They do differ, however, in their current role, with former engineers more likely to be in management or executive positions.

Are there Differences in Self-Confidence Beliefs or Interests Between Persisters and Non-Persisters?

In a word, no. In our study, we examined three types of self-confidence beliefs that can potentially influence one's decision to stay in, or leave engineering: first, confidence beliefs regarding one's ability to perform technical and engineering tasks, second, confidence beliefs regarding one's ability to navigate the political environment at work, and finally, confidence in one's ability to manage multiple life roles such as being a worker, parent, and/or spouse/partner. Our results revealed that, compared to women who are currently working in engineering, women who are no longer working in engineering did not have significantly different levels of confidence in their abilities to perform engineering tasks, navigate the political environment at work, or juggle multiple life roles.

Interests: According to prominent vocational psychologists, individuals seek out jobs, careers, and work environments that match or fit their dominant interests, which in turn enables them to fully flourish in those chosen fields or areas. Our analyses revealed no significant differences in different types of interests between women currently working in engineering and those that left the technical workplaces less than five years ago.

Are there Differences in Experiences of Workplace Support Between Persisters and Non-Persisters?

Yes. At a very broad level, workplace support is reflected in the extent to which a company values the contributions of its employees and shows care and concern toward the employees' wellbeing thereby inhibiting their desire to leave the firm.

Workplace support is also manifest in the overall climate that allows supervisors and managers to be accommodating and responsive to their subordinates' non-work responsibilities and makes it conducive to their managing multiple life role obligations. More tangibly, it also encompasses the extent to which formal work-life policies (such as part-time work, job-sharing, paid and unpaid leaves of absence, and flexible work arrangements) are provided and used to manage work-life roles. The supportiveness of a company may also be seen in the provision of training and development opportunities and clear and tangible avenues for advancement that were made available to employees. Finally, workplace support can also be gauged at a more immediate and micro level by understanding the social support provided by one's supervisors and co-workers.

In sum, we examined women engineers' perceptions of workplace support at two levels. First, the participants reported the extent to which their organizations supported their training and development, provided avenues for promotion, valued and recognized their contributions at work, offered work-life initiatives, and created a supportive climate for fulfilling multiple life role obligations. Second, we examined the extent to which the women engineers received support from their supervisors and coworkers.

Our analyses revealed three key findings. First, we found that women currently working in engineering were significantly more likely than women who left engineering to perceive opportunities for training and development designed to help them advance to the next level. They also perceived greater opportunities for advancement within their organizations compared to women who had left engineering. Second, women engineers currently working in engineering reported fewer work-life benefits available to them as compared to their counterparts who had left engineering, but were significantly more likely to have used those benefits. Finally, current engineers were significantly more likely to report both supervisor and co-worker support, and that the climate was supportive of their need to balance work and non-work roles. There were no significant differences between the two groups on all other workplace supports, nor were there any significant differences among different racial ethnic minorities in their experience of a supportive workplace.

Are There Differences in Experiences of Workplace Barriers Between Persisters and Non-Persisters?

Again, yes. Workplace barriers exemplify any influences that detract and hinder employees from pursuing their goals, deciding a course of action, and making a fulfilling choice. We examined two broad categories of barriers in this study, both of which were anchored in the work environment. The first set of factors tapped into the perceptions of incivility in the workplace that was captured by the extent to which supervisors, senior managers, and coworkers treated women in a condescending, patronizing, or discourteous manner (Minor-Rubino & Cortina, 2007). We also directly assessed the extent to which supervisors and co-workers engaged in undermining behaviors at work such as insulting women, talking badly about them behind their backs, belittling them or their ideas, making them feel incompetent, and/or talking down to them (Duffy, Ganster, & Pagon 2002). The second set of hindrances focused more on role-level barriers such as the extent to which women engineers lacked clarity in their roles, experienced contradictory and conflicting work requests and requirements, and felt overburdened with excessive work responsibilities without commensurate resources.

Women who are currently working in engineering have to face and contend with a variety of barriers at work. However, our results revealed few areas of differences between women who left engineering and those who stayed in the field. Compared to women who are currently working in engineering, one of the biggest barriers that former engineers reported facing was working in an environment that belittled and treated women in a condescending, patronizing manner. The former engineers also reported being systematically undermined by their supervisors compared to their counterparts still working in engineering. Racial and ethnic minorities also reported being undermined by their supervisors more frequently than their Caucasian counterparts. While there were no differences between current and former engineers in their experiences of work-role barriers, racial and ethnic minorities experienced more frequent role conflicts stemming from incompatible work demands from different stakeholders.

In sum, as compared to women who left engineering, those who are currently working in engineering have greater extent of support from their organizations in the form of training, development, and advancement opportunities, and supportive supervisors and coworkers. At the same time, current engineers experienced far fewer barriers at work in the form of incivility and undermining behaviors as compared to those who left less than five years ago.

What Influences Desire to Leave Engineering?

Some of the strongest and most proximal correlates of turnover intentions are job attitudes such as satisfaction and commitment. Women currently working in engineering reported being significantly more satisfied with their careers and the engineering profession than women who had left technical workplaces less than five years ago. Further, current women engineers were also significantly less likely to express intentions to leave the profession than women who had left technical workplaces. We also found that engineers who felt satisfied with their careers and committed to the engineering profession were less likely to want to leave the engineering profession. Finally, our results revealed a very strong positive correlation between engineers' intentions to leave their firms and their desire to leave the engineering profession.

STEMMING THE TIDE: KEY TRENDS THAT EXPLAIN WHY WOMEN ENGINEERS STAY OR LEAVE

The consideration to leave's one profession represents one of the significant events in any employee's career. Given that engineering represents one of the professions that is losing its highly trained personnel at a rate faster than comparable technical professions, the results of our study have important implications for the engineering profession as a whole as well as organizations that employ engineers. Our comparison between women who left engineering less than five years ago and those who are still working in engineering revealed four key trends:

- No differences between self-confidence in performing engineering tasks, navigating politics at work, and managing multiple work-nonwork roles.
- No differences in interests between persisters and non-persisters.
- What does differentiate these two groups of women engineers from one another is their experience of supportive and encumbering factors in the workplace.
- The two groups differ in their level of commitment and satisfaction with the engineering profession and their careers, respectively; persisters reported a higher degree of career satisfaction and career commitment than their counterparts who no longer worked in engineering.

Dispelling Some Common Myths about Women Engineers

One of the common misconceptions in the popular literature on women in engineering has centered around the notion that women who either quit engineering or are not successful in engineering careers lack the self-confidence in their technical abilities. Our finding is contrary to this anecdotal evidence as well as a few other small-sample studies that point to women's lack of self-confidence as a primary driver for their lack of persistence in engineering. Taken in

conjunction, these results imply that women engineers' self-confidence (or lack thereof) plays ***no*** role in their decision to leave the profession.

Along the same lines, the lack of significant differences in interests between the persisters and non-persisters implies that women who are currently working in engineering do not have different interests from their counterparts who left engineering workplaces. In other words, our finding dents the anecdotal narrative that a 'loss of interest' differentiates these two groups of women engineers, or in some way, guides these women to think about leaving the profession.

Another common notion that is commonly offered to explain why women engineers leave engineering has to due to with women's desire to stay home with the children. What is not captured in this narrative, but revealed in our data, is that women engineers who decide to quit engineering do so as a last resort, after exploring and exhausting all options for flexible work within their organizations. As evidenced in our study, women currently working in engineering reported making use of the few work-life benefits that were offered to them compared to their counterparts who quit engineering. What was more compelling is that former engineers reported working in organizations characterized by cultures that were not supportive of their needs to balance work and family obligations. In other words, lack of workplace flexibility and non-supportive work-life cultures operate to force women engineers to quit technical workplaces when faced with equally compelling sets of work and parenting responsibilities, rather than women's lack of willingness to persist in engineering when they become mothers.

Why Despite Leaning In, Women Engineers Are Getting Pushed Back (and Out): It's the Climate!

Clearly, women engineers' self-confidence and level of engineering interest does not appear to be related to their departure from engineering. Moreover, they work hard and long hours, and are committed to the engineering profession. What does set the current and former engineers apart is the workplace climate that they encounter: whether it is supportive or chilly. Overall, our findings revealed that women currently working in engineering, as compared to those who left engineering, experienced a supportive workplace that provided them with opportunities for training, development, and advancement within their organizations. Moreover, current engineers worked with empathic and understanding supervisors and coworkers, especially supervisors who were supportive of their need to balance work and non-work roles.

Another element of a supportive work environment that emerged as a differentiator between women working in engineering and those who had left was the presence of a family friendly work culture characterized by recognition of the importance of work-life balance. Although current women engineers reported fewer work-life benefits available to them as compared to their counterparts who had left engineering, they were significantly more likely to have used those benefits. Work-life benefit availability and use are closely anchored to the underlying work-life culture.

We also detected a complementary trend, albeit in the form of workplace barriers: women who were currently current engineers experienced far fewer barriers at work in the form of incivility and undermining behaviors as compared to those who left less than five years ago. Undermining and incivility behaviors are indicative of a toxic work environment that can pose a hostile and seemingly insurmountable barrier to women engineers' persistence and progress in engineering with the potential of driving them out of the profession.

Taken in conjunction, the results with regard to the experience of workplace barriers and supports point toward workplace climate being the biggest differentiator that sets apart women who are currently working in engineering from those left the technical field. What pushes women engineers away from persistence and success in engineering has nothing to do with their self-confidence or interests and everything to with inadequate training and development opportunities, lack of advancement avenues, role related stresses, and their experience of a hostile, chilly climate.

RECOMMENDATIONS FOR KEY STAKEHOLDERS

Implications and Recommendations for Organizations

In his State of the Union Address in 2011, President Obama exhorted the nation to "win the future" and stated that increasing the number of women engaged in science, technology, engineering, and math (STEM) fields is critical to our Nation's ability to "out-build, out-educate, and out-innovate" future competitors. The recommendations derived from our study help us to move one step closer to fulfilling President Obama's mandate by providing critical achievement data that can enable organizations, educators, and policymakers to thoughtfully craft initiatives and programs that advance and optimize women's engagement in technical careers.

At the very outset, we must emphasize that all data from our research points to one overarching conclusion which is that women engineers' departure from technical workplaces and engineering fields is not a "women's issue." Instead, it presents itself as organizational and institutional failure to utilize and optimize a significant portion of their technical workforce, and in doing so, hurts their own chances at long-term success. In that spirit, we first offer several recommendations to organizations and institutions that hire and retain women engineers. These recommendations are meant to be directional and not prescriptive and are designed to spark discussion, action, and reform.

First, we believe that efforts to retain and advance women engineers in technical workplaces cannot just be half-hearted, add-on programs, meant to superficially

address some perceived inequity. Our data highlight that the type of changes that will make a difference need to start at the top. Specifically—

- We call upon corporate leaders and managers at every level to invest in women engineers' careers in the same way they invest in their male engineers' careers – through systematic training and professional development activities that build and enhance skills and genuinely sponsor them for greater operational, strategic, and leadership roles.
- We believe that even if change efforts start at the top, they need to be accompanied by system-wide changes that place gender equity in central focus in every aspect of its talent management process, from allocating choice assignments, to performance monitoring and reward systems.
- Our data reveal that changes need not always be transformational and structural in nature. Micro-level changes that eliminate role related stresses, such as defining and clarifying how, when, and what needs to be done, can help women engineers be more effective in accomplishing their work goals. Similarly, by reducing or eliminating conflicting work role demands, expectations, excessive workload, and disruptions, women engineers can more fully contribute toward their organization's mission.

Our second set of recommendations calls upon the committed, senior leadership to consider not only breaking down structural and systemic barriers that are holding women engineers back and driving them out, but also dismantling some invisible barriers that are powerfully entrenched in a chilly workplace climate that underlies corporate decision-making. The climate issues that women engineers confronted were definitely not invisible or unintentional. In fact, these represented deliberate actions and behaviors that undermined women engineers' efforts to succeed at work. We suggest that leaders and managers at every level address climate issues by:

- Instituting zero-tolerance for incivility and undermining behaviors and creating a culture of respect for all facets of employees' lives.
- Initiating organizational support programs that enable all employees to better manage their work and nonwork demands. Structural changes, such as introducing "flextime," are inadequate and just skim the surface at best, and at worst, penalize the very employees they are meant to assist by reducing their advancement and developmental opportunities. In essence, mere introduction of "family friendly programs" without commensurate changes in workplace climate may do little to address the invisible but powerful gender inequity beliefs held by many managers that may subtly, and unintentionally, hamper women engineers' careers. To adequately address this, many of the nation's top workplaces have moved away from norms that emphasize "face-time" with its accompanying culture of excessive work hours to ones that stress "performance."

All this requires serious and sustained commitment and engagement not just from senior leaders and middle managers, but from all employees, including women, from all levels and ranks.

Implications and Recommendations for Policymakers

The results from our research have ramifications that go well beyond organizational and institutional boundaries; they have undeniable implications for policymakers as well. We believe that fully engaging and leveraging the talents of women engineers should be an integral part of our nation's strategy to out-innovate, out-educate, and out-build our competitors. In the words of First Lady Michelle Obama, "If we're going to out-innovate and out-educate the rest of the world, we've got to open doors for everyone. We need all hands on deck, and that means clearing hurdles for women and girls as they navigate careers in science, technology, engineering, and math" (9/26/11). Clearly, a vibrant and innovative scientific community can thrive only when it draws from all segments of the technically skilled workforce.

The foundation for economic prosperity and national security is innovation, particularly in STEM fields, and the key driver of innovation in STEM fields includes full engagement of women. Therefore, *retaining the talents of highly skilled women engineers* is not only a necessary step toward fulfilling President Obama's mandate for increasing our nation's competitive advantage, but it is also vital for our nation's economic prosperity and national security. According to a study by the U.S. Department of Commerce (2011), STEM careers offer higher earnings potential and job stability than non-STEM careers with women in STEM jobs earning 33 percent more than their counterparts in non-STEM occupations. However, a 14 percent gender wage-gap persists in STEM occupations (compared to 21 percent wage gap for non-STEM fields). This is in part due to outdated gender stereotypes along with archaic organizational models of career success that defines advancement as a linear climb to the top with few options to maximize a career-life fit.

Increasing opportunities for women to enter and succeed in STEM fields is an important step toward realizing greater economic prosperity for themselves and the nation as a whole. Policymakers have a vital role to play in crafting initiatives that strengthen the "all-hands on deck" approach advocated by President Obama and First Lady Michelle Obama and "clearing the hurdles" that prevent the full utilization of women STEM professional's human capital. One recent example, such as the 2011 *NSF-Career-Life Balance Initiative* promises to provide greater work-related flexibil-

ity to women and men in STEM research careers, and is a step in the right direction. By providing gender-neutral and family friendly policies and practices, this initiative could help employers such as colleges, universities, and research institutions to improve the placement, advancement, and retention of their women scientists and engineers.

Other initiatives could help improve STEM workplaces to promote gender equality and retention in addition to offering programs that enable re-entry and re-training for women STEM professionals. Policymakers could also strengthen the funding agencies by encouraging proposals that assess the effectiveness of various initiatives/policies designed to increase representation and promote retention of girls and women in STEM fields. Another way that policymakers can utilize the insights and information from our study to have an impact is by adopting some of the best workplace practices within the agencies they manage. For example, federal agencies can lead the way in becoming model workplaces that establish systems and practices that provide technical and professional developmental opportunities and an inclusive and equitable climate that enables all their employees to flourish and fulfill non-work obligations while pursuing a highly engaging career.

For over four decades, investment of significant sums of federal money has helped increase representation of girls and women in STEM fields and careers. All the well-intentioned policies and monetary investment comes to naught if the organizations that employee women scientists and engineers don't retain a significant portion of their highly talented workforce. If technical workplaces continue to be unappealing because of their outmoded cultures modeled after one pattern of career achievement and engagement, then not only female STEM professionals will be turned away to work for them, they will lose out on all talented individuals that seek an inclusive work climate with multiple career options and paths that allows for a fulfilling work life.

Implications and Recommendations for Professional Societies

Our recommendations to professional societies of engineering are likewise directional and not perspective. Professional associations and societies of engineering have a pivotal role to play in the retention, engagement, and advancement of women engineers in technical careers. In particular, the leadership at professional societies of engineering not only advocates on behalf of all its members, but more importantly, it carries with it the power to represent the voices of the women who are *not* at the table, and potentially changing the narrative to be more inclusive and equitable. Many of the leaders of professional engineering societies are uniquely positioned within an influential network of educators, university administrators, policymakers, corporate decision-makers, and funding agencies (to name a few). As such, they have the power to initiate, coordinate, and champion concrete efforts, across multiple platforms, that lead toward greater equity, inclusion, and representation of women in technical disciplines. Toward that end, we offer the following suggestions for consideration by the leadership of engineering societies:

- to empower women engineers to succeed and advance within technical disciplines by providing opportunities for leadership, skill building, and professional development
- to consistently advocate for gender equity across all stages of the talent pipeline within their home institutions (e.g., recruitment, performance monitoring, reward allocation, career development, and advancement) thereby modeling some of the best management practices.
- to increase gender representation in areas that serve as conduits for professional development and leadership roles such as administrative boards, editorial boards, committees, grant review panels, and conference programs. We add a cautionary note to avoid "tokenism" in any of these efforts.
- to champion for inclusion and representation of women's and URM's voices in STEM related public policies and legislative initiatives.
- to nominate high-achieving women and URM as Fellows within their professional engineering associations.
- create fellowship programs for women and URM and offer opportunities for formal and informal mentoring within the academies (e.g., developmental workshops)
- to partner and establish collaborative relationships with other national associations that specifically represent women and URM in STEM (e.g., AWIS, WEPAN, SWE, AAWIT, NCWIT)
- to actively promote women's and URM's career success and engagement in STEM by dismantling a variety of cognitive, cultural, systemic, and institutional barriers that marginalize these groups' contributions and increase their professional isolation.

CONCLUSION

Over three thousand women engineers from across the nation, representing a wide range of industries and engineering disciplines, participated in our groundbreaking research that captured and documented their experiences in the workplace. The results of our study have helped surface and give voice to the collective experiences that shape their decisions to stay in, or leave, engineering. The workplace represents the terminal destination of a long pipeline of technical education, full of twists and turns, through which many women have travelled, investing and sacrificing much along the way. To lose these human and monetary capital investments is to jeopardize our nation's long term economic

prosperity, national security, and technical leadership in the world. So change we must. The workplaces also represent the start of another pipeline, one that fuels and protects our nation in every which way. The results from our study highlight some possible intervention points and offer data-driven suggestions to effect change, both incremental, and transformational, so as to actively develop, promote, and capitalize on the different skills and perspectives of women and under-represented minority professionals within STEM.

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Appendix E

Women in IT: RECRUIT THEM & RETAIN THEM

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I. Introduction[1]

The lack of women represented in the Information Technology (IT) workforce is an economic issue that affects society at large. As women continue to experience barriers that discourage them from entering and staying in the IT industry, they are denied opportunities in a growing field that has, in recent years, seen gains in both earnings and employment. This study's aim is twofold: first, to analyze the barriers that prevent women from joining the IT field and second, to provide small businesses with three actionable interventions they can implement to better recruit and retain women in IT positions.

For this study, the US. Bureau of Labor Statistics' categorization of Computer and Information Technology positions will constitute our definition of the IT field and related occupations.[2] They include the following occupational titles:

- Computer Hardware
- Computer Network Architect
- Computer Programmer
- Computer Scientist
- Computer Software Engineer or Developer
- Computer Support Specialist
- Computer Systems Analyst
- Database Administrator
- Information Security Analyst
- Network and Computer Systems Administrator
- Technical Support Specialist
- Web Developer

While the definition of small business varies across sources, for the purpose of this study small businesses are considered independently owned companies employing fewer than 500 employees.

II. Literature Review

A comprehensive literature review was conducted to better understand and identify existing barriers that challenge the recruitment and retention of women in the IT field. The review was guided by four key questions (detailed in Table 1, below). Given the limited data available on women in IT positions within small businesses, the conclusions of this literature review were derived from studies conducted in larger corporations.

TABLE E-1 Guiding Questions for Literature Review

For Recruitment	For Retention
1. What strategies have been proven to be effective and are currently in place to attract women into the IT industry?	1. What factors about a company enables a woman to continue working in the field and avoid leaving the industry?
2. What are the current challenges in recruiting women for current computer science positions	2. What are the challenges to keeping talented women in their current positions, or, the industry in general?

For this review, variations of the following search terms and phrases were used: "retention of women in IT industry" or "recruitment strategies for women in IT industry". These words were systematically entered into 10 research databases. Collectively, they resulted in over 300 articles for review, from which 25 of the most relevant were chosen as supporting documents to this study. Additional articles were identified ad hoc as required. The barriers that are analyzed

[1]Businesses employ fewer than 500 employees represent 99.6 percent of all US companies and represent 43.4 percent of all reported payroll. Although IT occupations demonstrated strong potential for growth, women in IT occupations are declining—from 35 percent in 1994 to 25 percent in 2011. This study addresses issues and challenges faced by women in small and medium businesses in IT fields and related occupations

[2]US Bureau of Labor Statistics. 2012. Computer and Information Technology Occupations. Available at www.bls.gov/ooh/computer-and-information-technology/.

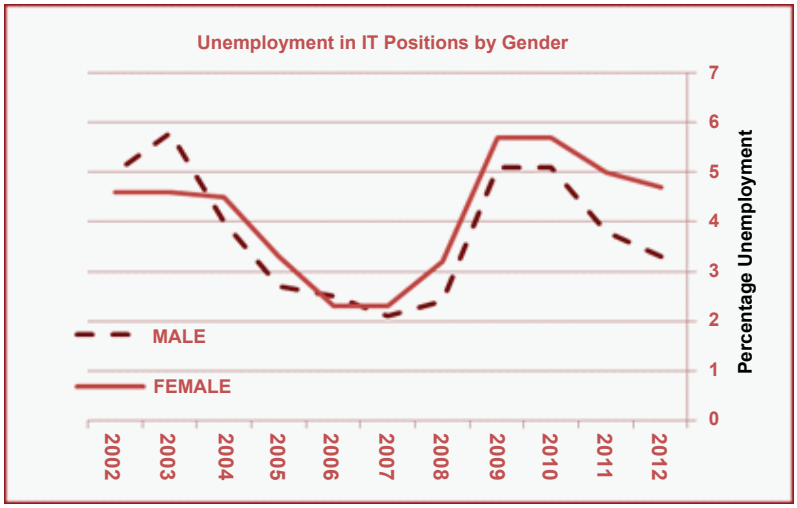


FIGURE E-1 Unemployment in IT Positions by Gender, 02-12. SOURCE: "Unemployed Persons by Occupation and Sex." US Bureau of Labor Statistics - Labor Force Statistics from the Current Population Survey. U.S. Bureau of Labor Statistics, 5 Feb. 2013.

in the sections below were deemed to be the most relevant to small businesses.

A. IT and Small Business Overview

Steady economic gains in employment opportunities and earnings have been documented in the IT industry. IT occupations have consistently demonstrated strong potential for job growth.[3] The US Bureau of Labor Statistics projects a 17 percent employment increase across all IT occupations between 2010 and 2020, creating approximately 2.8 million jobs. Software Developers and Database Administrators, for instance, are expected to see the largest employment increases at 32.4 percent and 30.6 percent respectively.[4]

In January 2012, while the nation was experiencing 8.3 percent unemployment, IT occupations reported unemployment numbers as low as 3.8 percent.[5,6] When unemployment increased to 8.8 percent nationally in January 2013, total unemployment in IT positions only marginally increased to 3.9 percent. However, in spite of these optimistic numbers, there is stratification across gender within the IT workforce. According to the Bureau of Labor Statistics, in 2011 women in computing positions experienced 5.0 percent unemployment while men reported much lower rates at 3.8 percent. By 2012, the unemployment rate for women in IT dropped marginally to 4.7 percent, but the rate for men remained even lower at 3.3 percent. As is evident in Figure E-1, unemployment disparity between men and women in IT occupations has gotten worse in recent years.

Despite the expected growth in IT occupations, the representation of women in IT positions continues to decline. From its peak in 1991, the percentage of women serving in IT positions has steadily decreased, reaching its current level of less than 20 percent (See Figure E-2).

The US Small Business Administration identifies small businesses in one of two ways: either by average annual receipts or average employment levels. Depending on the industry, the average small business can employ fewer than 500 people, but as many as 1,500. Similarly, annual receipts can range from less than $750,000 to $33 million.[7] According to the United States Census Bureau, businesses that employ fewer than 500 employees represent 99.6 percent of all U.S. companies.[8] For firms employing less than 500 workers, they represent 43.4 percent of all reported payroll and firms with less than 1,500 employees report controlling 52 percent of the total U.S. payroll. Given that small businesses represent a considerable part of the U.S. workforce, focusing on them is particularly compelling.

B. Barriers to Recruitment

Relevant literature suggests that gender bias in the workplace is a result of social inequalities that are perpetuated by institutional mechanisms.[9] These institutional mechanisms include - but are not limited to - factors such location, work

[3]Luftman, J., and Kempaiah, R.M. 2007. "The IS organization of the future: The IT talent challenge." *Information Systems Management* 24(2):129–138.

[4]"Career Outlook Information." US Bureau of Labor Statistics, US Department of Labor, Web. 14 Mar. 2013.

[5]"Databases, Tables & Calculators by Subject." Bureau of Labor Statistics Data, US Department of Labor, n.d. Web. 14 Mar. 2013.

[6]"A-30. Unemployed Persons by Occupation and Sex." US Bureau of Labor Statistics, Web. 14 Mar. 2013.

[7]"Table of Small Business Size Standards Matched to North American Industry Classification System Codes." US Small Business Association. 19 Mar. 2013

[8]"US – All Industries – by employment size of Enterprise." *Statistics of US Businesses*. United State Census Bureau. Web. 19 Mar. 2013.

[9]Sidanius, Jim, Felicia Pratto, and Lawrence Bobo. 1994. "Social dominance orientation and the political psychology of gender: A case of invariance?" *Journal of Personality and Social Psychology* 67(6):998–1011.

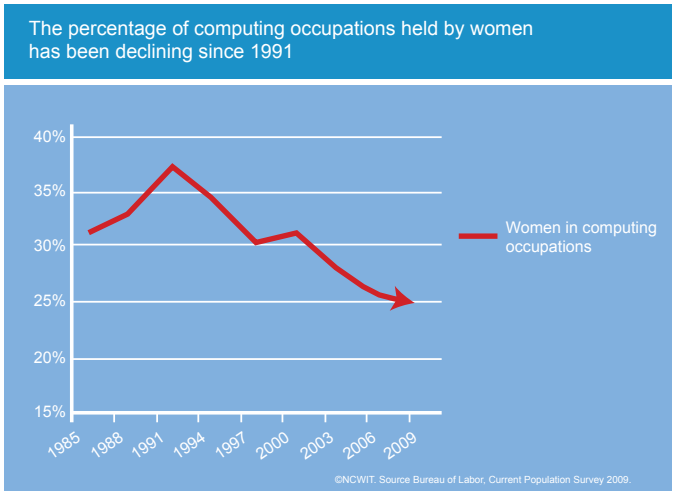


FIGURE E-2 Percentage of Computing Occupations Held by Women (1985–2009). SOURCE: NCWIT. Bureau of Labor. Current Population Survey 2009.

place policies, the physical environment, culture and other ancillary elements such as benefits or services that characterize an employee's work experience. These institutional mechanisms, which promote gender bias, exist across many industries; however the IT industry is especially susceptible to this gender bias, as it is largely male-dominated.

Job Posting Bias

Literature reveals that there is subtle gender bias in IT job postings, deterring women from seeking technical positions. Specific words used in job postings can be associated with a single gender, and can have the effect of appealing to one gender over another depending on the cue words used. Most women prefer jobs targeted for their own gender to jobs targeted for men.[10] Cue words have the effect of appealing not just to a particular gender but also to the belief systems that ultimately construct the gender stereotypes. In general, women respond better to language that communicates more communal and interpersonal qualifications, in contrast with men who prefer language associated with leadership and agency.[11]

Masculine words	Vs.	Feminine words
Analyze	Vs.	Understand
Determine	Vs.	Establish
Competitive	Vs.	Supportive

FIGURE E-3 Examples of Masculine Words Versus Feminine Words

[10]Gaucher, Danielle, Justin Friesen, and Aaron C. Kay. 2011. "Evidence that gendered wording in job advertisements exists and sustains gender inequality." *Journal of Personality and Social Psychology* 101(1):109–128.

[11]Stahlberg, Dagmar, Friederike Braun, Lisa Irmen, and Sabine Sczesny. 2007. "Representation of the Sexes in Language," pp. 163–181. In: *Social Communication*, ed. Klaus Fiedler. New York: Psychology Press.

Literature indicates that the wording in male-dominated jobs (such as engineering, computer science, and mechanics positions) is often characterized as more masculine language than feminine.[12] Language is one of many situational cues which individuals rely on in determining fit. Studies show that situational cues affect a women's sense of belonging especially in math and science fields. Women prioritize a sense of belongingness as important in employment.[13] Current literature indicates that cue words in job postings that motivate women convey a greater sense of belonging than the masculine words used.[14] Ultimately, if women do not view the industry as welcoming, they will be less likely to even apply to for IT jobs. This subtle bias in the job posting language is deterring women from even applying for jobs in male-dominated fields, including the IT industry. This language bias is an example of an institutional mechanism, which is perpetuating the gender gap in IT.

The Physical Environment

The physical environment is an important element in attracting women to IT positions. Physical environment includes the external environment as well as the structural and material components of a physical workspace. Both the geographic location of a company, as well as the actual office space, can be factors affecting the recruitment of women in the industry.

Relevant literature indicates that workspaces, which take into consideration the cultural priorities of their employees, are the most successful at increasing productivity and enabling employees to achieve their full potential.

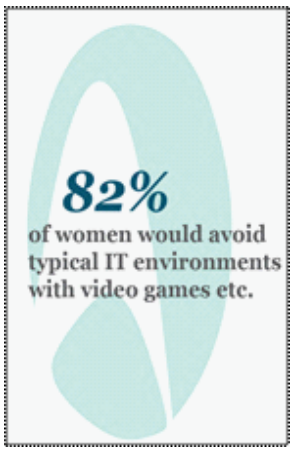
[12]Gaucher et al. (2011), op.cit.

[13]Ibid.

[14]Bem, S.L., and Bem, D.J. 1973. "Does sex-biased job advertising 'aid and abet' sex discrimination?" *Journal of Applied Social Psychology* 3(1):6–18.

As employees attach sentiments and a sense of identity to their workplace, they prioritize the physical space.[15] Both males and females have a desire to fit into their work environment. Fit is measured by both the sense of belonging employees feel to their environment as well as how similar they feel to other individuals in that environment.[16] Physical environment includes objects such as the lighting, posters, the décor of common spaces and decorative objectives such as books, magazines, etc. and any other component of the environment, which dictates a particular culture or feeling. Current literature has shown that the layout of physical workspace not only improves an employee's feelings about their work environment but can also positively affect work performance.[17]

Research reveals that stereotypical environments marginally reduced women's identification with the computer science field. However, the environment had little effect on men's identification. Women also avoid environments populated with stereotypical objects associated with computer science such as Star Trek posters and video games.[18]



These elements inform the culture of a particular space, which women often associate with feelings of fit. Male-dominated fields, such as computer science, typically have work environments that reflect this male. This can include items ranging from gaming posters to certain magazines, and even something as innocuous as soda cans. Women who perceive that they will not be in an inclusive workspace are likely to be deterred from entering into it. As workspaces become increasingly more open, employees strive to personalize their workspace.[19]

It is clear that environments can play a role in shaping gender stereotypes. However, research indicates that the way employees view their physical workspace has shifted from previous sentiments. Today, employees look beyond functional comfort in their physical environments to improve their productivity.[20] Reducing stereotypes in an environment is no longer dependent on there being a gender balance.

The external environment can also play a crucial role in shaping a woman's sense of belonging. As the IT industry continues to grow, cities where the industry is dominant are beginning to see cultural and economic shifts that subtly change the very character of those cities.[21] This character shift contributes to the desirability of an IT position being made available in one geographic area over another, and can be another factor influencing recruitment of women in IT. Another factor important to women is the cultural environment as it relates to livability.[22] This includes the cultural mindset of a city, the personal and professional networks available, perceived livability of a city, cultural diversity as well as the communities and schools. Economic factors important to women include cost of living and dominant industry in a particular location. These factors can influence the social acceptability of women participating in the workforce. For instance, if the dominant industry is male-dominated or if the cost of living is so high that it requires a second income; there is a recognized need for a two-income household. This might mean that women will participate more in the work force.[23] In cities with a more diverse industry base, the social acceptability of women working is higher.

Both the internal and external environment plays a role in determining a woman's sense of belonging in their workplace. Employees prioritize the need to fit into their work environment - both the physical office space as well as the geographic location of their office. Removing stereotype from the internal physical environment can lead to a greater sense of belonging and better fit for an individual.

C. Barriers to Retention

While recruiting efforts are crucial for increasing the representation of women in IT positions, it is equally important that women, once recruited, are retained.[24] Recognizing employees' needs and individual desires is essential for understanding what influences their occupational selection or intention to leave an organization.[25] Workplace culture and the theory of gendered roles are critical factors to examine for the retention of women in any industry but especially

[15]Meerwarth, Tracy L., Robert T. Trotter II, and Elizabeth K. Briody. "The Knowledge Organization: Cultural Priorities and Workspace Design." *Space and Culture* 11(4):437-454.

[16]Cheryan, Sapna, Victoria C. Plaut, Paul G. Davies, and Claude M. Steele. 2009. Ambient Belonging: How Stereotypical Cues Impact Gender Participation in Computer Science. *Journal of Personality and Social Psychology* 97(6):1045–1060.

[17]Vischer, Jacqueline C. 2008. "Towards an Environmental Psychology of Workspace: How People Are Affected by Environments for Work." Research Group on Environments for Work, Faculty of Environmental Design, University of Montreal.

[18]Cheryan et al. (2009), op. cit.

[19]Vischer (2008), op. cit.

[20]Ibid.

[21]Trauth, Eileen M., Jeria L. Quesenberry, and Benjamin Yeo. 2005. The influence of environmental context on women in the IT workforce. *Proceedings of the 2005 ACM SIGMIS CPR Conference on Computer Personnel Research*. New York: Association for Computing Machinery.

[22]Ibid.

[23]Ibid.

[24]Tapia, Andrea H., and Lynette Kvasny. 2004. "Recruitment Is Never Enough: Retention of Women and Minorities in the IT Workplace." ACM SIGMIS Database 10. http://dl.acm.org/citation.cfm?id=982392

[25]Chang, C.L., Chen, V., Klein, G., and Jiang, J.J. 2011. "Information system personnel career anchor changes leading to career changes." *European Journal of Information Systems* 20(1):103–117.

key to combat attrition in IT occupations.[26] Their departure, in turn, can lead to both high economic and social costs, as companies lose organizational experts and expend resources trying to secure a replacement.[27]

Workplace Organizational Factors

Academic literature on the IT workforce consistently reports that women excel in environments that promote cooperation and hands-on learning.[28] However, this organizational culture is often not indicative of the IT field, and the lack of such a culture can cause women who enter the industry to feel isolated within their work environments. Without internal support networks, such as a mentor who might help mitigate these feelings, women may become dissatisfied with their jobs and subsequently exit the IT workforce.[29] However, ongoing professional development facilitated through mentorship programs and female role models can be highly effective in mitigating the daily pressures encountered in the IT field (such as the constant need to acquire new skills, adjust to new roles, and manage competing priorities), ultimately enhancing work satisfaction and increasing the overall retention of women in the field.[30,31]

Women, who are in an IT environment that actively promotes such collaborative initiatives, have been shown to benefit greatly. As they build close relationships and establish support networks within the organization, they learn how to successfully navigate challenges and barriers they are likely to encounter in the field. These internal connections can also play a critical role in their advancement within the IT industry.[32]

Organizational use of role models can also be effective in retaining women in IT positions. Linking female employees with other IT professionals, especially another female, can help mitigate the risk of role ambiguity common to the IT field. Factors, such as extended work schedules without consideration for outside commitments, an emphasis on individual innovation over teamwork and valuation of an employee based on technological rather than soft skills, are all industry characteristics which lead to uncertainty among women about job responsibilities or work expectations.[33] Role models can serve as socializers within the organization, helping women acclimate to the culture and workplace environment.[34] The benefits accrued when women form bonds, even informally, with other women in their workplace positively impacts the retention of women in IT occupations. These connections provide a platform for women to share best practices and learn the tools they need to succeed in their jobs.[35]

Gendered Roles

Some of the relevant literature suggests that the way children are socialized may carry over into the workplace. The concept of *gendered roles*, where from an early age girls are taught to be caregivers, while boys are encouraged to be competitive, is often thought to be an influencing factor. This theory might explain why women gravitate towards communal careers and eventually exit the IT workforce.[36] While men are more likely to pursue careers that grant them agency, usually in the form of status and financial gain, women instead seek positions that enable them to make a contribution and tend to prioritize helping society.[37] Consequently, women can perceive IT-related careers as being incompatible with their communal goals, whereas men are drawn to the high earnings and relative prestige that the field provides.[38]

These gendered schemas lead to the perception that women are only good at certain tasks and ultimately lead to an undervaluation of their skills by society. For instance, although identified as important to the IT industry, skills such as relationship building and communication are valued less because they come "naturally" to women and are not considered an achievement. Moreover, since women are often considered to be more detail-oriented than technical, they are pushed into administrative, documentation-oriented and training roles. The perception of women as less technologically capable than men will only continue to contribute to the underrepresentation of women in the field.[39]

Already an occupation characterized by the need for

[26] Wentling, R.M., and Thomas, S. 2009. "Workplace culture that hinders and assists the career development of women in information technology." *Information Technology, Learning, and Performance Journal* 25(1):25–42.

[27] Riemenschneider, Cynthia K., Deborah J. Armstrong, Myria W. Allen, and Margaret F. Reid. 2006. "Barriers Facing Women in the IT Work Force." ACM SIGMIS Database 37.4:58. http://dl.acm.org/citation.cfm?id=1185345

[28] Tapia and Kvasny (2004), op. cit.

[29] Trauth, E.M., Quesenberry, J.L. and Huang, H. 2009. "Retaining women in the US IT workforce: Theorizing the influence of organizational factors." *European Journal of Information Systems* 18(5):476–497.

[30] Simard, Caroline, and Shann K. Gilmartin. 2010. "Senior Technical Women: Profiles of Success." Palo Alto: Anita Borg Institute for Women and Technology. Available at http://anitaborginstitute.org/news/archive/senior-technical-women-profiles-of-success/.

[31] Tapia and Kvasny (2004), op. cit.

[32] Wentling and Thomas (2009), op. cit.

[33] Riemenschneider, Cynthia K., Deborah J. Armstrong, Myria W. Allen, and Margaret F. Reid. 2006. "Barriers Facing Women in the IT Work Force.: The Database for Advances in Information Systems 37.4.

[34] Drury, Benjamin J., John Oliver Siy, and Sapna Cheryan. 2011. "When do female role models benefit women? The importance of differentiating recruitment from retention in STEM. *Psychological Inquiry: An International Journal for the Advancement of Psychological Theory* 22(4):265–269.

[35] Roldan, Malu, Louise Soe, and Elaine K. Yakura. 2004. "Perceptions of chilly IT organizational contexts and their effect on the retention and promotion of women in IT." ACM SIGMIS Database, available at http://dl.acm.org/citation.cfm?id=982399..

[36] Riemenschneider et al. (2006), op.cit.

[37] Cheryan, S. 2012. "Understanding the paradox in math-related fields: Why do some gender gaps remain while others do not?" *Sex Roles* 66(3-4):184–190.

[38] Harris, N., Cushman, P., Kruck, S.E., & Anderson, R.D. 2009. "Technology majors: Why are women absent?" *Journal of Computer Information Systems* 50(2):23–30.

[39] Roldan et al. (2004), op. cit.

continuous education; as one known for its extreme and unusual time demands and filled with professionals stereotyped as geeks; the organizational climate found in many IT occupations does little to reduce attrition rates of women.[40] If a woman's perception of an organizational environment is hostile, male-dominated or unwelcoming, it can negatively influence her decision to remain in an IT position. Unfortunately, most studies have focused on assimilating women into the dominant organizational environment instead of addressing the need for these organizations to modify existing values and change negative perceptions. If companies hope to effectively recruit and retain women in IT professions, they need critically reevaluate current occupational climates.[41]

D. Summary

The comprehensive review of relevant literature revealed a couple key barriers preventing women from wanting to work in IT positions. While several main factors emerged as important, this study's aim is to analyze those barriers most relevant to small businesses. Therefore, the literature review strove to provide an understanding of the small business landscape and an analysis of the IT industry, and then aimed to use these factors to analyze the main barriers preventing women from joining IT roles in small businesses.

The combination of the large number of small businesses in the U.S., a projected growth in the IT industry, and the low percentage of women in IT makes small businesses an excellent platform from which to improve the recruitment and retention of women in IT occupations.

In identifying barriers to recruitment the main factors that emerged were largely institutional biases, including biases in job posting language and the physical work environment. Relevant literature reveals that there is a bias present in current job posting language which has the effect of deterring women from applying to IT occupations. As online job postings are the most prevalent place to find jobs, and the Internet the greatest search tool, it seems that the removal of this barrier could serve as an achievable target for small businesses. Often, small businesses do not have recruitment resources like recruitment fairs or professional services and therefore rely more heavily on Internet postings to recruit candidates.

The physical environment was also identified as a barrier to both recruitment and retention for women in IT occupations, with the internal physical environment representing a priority to employees. Employees - both male and female - associate the physical environment with their feeling of fit into an organization or culture. Environments help create a sense of belonging among employees, and currently most IT environments are largely male dominated which detracts from a woman's sense of belonging in the space. Thus, the design, décor and layout of the physical work environment is important in making women feel connected to their work culture and the people they work with.[42] Small businesses are at a unique advantage to combat this barrier as usually they have smaller offices, fewer employees and flexible policies, which would allow them to more easily dictate how the physical space is used and use it to avoid this as a barrier to women.

The main barriers to retention that were identified as being particularly important to small businesses are organizational factors in the workplace and gendered roles. Collaborative work environments motivate women and they prioritize them in evaluating their job satisfaction.[43] Mentorship, professional development programs, and internal networks are all factors that contribute to a collaborative work environment.[44] A presence of these initiatives has been shown to improve a woman's work experience as it provides strong internal networks and builds personal relationships, both of which increase a woman's job satisfaction and help them advance in the field.[45]

Furthermore, the idea of gendered roles is a barrier to recruiting women in IT positions. Males and females are socialized with the idea that each gender has a designated role that each is better suited for.[46] By and large, women are considered to be more suitable for work that is communally oriented and that contributes to society. However, the nature of the IT industry and expected duties conflict with that notion, consequently deterring women from wanting to stay in the field.[47]

The removal of these barriers are important and achievable by small businesses as they are more readily able to make changes in the work environment, and have more flexibility implementing initiatives when compared to larger companies. The latter may be constrained by stringent policies and often have a more complex process to implement change.

[40]Ghazzawi, I. 2008. "Job satisfaction among information technology professionals in the U.S.: An empirical study." *Journal of American Academy of Business, Cambridge* 13(1):1–15.

[41]Trauth, E.M., Quesenberry, J.L. & Huang, H. 2009. "Retaining women in the U.S. IT workforce: Theorizing the influence of organizational factors." *European Journal of Information Systems* 18(5):476–497.

[42]Cheryan, Sapna, Victoria C. Plaut, Paul G. Davies, and Claude M. Steele. 2009. "Ambient belonging: How stereotypical cues impact gender participation in computer science." *Journal of Personality and Social Psychology* 97(6):1045–1060.

[43]Wentling, R.M., and Thomas, S. 2009. "Workplace culture that hinders and assists the career development of women in information technology." *Information Technology, Learning, and Performance Journal* 25(1):25–42.

[44]Senior Technical Women

[45]Wentling, R.M., and Thomas, S. 2009. "Workplace culture that hinders and assists the career development of women in information technology." *Information Technology, Learning, and Performance Journal* 25(1):25–42.

[46]Riemenschneider, Cynthia K., Deborah J. Armstrong, Myria W. Allen, and Margaret F. Reid. 2006. "Barriers facing women in the IT work force." ACM SIGMIS Database 37(4):58.

[47]Cheryan, S. 2012. "Understanding the paradox in math-related fields: Why do some gender gaps remain while others do not?" *Sex Roles* 66(3-4):184–190.

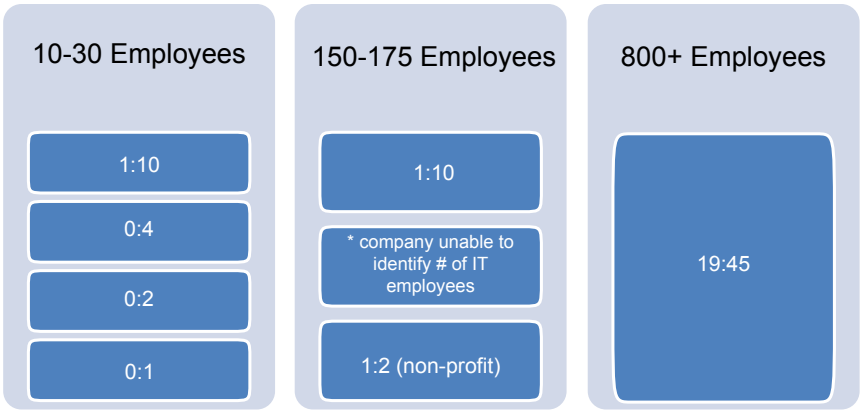


FIGURE E-4 Ratio of Female to Male IT Employees in Each Participating Company (Grouped by Company Size)

III. Methodology

Data gaps revealed in the literature review were explored through the development of case studies of eight companies. Case study information from each company was gathered from both the employer perspectives and employee perspectives. To obtain the employer perspective, an interview with one hiring manager, human resource professional, and/or IT supervisor within the organization was conducted. To obtain employee perspectives, an electronic survey was administered to employees that the company identified as filled IT positions.

Company Selection

Initially, 49 companies were contacted by phone, email, or through the use of LinkedIn postings that were placed advertising an opportunity to participate in the study. Ultimately, eight of the 49 companies (16 percent) were recruited to participate in both the interviews and surveys. Those eight companies represented a combination of privately and independently-owned small businesses, as well as one non-profit organization, and one medium-sized business (the latter two companies were included for comparative purposes).[48] Only companies employing full-time IT employees were included in this study. Companies that used only contracted IT sources were not included, and contract IT employees within the selected companies were also not included as part of the case studies. (See Appendix E-5. Participant Company Descriptions for company descriptions.)

Employer Interviews

The employer interview questions were designed to gather specific information about recruitment and retention efforts from the employer perspective. The questions required the interviewee to discuss the company's hiring practices, organizational culture, and investment in their employees. The interviews were intended to determine the strategies used by companies to address barriers to recruitment and retention of women in IT positions, and what they have done to create more inclusive environments in their workplace, especially among IT professionals. (See Appendix E-4. Interview Questions.)

Employee Surveys

To gather employee perspectives, the general hiring manager (or IT manager) who was interviewed was asked to distribute an online survey link to employees whom they identified as filling IT positions. Surveys were administered and collected within four to seven days. The survey was developed to gather insight into an employee's perception of belonging, investment within the company, and experience in IT roles within a small business. The survey included rating scale, multiple choice, and "yes" or "no" questions. Participants were incentivized to respond to the survey with the opportunity to win a $50.00 Amazon gift card. (See Appendix E-3. Online Survey.)

IV. Case Study Findings

A. Interview Results

The following section provides an overview of the responses from eight case study interviews.

Demographics– Gender Landscape

The first interview question sought to identify gender representation among the total employees within each company, as well as among just IT employees. Of the four companies employing 10-30 employees total, one company had 1 female IT employee (of 11 IT employees), and the other three companies employed no female employees (of 2, 4, and 1 IT employees employed within those three firms). Of the three companies employing approximately between 150-175 employees total, one company reported employing 1 female IT employee (of 11 IT employees); the interviewee for the second company was unable to enumerate their number of IT employees; the third company was a non-profit organization employing three IT employees, one of whom

[48]The Small Business Administration (SBA) defines a small business concern as "one that is independently owned and operated, is organized for profit, and is not dominant in its field. Depending on the industry, size standard eligibility is based on the average number of employees for the preceding twelve months or on sales volume averaged over a three-year period."

was female. Figure E-4, represents each of the eight companies in our case study and their ratio of female to male IT employees. All companies are grouped by company size.

The four companies who could be described as "tech-oriented"[49] (their major services include web development, hosting services, data collection, e-commerce, data delivery, etc.) employed not only fewer women in IT positions than men, but also fewer female employees across all positions [19 percent-38 percent] (the non-tech-oriented firms had greater representation of women across their total number of employees [48 percent - 83 percent]). (Figure E-5)

Attracting Applicants Through Job Postings

Each company described their recruitment process and the specific strategies that they employ to attract talent. The four companies with 10-30 employees all described processes where they post open positions on trusted job sites. One of these small companies uses a third-party recruiter, similar to that of a headhunter to find appropriate talent. The most common recruiting efforts were posts on job sites, job boards, and promoting through colleges and universities. Craigslist in particular has been utilized as well as access to talent through relationships with universities. Once received, resumes are then filtered through by subject matter experts based on resume and experience. The remaining larger companies employing around 150-175 employees indicated similar hiring efforts as those of smaller organizations.

Job Posting Response

We also asked about the most recent technical position for which the company sought applicants, along with the number of people that applied, estimated number of female applicants, and final outcome of the search. Although companies could not definitively provide the number of female applicants,[50] three of the companies with 10-50 employees reported interviewing at least 1 female applicant.[51] One of those companies made an offer to a female candidate (final outcome pending), one company hired a man, and one company did not hire anyone, citing a lack of qualified candidates of either gender. When asked this set of questions, three of the companies cited the following reasons for not hiring women: Not qualified, didn't have background/training relevant to the open position, lack of women in the field (specifically for "developer-oriented" positions), lack of "technical" skills.

> "… the skills we saw on resumes were not technical enough. They were mostly database admins or co CPAs."62
> - Interviewee IT Manager

[49]See Appendix E-5. Participant Company Descriptions for more information on companies defined as tech vs. non-tech.

[50]Because they could not identify gender through resumes submitted.

[51]Employer G did not participate in this question because the interviewee did not have data for this question.

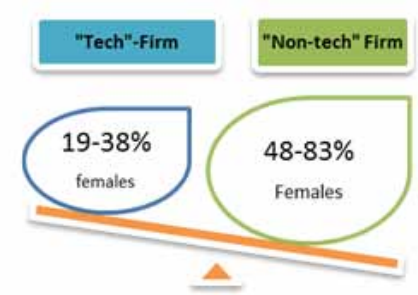


FIGURE E-5 Total female representation within participating companies – Comparing "Tech" vs. "Non-Tech" firms*

For the larger companies: two of the three companies with approximately 150-175 employees demonstrated greater numbers of female applicants, citing that 22 [50 percent] and 14 [23 percent] women applied of 44 and 62 applicants, respectively. The latter company stated that they ultimately hired a male because "the skills we saw on resumes were not technical enough. They were mostly database admins or co-CPAs[52]." The third company (the non-profit) reported having 2 or 3 female applicants of 12-13 total resumes [20 percent]. The company with >500 employees could not state the number of female applicants among males, but they estimated that about 50 percent of resumes received were from females.

Determining Fit through the Hiring Process

As a part of the hiring process all of the employers mentioned the need for candidates to feel that these companies were a good fit. One of the smallest companies in the study requires new-hires to undergo a 30-day trial period before they join full-time. They essentially work as contractors for 30 days to prove their skills match what they have claimed, and allow an opportunity for the company to see if they are a good fit. Another employer said, "After the in-person interview at that point we're trying to get a feel for a culture fit."

Targeted Recruitment and Retention Initiatives for Women

The results of the interviews also provided information on each company's recruitment and retention activities for women specifically. The companies with 10-30 employees indicated that they do not participate in efforts specifically targeting women. One of these companies commented, "A lot of the – what we'll call, company diversity initiatives – they're not explicit." Results of the employer interviews revealed the majority of retention efforts do not include specific efforts to retain women like maternity leave or other female-targeted initiatives (Figure E-6).

> "A lot of the – what we'll call, company diversity initiatives – they're not explicit."
> - Interviewee IT Manager

[52]Co-CPAs refer to certified public accountants who are also database administrators.

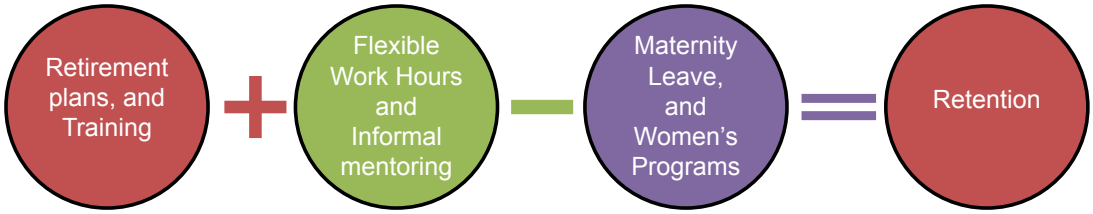


FIGURE E-6 Elements that add or subtract from retention efforts.

All eight companies mentioned similar benefits such as retirement plans, informal mentoring programs, and paying for IT skill improvement classes. When asked about benefits programs, not one company mentioned maternity leave. One of the businesses with less than 50 employees explicitly stated they do not offer maternity leave, adding that no one has requested such a leave. When asked what would happen if a potential new female hire were to ask about maternity leave, they responded, "I'm pretty sure that would be one of their questions, and that would obviously be one consideration. The decision would ultimately be up to the lead hirer, though. I would see it as a hiring negotiation."

The larger companies with about 150-175 employees do not have special campaigns or initiatives that target women during their recruitment efforts. One larger company said, "I just want to hire the best candidate to be totally honest." Alternate work schedules were popular benefits provided by the larger companies, but there were no formal mentoring programs available.

Elements of Organizational Culture

Lastly, the employer interview aimed to measure what elements made up the culture of their organizations. Companies with 10-30 employees typically describe their organizations to be creative and open environments that are flexible to employees' needs. They described their cultures as, laid back and casual even outside the workplace. All the companies in our study with 10-30 employees have two or fewer women working in their IT departments. Companies with about 150-175 employees describe their workplaces to be results-oriented, but also casual. Dress code is rarely emphasized, and hard work is often rewarded with social events. The theme of work hard, play hard was typical throughout the interviews.

Workplace Factors - Workload/Time Commitment

To better understand the expected hourly commitment for IT employees, we asked employers about their practices related to employees being on-call outside of regular business hours. Four of eight companies in the study were asked whether they require IT employees to be on call.[53] Of those four companies, only one company required all IT employees to rotate on-call duties (one of the four tech-oriented firms). Two companies reported only managerial positions (only men were in managerial roles in these companies) to occasionally be on call or to have to work non-scheduled evening hours. One company did not require on-call duties from any employees.

Interview Results for Medium Sized Companies

We interviewed one company with just under 900 employees, that we are calling medium sized to compare to the small sized companies included in the study. The firm is female dominated, but the IT department is less than 50 percent female. The company is large enough offer full benefits for healthcare, but they do not offer telework. The culture is very demanding and corporate and IT professionals are expected to be readily available to perform their duties with high quality and very timely. They did not provide or target women specifically in their recruiting or retention efforts.

Interview Results for Non-profits

Additionally for comparison, we included a small non-profit in the study with 170 employees. This is an academic organization that ties benefits to incentives by offering discounts to their employees on the services they provide. For example, employees who have been employed more than 1 year receive a discount on tuition for their child. The organization is largely female due to the benefits offered. There are no formalized programs for alternative work schedules, mentoring or training; but they are offered and received on an as needed basis. The mentoring program that is available is geared toward faculty and not the staff. The non-profit does not have any formal recruitment programs and does not target women specifically, even though they do think it would be beneficial to have a structured program because qualified technical professionals have been hard to find.

B. Survey Results

Demographics of Survey Respondents

The companies that participated in our study varied widely in size and in IT capacity. Naturally, the bigger companies employed more IT personnel in comparison to the smaller ones. This variation is reflected in the number of respondents (See Table E-2, below). Of the 45 employees surveyed, 39 submitted complete responses. These results were then analyzed and formed the basis for our analysis. Males outnumbered females in the survey sample, with about 79 percent of the respondents identified as male and 21

[53] The other four were not asked this question because the interviewees participating in this study were general hiring managers or human resource professionals who could not provide this information.

TABLE E-2 Participating Companies: Size and Employee Respondents

Company	Company Size	IT Department Size	# of Employee Respondents
A	10-30	6	4
B	10-30	4	2
C	10-30	11	7
D	500-1000	64	19
E	150-175	11	2
F	150-175	3	2
G	11-50	1	1
H	100-500	--*	2

* Employer was unable to identify the number of IT employees.

percent as female. Small business employees represented 46 percent (18 respondents) of total respondents, while 49 percent (19 respondents) were employed at the medium-sized company and 5 percent (2 respondents) were employed by a nonprofit.

Job Posting

With respect to staffing and recruitment methods, the majority of the small business respondents reported finding their jobs with current employers through job search websites (including Craigslist) and a few reported finding their position through a referral. For every three employees in a small business, at least one reported to have found their current position through an online job post than through a referral. In contrast, the medium-sized business respondents were divided between referrals (38 percent of respondents) and job search sites (33 percent). Analysis by gender revealed that women were more likely to have found their jobs via referral, with 62.5 percent of all female respondents indicating that they found their position this way and 13 percent who reported finding their position through a job posting.

Physical Environment

When respondents were asked about comfort levels within their physical environment, they were more likely to respond positively concerning their workspace. Of the 39 respondents, 33 reported feeling "Somewhat Comfortable" or "Very Comfortable." Small business employees were 20 percent more likely to be "Very Comfortable" than employees at the medium-sized business. Breakdown by gender indicates that the males in the survey were typically "Somewhat Comfortable" in their physical space. Of the male respondents, 90 percent reported feeling "Somewhat Comfortable" to "Very Comfortable" in their physical work environment. The women are more evenly divided, with 5 of the 8 respondents feeling "Somewhat Comfortable" to "Very Comfortable" with the remaining 3 feeling "Somewhat Out of Place" and "Very Out of Place". These results indicate that women are often less comfortable in the IT workspace than their male counterparts, but that small business environments tend to be more welcoming overall. Small businesses can create a greater sense of ambient belonging among women by examining what aspects of the physical environment cause sentiments of discomfort. Ambient belonging is a concept that explains the connection between physical environment and fitting in.[54]

Competing Priorities

[54]Cheryan, Sapna, Victoria C. Plaut, Paul G. Davies, and Claude M. Steele. "Ambient Belonging: How Stereotypical Cues Impact Gender Participation in Computer Science." *Journal of Personality and Social Psychology* 97.6 (2009): 1045-060. Print.

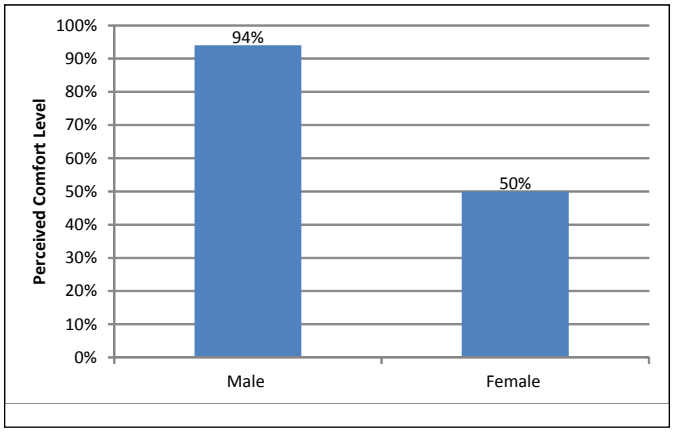


FIGURE E-7 Small Business Respondents Who Felt at Least Somewhat Comfortable in the Physical Environment.

FIGURE E-8 Survey responses on mentorship

Company-sponsored programs, which enabled employees to balance work and personal priorities, were also a focus of the surveys. The questions were meant to assess the impact such programs had on employee retention rates. Survey responses indicate that all of the companies provided at least one type of work-life balance initiative (telework or alternative schedules), while employees at the non-profit reported that such initiatives were not offered. However, responses varied within companies, where some employees from one company reported participating in a program, and others within the same company indicated that no programs or initiatives were offered. Of the 39 respondents, just under half (17) reported participating in a company program aimed at helping employees manage competing priorities, and 14 reported that such a program positively impacted their decision to stay within the company. The remaining 3 respondents reported that they felt no impact from participating and none of the participating respondents reported a negative impact (Figure E-8).

When examining female responses, of the eight women surveyed, only two indicated they participated in company programs aimed at enabling employees to manage competing priorities. There were four respondents that did not participate in such programs, three of them worked for one company (identified as Company H), and the fourth female respondent worked at the nonprofit where such initiatives were not offered. The remaining two female respondents declined to answer.

The level of male participation in work life balance initiatives was high compared to the level of female participation. Across all companies, participation of women was only 25 percent, compared with the 50 percent participation rate among male respondents.

Since preliminary results indicate that participation in such programs positively impacts the respondent's decision to stay with the company, but that few employees were actually aware of or participated in them, it follows that increased information and encouragement to participate could positively impact overall employee retention rates.

Gendered Roles

In an attempt to examine how closely the research findings discussed above, which state that women gravitate toward fields that foster a sense of belonging, match the sentiments of IT employees respondents were asked if they felt their work environment was "Fair", "Inclusive," "Cooperative," "Supportive" and "Empowering".[55] These responses were then scaled from "Very" to "Somewhat" to "Not at All." Most employees rated all categories between "Very" and "Somewhat," with only a few respondents answering "Not at All." However, comparison across genders demonstrated that women were more likely to reply "Somewhat" in all categories than their male counterparts.

In the inclusiveness category men were evenly divided, with 14 reporting their workplaces were very inclusive and 16 indicating that they were only somewhat inclusive. While only one male employee responded that the environment was not inclusive at all. Only 12.5 percent of women reported that their work environment was very inclusive, while 75 percent felt only it was somewhat inclusive, and the remaining 12.5 percent felt it was not at all inclusive. Comparison across companies demonstrated that employees at small businesses were 21 percent more likely to feel their work environment was inclusive than at nonprofit or medium size business.

When analyzing response within the "Supportive" category, the majority of women reported feeling their workplace was somewhat supportive, while the majority of men reported feeling their workplace was very supportive. The majority of male respondents also reported their workplaces to be Very Fair, Very Supportive, Very Cooperative, and Very Empowering, while the majority of women reported their workplaces to be Somewhat Fair, Somewhat Cooperative, Somewhat Supportive, Somewhat Inclusive and Somewhat Empowering. These results do little to refute women's current perception of the IT workplace being unwelcoming and an environment where they would not feel the same sense of belonging that their male colleagues reported.

When respondents were asked if their current work environment encouraged them to stay in an IT occupation, 85 percent of all respondents said "Yes." Among women, 62.5 percent replied that their current work environment encouraged them to stay in an IT position, whereas 87 percent of men expressed the same sentiment. Examining the data by the size of company also revealed similar breakdowns, with 83 percent of small company employees responding "Yes" and 86 percent from the medium company and nonprofit.

C. Summary

Upon analyzing the case studies several themes of interest emerged between employer and employee responses. One such theme within the recruitment process was that of

[55] Gaucher, Danielle, Justin Friesen, and Aaron C. Kay. "Evidence that gendered wording in job advertisements exists and sustains gender inequality." *Journal of personality and social psychology* 101.1 (2011)

job postings. Survey analysis revealed that the majority of respondents from small companies and the comparison firms (i.e., the medium-sized company and non-profit) found their positions through referrals, word of mouth or job postings on the internet. As the research has shown, job postings for IT jobs can be problematic in that they tend to favor syntax that describes typically male traits, and therefore males tend to gravitate to those jobs. Most of the companies that participated in our study did not have formal recruitment pathways (i.e., human resource professionals, use of third-party headhunters). Instead, they favored the use of common job sites (e.g., Craigslist) to post open positions. Although the lack of formal recruitment pathways is likely more attributable to a lack of resources or low turnover rates within small companies, instead of disinterest, it means that companies are often limiting future candidates to personal contacts instead of attracting a diverse pool of applicants.

Organizational fit was another reoccurring theme that emerged in the research as an important factor for both employees and employers. The employer interview responses revealed that employers highly value "organizational fit" among their employees and stress the importance of determining fit during the hiring process. One employer said, "*After the in-person interview, at that point we're trying to get a feel for a cultural fit.*" The analysis showed that most companies describe their work environments to be "casual", "laid-back" and "familial" for all employees regardless of gender. However, survey results showed that the women surveyed do not feel as included at work as men do. Of the women who took the survey, 13 percent responded feeling "very inclusive" in their work environment, while 45 percent of men responded feeling the same. Additionally, three out of 8 women who responded to the survey discussed culture with their employer during the hiring process, but none of those women strongly felt that their culture matched that description once they were hired.

Finally, survey and interview responses showed that work life balance programs and mentorship were important but underutilized. It was clear in the survey section that although work-life balance programs were common at the private companies, participation and knowledge of such programs was low. The interviews revealed that although these programs existed, information was not always available and participation not necessarily encouraged. Additionally, it was evident from the interviews that these programs were often not geared toward women. Maternity leave and mentorship are examples of two programs that benefit women more than their male counterparts, but not all case study companies offered these programs. Finally, it became apparent that even when programs existed, there was a lack of formal program structuring, which could contribute to the lack of participation among IT employees.

V. Suggested Interventions

The results of the literature review and the case studies revealed three areas that were especially important to address. Three recommendations to small businesses have been identified that are feasible for employers and employees to implement into their work environments. The three recommendations were identified after careful analysis of the case study results, specifically when employee's responses from the surveys did not align with their corresponding employer responses from the interviews to similar questions. For example, when employers post jobs online where most potential applicants search, but the majority of men find their IT jobs through this mechanism versus women. These recommendations are also identified in the research to be important to the recruitment and retention of women in IT positions.

1. Reduce Job Posting Bias

One intervention necessary for mitigating barriers to attracting and keeping women in IT positions would be to reduce gender bias pervasive throughout job posting language.[56] A primary challenge for women in regard to job posting language is that word choice does not promote feelings of belongingness to the company or the position. [57]Women are less inclined to apply for jobs that convey an isolated work environment or individualized work culture, which is often what masculine job posting language conveys.[58] For example, the words "analyze" and "determine" are usually perceived as masculine words while words like "understand" and "establish" are usually perceived to be feminine. All of these words have been used in job postings before, but it is important to recognize bias within them. The phrases below compare common language found in job postings: one that uses masculine words and one that might appeal more to women.

"Perform in a COMPETITIVE environment" vs. "Collaborates well in a SUPPORTIVE environment"

The employers who were interviewed in this study revealed how much they rely on job posting sites and similar avenues to promote open positions across the IT field. They rely heavily on these sites and the employees survey results show that individuals looking for positions rely on these sites as well. Of the women surveyed in this study, 13 percent found their current position online, compared

[56]Gaucher, Danielle, Justin Friesen, and Aaron C. Kay. "Evidence that gendered wording in job advertisements exists and sustains gender inequality." *Journal of personality and social psychology* 101.1 (2011)

[57]Cheryan, Sapna, Victoria C. Plaut, Paul G. Davies, and Claude M. Steele. "Ambient Belonging: How Stereotypical Cues Impact Gender Participation in Computer Science." *Journal of Personality and Social Psychology* 97.6 (2009): 1045-060. Print.

[58]Gaucher, Danielle, Justin Friesen, and Aaron C. Kay. "Evidence that gendered wording in job advertisements exists and sustains gender inequality." *Journal of personality and social psychology* 101.1 (2011)

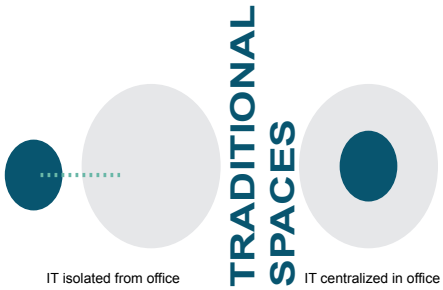


FIGURE E-9 Traditional workspaces, as seen below, often reflect a situation where IT employees are located in a separate physical space from other employees.

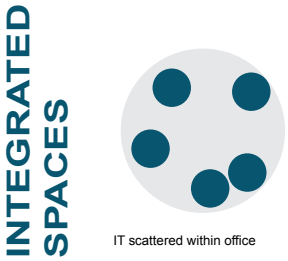


FIGURE E-10 An example of an integrated workspace where IT employees sit among non-IT employees.

to 48 percent of men. The language used in job postings is especially important as it what is used to explain the open position, describe what and who the company is looking for, and attract the potential candidate to the company.

Our case studies revealed that small companies with less than thirty employees rely heavily on trusted job sites, and these same companies also indicated that fewer women than men are applying for these open positions. In order to reduce gender biased language we suggest the use of gender neutral language. Small businesses, even those without formal H.R. departments or those that are not able to employ professional recruiters, can use a myriad of valuable resources available for constructing gender neutral language in their job postings. Companies can take advantage of organizations such as the Anita Borg Institute and National Center for Women & Information Technology (NCWIT) that can provide examples of gender-neutral language and job postings. These resources are intended to educate and inform employees on how to construct postings, which will not deter women from IT positions.

Raising awareness around the gender bias is the first step for small businesses to carry out, ensuring that the employees responsible for hiring IT personnel are properly informed. Use of easily available tools, such as those described above, is the second step to educate employees on the phrases and words to use to avoid gender bias and will help remove some of the institutional barriers present in the recruitment of women to IT occupations. Often these resources or even trainings are available at low or no cost, which makes them an ideal application for small businesses.

2. Integrating Physical Space

The concept of ambient belonging explains the connection between physical environment and fitting in.[59] The employers that participated in the case studies all valued fit among their employees. Employers in the case studies not only valued fit among their employees, but they also described the culture of their organizations to be fitting for women and men equally; describing the culture of their companies as, "communal, laid-back, like a family, casual." However, the survey results reveal that only 3 out of 8 women discussed organizational culture with their current employers during their hiring process and none of them felt strongly that the culture matched the description they were given once they started employment.

One company with 10-30 employees who participated in the case study described their workplace to be collaborative and flexible because their employees do not work in a cubicle environment. However, the same employer said that their programmers are segregated and sit together in a separate office, which is a common arrangement across employers (See Figure E-9). As the group is segregated from the main office, the employer could not say for sure but he assumed employees are comfortable in that environment and assumed if a woman were to start working there she would be fine.

Research has found that employees who do not feel that sense of belonging can be deterred from entering or remaining in a position.[60] We propose an intervention which would integrate physical workspaces to reduce isolation among IT employees. An open workspace would reduce physical barriers between IT and non IT employees as well as between men and women. A more integrated workspace between IT and other employees will encourage forming informal networks between coworkers throughout the organization. Additionally, it can promote a more collaborative environment and increase flexibility. Physically integrating IT employees among non-IT employees via seat or desk assignment can lead to an increased sense of belonging and promote collaboration among employees regardless of position.

Integrating IT employees into the physical space is a feasible and cost-effective application that small business can execute. Half of the participating companies in the case study employed 30 or less employees. Arranging workspaces to encourage IT employees to sit among other departments is a feasible alteration (See Figure E-10 for a

[59]Cheryan, Sapna, Victoria C. Plaut, Paul G. Davies, and Claude M. Steele. "Ambient Belonging: How Stereotypical Cues Impact Gender Participation in Computer Science." *Journal of Personality and Social Psychology* 97.6 (2009): 1045-060. Print.

[60]Cheryan, Sapna, Victoria C. Plaut, Paul G. Davies, and Claude M. Steele. "Ambient Belonging: How Stereotypical Cues Impact Gender Participation in Computer Science." *Journal of Personality and Social Psychology* 97.6 (2009): 1045-060. Print.

sample arrangement). This improved sense of belonging can help to effectively reduce some barriers to recruitment and retention of qualified women in the IT world for small businesses.

3. Support Systems for Women

The absence of women from the IT fields results in a male-dominated environment, creating a cycle of affirmation that the industry is not a viable career for them. Women perceive the work to be difficult, isolated, and lacking social interaction.[61] They conclude from preconceived stereotypes that they have very little in common with the people in the IT field and that they do not belong. The more they perceive the environment to be masculine, the less interested they are in it.[62] These effects can be mitigated however, by linking female employees with mentors within the industry.[63] Companies that hope to increase gender diversity and create workplace environments that reduce the high rates of female attrition from IT positions, can do so by actively promoting membership to professional IT associations and fostering the development of internal collegial relationships through the use of mentorship programs.

When companies are able to facilitate and create welcoming environments, women are more likely to advance and stay in their IT roles.[64] Our study found that employees attributed participation in their company's mentorship program to positively influencing their decision to stay in the industry. As such programs essentially serve a supportive role and mentors help facilitate women's professional development. Mentors provided an outlet for employees to share best practices and learn tools to better deal with the daily challenges indicative of the field.[65] About 83 percent of the employees surveyed stated that mentoring positively impacted their decision to stay in their IT role. Not a single responded felt that it negatively impacted their decision. However, more than half of the employees surveyed stated that such programs were not offered. For an industry that is projected to have the highest growth in comparison to any other sector, this is a missed opportunity for small businesses, but one that they can easily capitalize on.[66]

If resources are limited or there are personnel constraints that impede implementation of mentorship programs, small businesses can also actively promote membership to professional associations. They are widely accessible and a great alternative for small businesses looking to provide a supportive platform externally. Organizations such as NCWIT or Association for Women in Science (AWIS), are just two out of the dozens of associations that currently exist and can be very effective if the establishment of internal networks are not feasible. An initiative that can be undertaken outside of the work environment, it is a resource that does not require many inputs and can be an effective tool for women in IT.

VI. Limitations

Building upon the current literature, this study strove to identify these barriers within the context of small businesses. Given our focus, the findings cannot be generalized to medium and large companies although the interventions proposed could be effective throughout the industry. It is equally important to note that small businesses are defined by the Small Business Administration, as entities with 500 or less employees. The size of the participating companies within our study is not representative of all small businesses in the U.S. Our study disproportionately included companies that had less than 50 personnel. Once a company reaches a certain threshold, internal changes occur in relation to corporate systems and infrastructure. Implementing the suggested interventions becomes a bit more complex, as formal internal policies take precedence over employee preferences.

Due to the small sample size of participating companies and survey respondents, the findings cannot be interpreted as indicative of the entire IT industry. The number of IT employees within each company varied, as did the number of IT workers who eventually responded to the surveys. As a result, there was a small sample of female IT workers in comparison to the number of male respondents. While this could be reflective the overall lack of women in the industry, we lack the data to make this correlation. Other factors that affect the representation of women in IT, such as the geographic location of the company, recruiting strategy, and advert language for openings within the company, could not be examined and thus, were not taken into consideration.

This study also does not examine other factors that may impact the ability of small businesses to hire more women for IT roles, including factors such as contracting, resource constraints, and limited experience exercising IT industry strategies in the recruitment and retention of women.

[61] Wentling, R.M., & Thomas, S. (2009). Workplace culture that hinders and assists the career development of women in information technology. *Information Technology, Learning, and Performance Journal* 25(1), 25-42.

[62] Cheryan, S. (2012). Understanding the paradox in math-related fields: Why do some gender gaps remain while others do not? *Sex Roles* 66(3-4), 184-190.

[63] Drury, Benjamin J., John O. Siy, and Sapna Cheryan. "When Do Female Role Models Benefit Women? The Importance of Differentiating Recruitment From Retention in STEM." *Psychological Inquiry: An International Journal for the Advancement of Psychological Theory* 22.4, 265-69.

[64] Roldan, Malu, Louise Soe, and Elaine K. Yakura. "Perceptions of Chilly IT Organizational Contexts and Their Effect on the Retention and Promotion of Women in IT." Computer Personnel Research 2004. CPR 2004: Tucson.

[65] Ibid.

[66] Cheryan, S. 2012. Understanding the paradox in math-related fields: Why do some gender gaps remain while others do not? Sex Roles 66(3-4): 184-190.

VII. Implications for Further Research

This study attempts to provide specific and implementable solutions for employers to execute, however continued research is necessary to develop more robust interventions.

The conclusions in the literature review on the recruitment and retention of women in IT were largely derived from studies conducted in larger corporations. Given the market share of small and medium size businesses, it would be beneficial for future research to further examine these barriers. Additionally, most research views women as a homogeneous group. Further research should explore the unique differences among women including generational or cultural factors.

If further case studies were conducted on women in IT positions, another consideration that should be explored is the collection of data on where women go after they leave their current position. Additionally, collecting data that allows for a comparison between individual experiences at a large business versus a small business could provide unique insights into why women leave their current position.

VIII. Conclusion

Where large business can be rigid, small business can be more flexible and better able to quickly implement changes such as a new office layout and rewording job postings. Small businesses may not always have enough staff to support internal mentoring among colleagues, but they can partner with a wealth of external organizations that specialize in mentoring women in IT and related technical fields. Small businesses are at the epicenter of attracting and keeping more women in IT positions.

IX. Appendices

Appendix E-1. Frequently Asked Questions
Appendix E-2. Participant Consent Form
Appendix E-3. Online Survey
Appendix E-4. Interview Questions
Appendix E-5. Participant Company Descriptions
Appendix E-6. Methodology
Appendix E-7. Literature Review – Databases

Appendix E-1. Frequently Asked Questions

Promising Practices for Recruitment and Retention in the IT Workforce

Frequently Asked Questions

Who are you and what is this project?

We are a group of graduate students at the H. John Heinz III College at Carnegie Mellon University working on a capstone project for the National Academies. Our project will identify Promising Practices for Recruitment and Retention in the IT Workforce. As part of our research we are conducting case studies of small and medium size companies with IT Departments.

Why is my participation important?

Your response is valuable in helping to advance recruitment and retention strategies throughout IT departments across the country.

Who else are you interviewing during the course of this project?

Our study will conduct interviews and surveys with H.R. personnel, hiring managers and employees in IT Departments. We will be talking to a diverse group of companies in different industries across the country.

Will my answers be shared with my employer or my co-workers?

Protecting the employee-employer relationship is of utmost importance to us. Your survey responses will be kept anonymous. Individual survey responses will not be shared with your fellow employees or your employers.

What are you going to do with your findings?

Individual survey responses will be analyzed and will inform the conclusions for our study. Our final product will be presented at a careers pathways workshop for the National Academies.

What's in it for me?

Your response contributes to the success of this project. We will provide you with our published report, in which we will outline promising practices for how companies across America can find and keep the best employees for the job.

Appendix E-2. Participant Consent Form

Promising Practices for the Recruitment and Retention in the IT Workforce

Consent to Participate in an Interview

Graduate students at the H. John Heinz III College at Carnegie Mellon University are working on a capstone project for the National Academies. The purpose of the project is to identify Promising Practices for the Recruitment and Retention in the IT Workforce. As part of our research we are conducting case studies of small and medium size companies with IT Departments. These case studies will consist of interviews with H.R. personnel and hiring managers as well as surveys with employees in the IT Departments. We will be talking to a diverse group of companies in different industries across the country. Individuals from these groups will be asked to participate in the interview. The interview will inquire about the company's recruitment processes and retention strategies. No personally identifying information will be collected during the interview.

The students will conduct all interviews. The interviewer will take hand written notes as well as record the interview electronically. We expect interviews to take no more than thirty minutes. One week after the interview we will send you a copy of the interview notes that you can correct or modify. Individual survey responses will be kept anonymous. They will be analyzed into one collective report.

The information you provide will be invaluable in helping to advance recruitment and retention strategies throughout IT departments across the country. Your response contributes to the success of this project. We will provide you with our published report, which will outline promising practices for how companies across America can find and keep the best employees for the job.

Taking part in this evaluation is completely voluntary. There is no penalty if you choose not to participate in the interview and your relationship with Carnegie Mellon University or any other stakeholders affiliated will not be affected.

Participant: I have read this consent form. I understand the information and have no remaining questions. I understand I will be provided with a signed copy of this form. My signature of this consent form indicates that I agree to take part in this interview.

Print Name _____ **Date: _____**

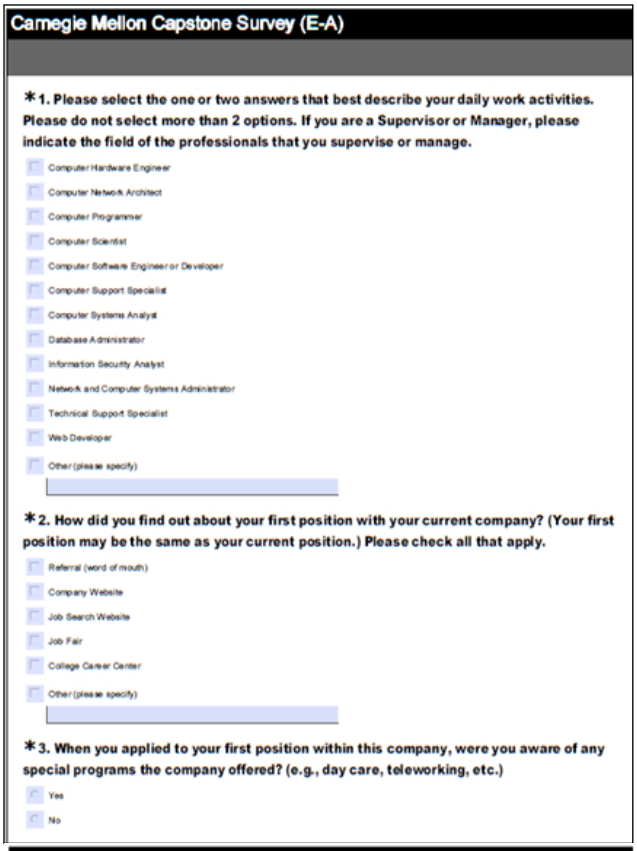
Signature _____

Interviewer: I have fully explained to the participant the nature and purpose of the evaluation interview. I have answered any and all questions to the best of my ability.

Print Name: _____ **Date: _____**

Signature: _____

Appendix E-3. Online Survey



Carnegie Mellon Capstone Survey (E-A)

*1. Please select the one or two answers that best describe your daily work activities. Please do not select more than 2 options. If you are a Supervisor or Manager, please indicate the field of the professionals that you supervise or manage.

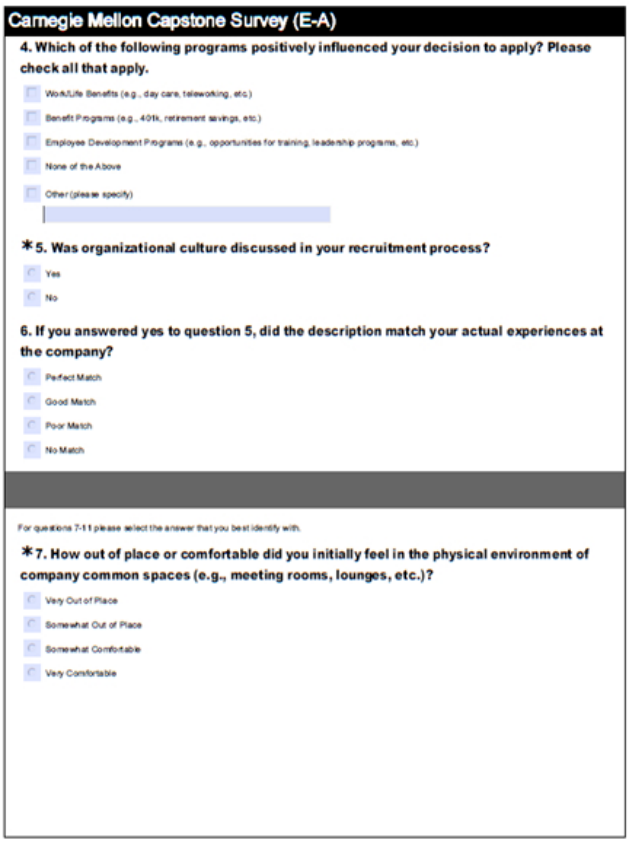
- Computer Hardware Engineer
- Computer Network Architect
- Computer Programmer
- Computer Scientist
- Computer Software Engineer or Developer
- Computer Support Specialist
- Computer Systems Analyst
- Database Administrator
- Information Security Analyst
- Network and Computer Systems Administrator
- Technical Support Specialist
- Web Developer
- Other (please specify)

*2. How did you find out about your first position with your current company? (Your first position may be the same as your current position.) Please check all that apply.

- Referral (word of mouth)
- Company Website
- Job Search Website
- Job Fair
- College Career Center
- Other (please specify)

*3. When you applied to your first position within this company, were you aware of any special programs the company offered? (e.g., day care, teleworking, etc.)

- Yes
- No



Carnegie Mellon Capstone Survey (E-A)

4. Which of the following programs positively influenced your decision to apply? Please check all that apply.

- Work/Life Benefits (e.g., day care, teleworking, etc.)
- Benefit Programs (e.g., 401k, retirement savings, etc.)
- Employee Development Programs (e.g., opportunities for training, leadership programs, etc.)
- None of the Above
- Other (please specify)

*5. Was organizational culture discussed in your recruitment process?

- Yes
- No

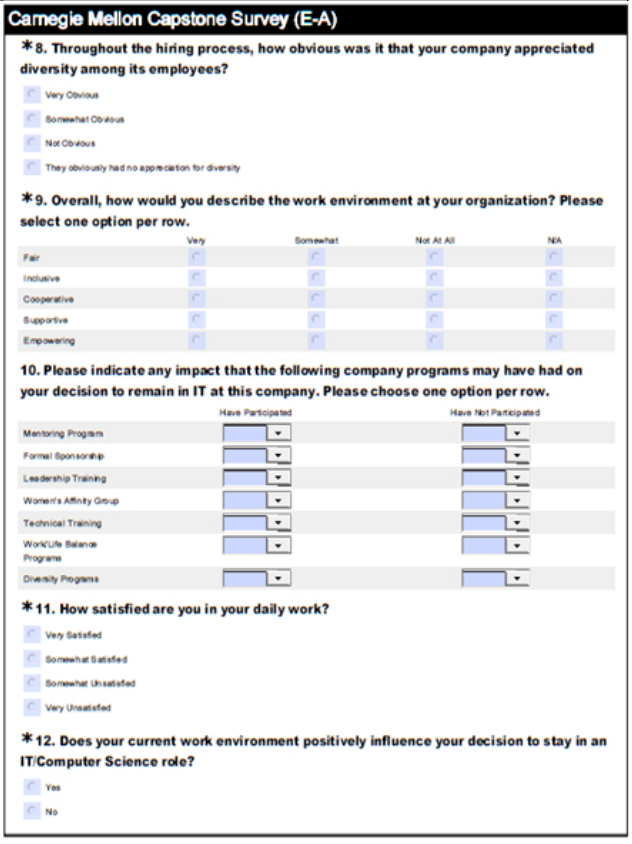
6. If you answered yes to question 5, did the description match your actual experiences at the company?

- Perfect Match
- Good Match
- Poor Match
- No Match

For questions 7-11 please select the answer that you best identify with.

*7. How out of place or comfortable did you initially feel in the physical environment of company common spaces (e.g., meeting rooms, lounges, etc.)?

- Very Out of Place
- Somewhat Out of Place
- Somewhat Comfortable
- Very Comfortable



Carnegie Mellon Capstone Survey (E-A)

*8. Throughout the hiring process, how obvious was it that your company appreciated diversity among its employees?

- Very Obvious
- Somewhat Obvious
- Not Obvious
- They obviously had no appreciation for diversity

*9. Overall, how would you describe the work environment at your organization? Please select one option per row.

	Very	Somewhat	Not At All	N/A
Fair				
Inclusive				
Cooperative				
Supportive				
Empowering				

10. Please indicate any impact that the following company programs may have had on your decision to remain in IT at this company. Please choose one option per row.

	Have Participated	Have Not Participated
Mentoring Program		
Formal Sponsorship		
Leadership Training		
Women's Affinity Group		
Technical Training		
Work/Life Balance Programs		
Diversity Programs		

*11. How satisfied are you in your daily work?

- Very Satisfied
- Somewhat Satisfied
- Somewhat Unsatisfied
- Very Unsatisfied

*12. Does your current work environment positively influence your decision to stay in an IT/Computer Science role?

- Yes
- No

Carnegie Mellon Capstone Survey (E-A)

*13. What is your gender?

- Female
- Male

*14. What is the highest level of education you have completed or the highest degree you have received?

- Less Than High School Degree
- High School Degree or Equivalent (e.g., GED)
- Some College But No Degree
- Associate Degree
- Bachelor Degree
- Graduate Degree

15. If you have a Bachelor's degree, what was your undergraduate program of study?

- Computer Science
- Information Sciences
- Computer Engineering
- Other (please specify)

16. To enter a raffle for a $50 Amazon gift card, please enter your email address

Appendix E-4. Interview Questions

CMU Case Study Employer Questionnaire

Estimated Time Commitment: 15-20 Minutes

1. How many employees are in your company?
   a. What is the gender breakdown within that?
   b. How many IT employees do you have, and what is the gender breakdown?

2. What is the daily workload for your IT workers or IT department like?
   a. Do you require employees to be on call?
   b. If so, how often?

3. For your most recently posted technical position, how many people applied?
   a. Out of the total, how many were women?

4. Could you describe briefly what your recruitment process is and what that entails?
   a. How many of your employees are involved in the recruitment process?
   b. Do you have any special campaigns or initiatives that are targeted toward women?

5. Could you describe or would you be able to provide us with a list of what benefits or employee development initiatives your company offers?
   a. For example, mentoring, alternative work schedules, daycare, etc…

6. Do you have any initiatives that you have implemented which specifically target improving and recruitment and retention of women?
   a. If so, what are they?
   b. Are any of these specifically aimed at improving recruitment and retention of women in IT positions or technical roles?
   c. Which of these would you consider most effective?

7. Can you describe the culture here, so that I could get a sense of what some of the daily interactions entail?

8. Did you have any questions for me or any other comments that you would like to make?

Appendix E-5. Participant Company Descriptions

Employer A involves the development of a unique search engine specific to their industry and offers a marketplace allowing sellers and buyers in real estate to more easily conduct searches. Headquartered in Pittsburgh, the company is 3 to 5 years old. The business has fewer than 20 employees, 11 of which are considered IT employees. None of the IT employees are women. This company is considered "tech-focused" by this study.

Employer B offers "uniquely created e-commerce services," some of which include client branding capabilities, digital storage, and marketplace capabilities. Located near Greenville, South Carolina (the state's third largest urban area), the company is 12-15 years old and has fewer than 20 employees, 4 of which the company considers IT employees; none of the IT employees are women. This company is considered "tech-focused" by this study.

Employer C, based near Los Angeles, provides services such as software development, web hosting, web development, and e-commerce web design. The company is 12-15 years old and has fewer than 20 employees, 11 of which are considered IT employees. One of the IT employees is a woman. This company is considered "tech-focused" by this study.

Employer D is a law firm headquartered in Pittsburgh. The company is more than 30 years old and was not a considered a "small business" in our study as it has more than 500 employees, 64 of which the company considers IT employees. Nineteen of the IT employees are women.

Employer E is a data and content company serving a specific industry. The company has corporate offices around the globe, with headquarters in Chicago. The company is approximately 30 years old and has 150-175 employees, 11 of which the company considers to be IT employees; one of the IT employees is a woman. This company is considered "tech-focused" by this study.

Employer F is a nonprofit academic organization based in Annapolis, MD. It is approximately 55 years old and provides educational services to pre-K-12 students. The organization has 107 full-time and part-time staff and a 3-person IT department. Of the 3 employees, 1 is a woman who is part-time. This is company is considered "non-tech focused" by this study.

Employer G is a healthcare organization based in Washington, DC and the surrounding area. It employs 23 individuals; 19 females and 4 males. The one employee in the IT department is a male who fulfills another role in the organization also.

Employer H is a public affairs firm headquartered in Washington, DC metropolitan area. The company is 15-20 years old. It provides technology services as part of a broader suite of public affairs services and has 150-175 employees. The interviewee for this company was unable to identify the number of IT employees in the company.

Appendix E-6. Methodology

Interview Administration & Follow-Up

Within each company, one general hiring manager (or manager within the IT Department) was asked to participate in the interview. These managers were provided with a written consent form in advance of the interview, along with a description of the study, and a list of frequently asked questions (FAQ) describing the purpose of the study and how the information from interviews and surveys would be used. Consent forms were either signed or returned electronically, or verbal agreement was obtained prior to the interview. Five of the eight interviews were electronically recorded and transcribed; the other three involved the use of hand-written notes. All of the transcripts and notes were returned to employers who were allowed to review and revise the transcripts or notes, if desired. Two companies provided revisions to their transcripts or notes. Each company that agreed to participate in the study was informed they would receive a summary of the study findings, specific to the company.

Analysis of Surveys and Interviews

1. Interviews

The transcribed interview responses were reviewed and responses by all companies were aggregated by question. The aggregated responses were then qualitatively analyzed, and examined to identify any commonalities or major differences among responses. The approach to interview analysis was thematic in nature, seeking to descriptively identify existing programs or initiatives that were successful/unsuccessful in recruiting women in IT to small businesses.

2. Surveys

All survey responses were collected and downloaded into Excel. The responses were then categorized into three groups: Demographics, Recruitment and Retention. Responses were analyzed by gender and by company type using descriptive statistics methods when possible. Small businesses were grouped together and compared to the medium size business and nonprofit. Analysis tried to highlight questions in which responses differed between male and female employees or between employees from small businesses and employees from the medium sized business or nonprofit. Survey responses were discarded if the respondent answered less than 11 of the 16 total questions or they failed to identify their gender. Responses were also discarded if the respondent did not self-identify as an IT professional.

Survey/Interview Implementation Methodology

Methodology

1. Systems team contacts initial personal contact (CONTACT #1) within the company. CONTACT #1 then provides a company representative (CONTACT #2) with whom we can work with directly (e.g., HR personnel; hiring manager)
2. CONTACT #2's information is passed-off to someone in the Survey Team (Angie, Sara, Channing)
3. Assigned Survey Team member initiates contact with CONTACT #2 via phone or email.
   a. Send FAQ and Letter (INCLUDE TIMELINE) to CONTACT #2
   b. Identify at least 2 people in the company to participate in interview BEFORE FRIDAY, 3/29 (CONTACT #2, if appropriate, can be one of the interviewees)
   c. Confirm with them HOW MANY EMPLOYEES will receive the survey
   d. Identify if there are any persons that will NOT be receiving the survey (we want to really be clear about WHO in the company gets the survey. It might be helpful to know who doesn't get the survey, such as "the admin people supporting IT" or maybe contract workers)
4. Once Company agrees to participate in survey
   a. Survey Team Contact emails CONTACT #2 (or other identified person) link to the Survey Monkey
   b. CONTACT #2 (or proxy) forwards link to IT employees (Survey Team Contact should be cc'd on the email so we can identify the start date)
   c. On DAY 3 of survey, Survey Team Contact sends friendly reminder email to CONTACT #2
      i. Express appreciation in their participation.
      ii. XXX people have responded so far
      iii. Reminder that the survey will end on XXX date

5. For Interviews
   a. Identify people to interview
   b. Contact interview persons and confirm interview date and times (BY FRIDAY 3/22)
      i. Confirm whether the interview will be held via phone or Skype
      ii. Ensure the interviewee has Skype capabilities if held via Skype
      iii. Provide Interview consent form in advance of the interview; or at the interview
   c. Conduct the interview
   d. Transcribe interview recordings (or Skype transcription)
6. Survey Analysis
   a. Each Survey Team Contact will fill in data in the Analysis Template (to be made)

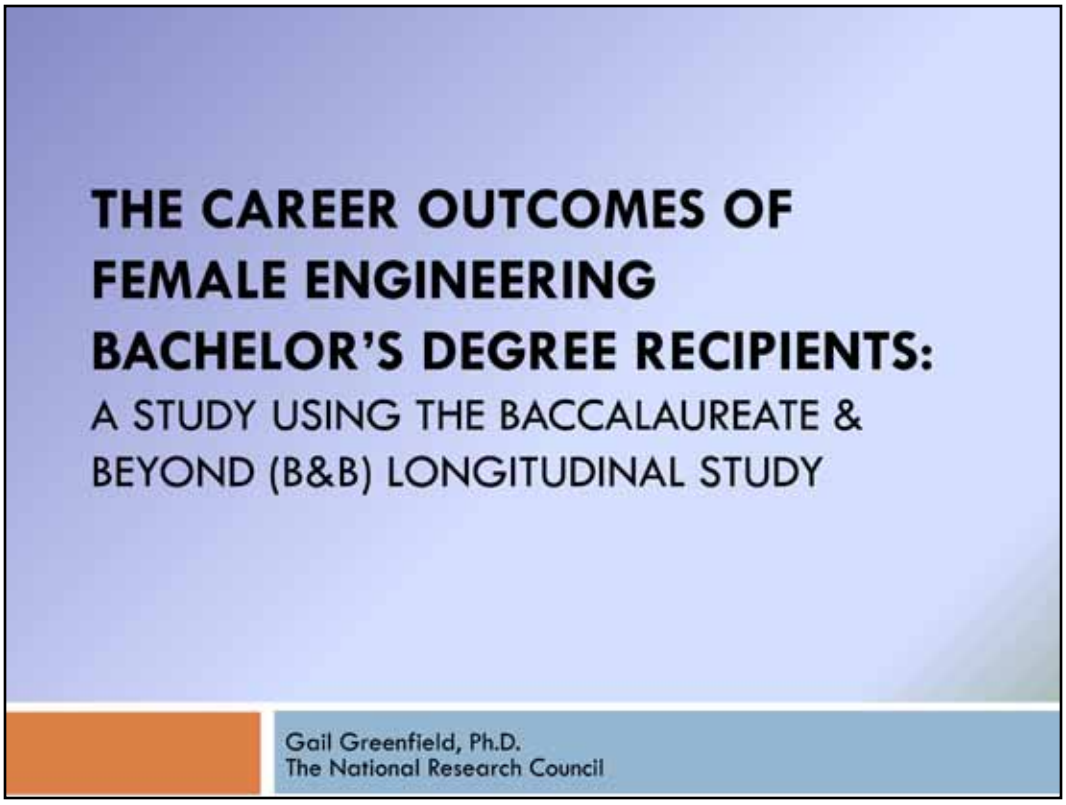
Appendix E-7. Literature Review – Databases

- EBSCOhost
- ProQuest
- Scopus
- Sage Journals Online
- ProQuest Engineering and Science
- ProQuest Business
- ACM Digital Library
- ACS Publications
- Wiley Online Library

F

Presentation Slides on Career Outcomes of Women Engineering Bachelor's Degree Recipients

Gail Greenfield



What is the B&B Longitudinal Study?

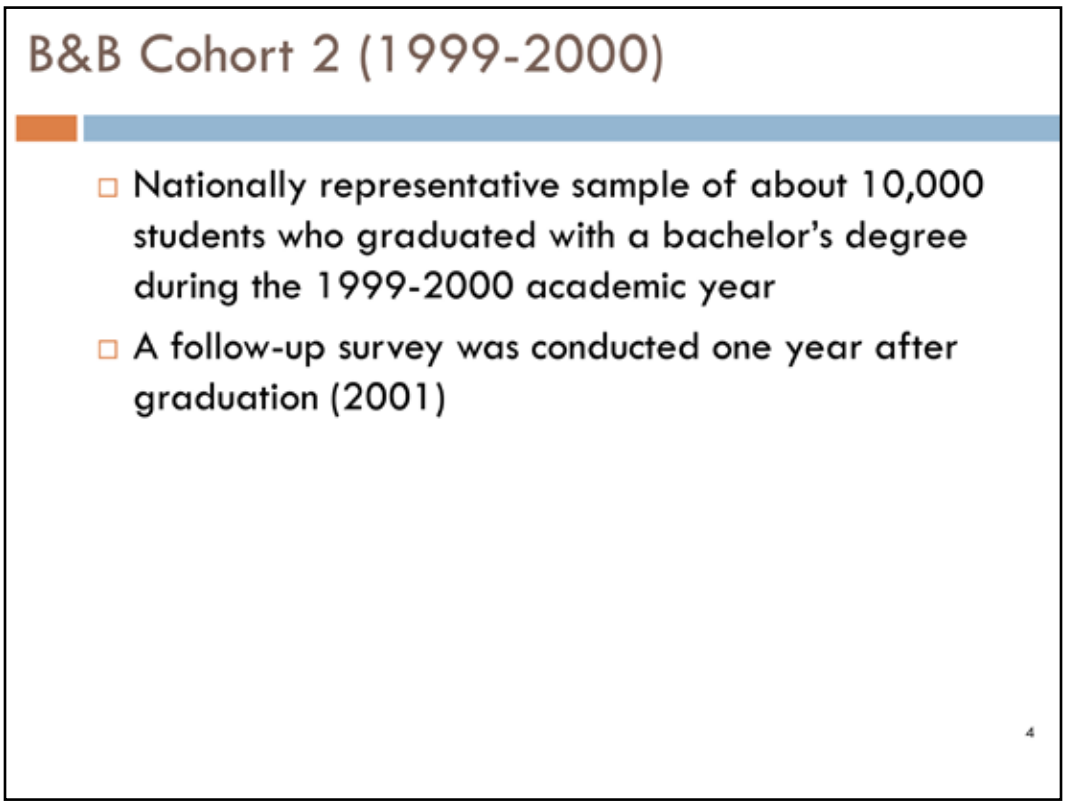
- Conducted by U.S. Department of Education's National Center for Education Statistics (NCES)
- Examines post-graduation experiences – e.g., education, employment, and family – of those who have graduated with a bachelor's degree
- Captures information on degree recipients' undergraduate experiences and key demographic information
- Follows multiple cohorts of students over time

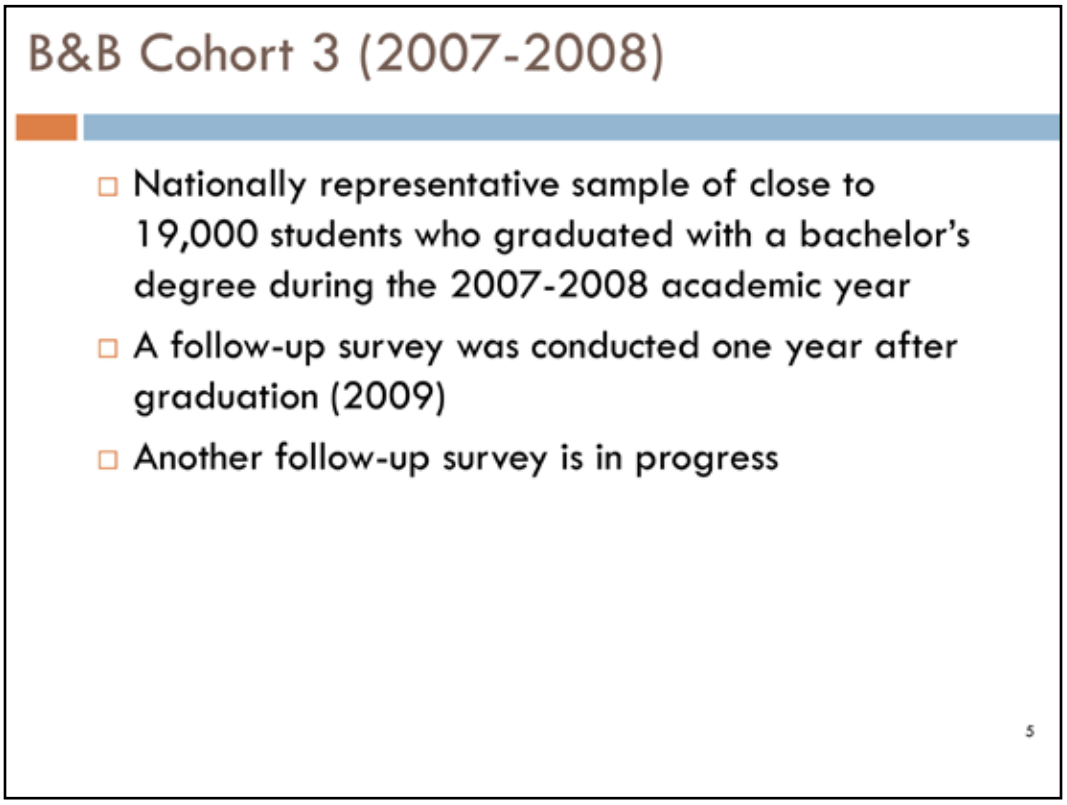
2

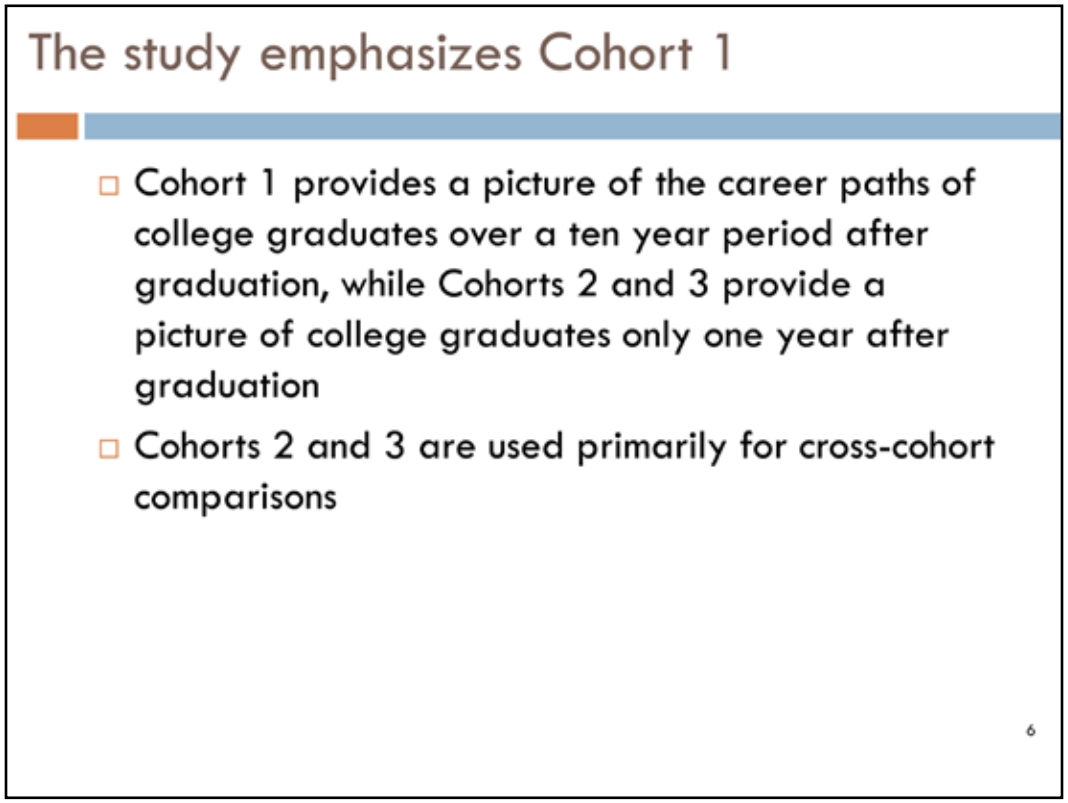
B&B Cohort 1 (1992-1993)

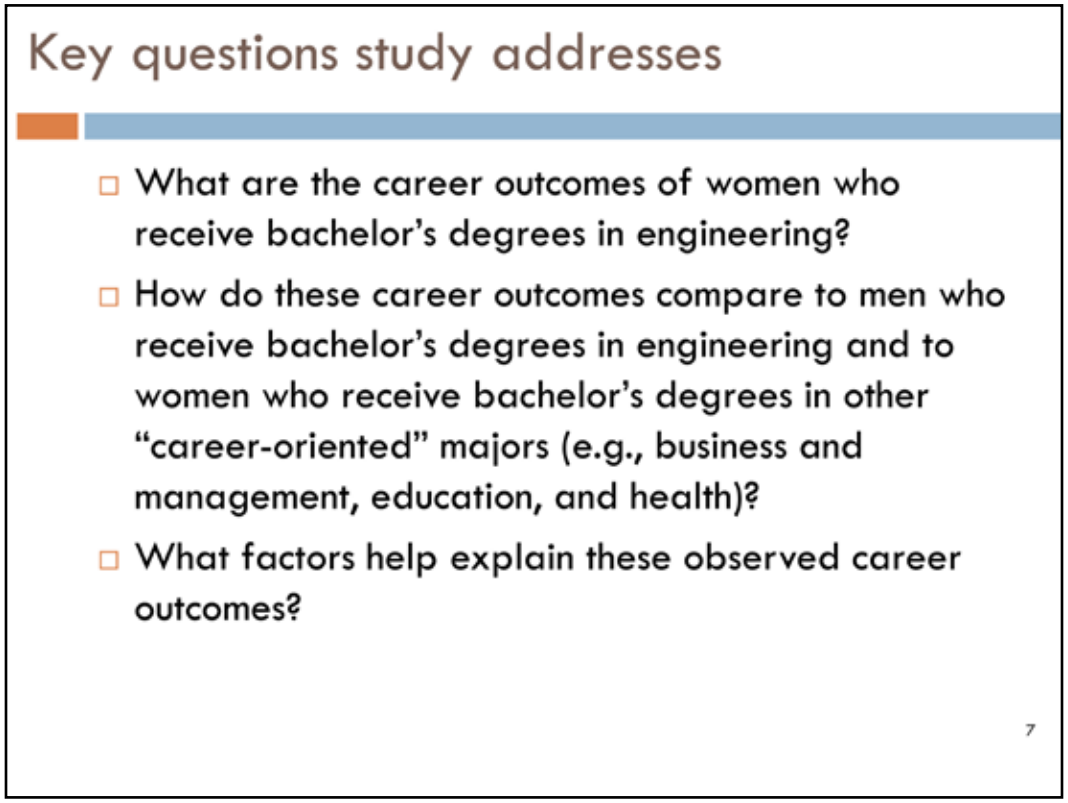
- Nationally representative sample of approximately 11,000 students who graduated with a bachelor's degree during the 1992-1993 academic year
- Students were surveyed in their last year of college, with follow-up surveys conducted one year after graduation (1994), four years after graduation (1997), and ten years after graduation (2003)

3









Primary limitations of the B&B data

- Limited number of engineers represented in each survey
  - For example, of the approximately 8,000 in Cohort 1 who responded to all four surveys, fewer than 7% graduated with a degree in engineering
  - Of these, only about 80 are women
- The online tool that provides access to the data does not permit the pooling of cohorts and limits the ways in which variables can be used and created

8

Cases for each cohort and survey

Cohort	Survey year	Engineering graduates responding to the survey		
		All	Male	Female
1	1994	640	550	90
	1997	625	535	90
	2003	575	490	85
	All surveys*	520	440	80
2	2001	580	480	100
3	2009	930	750	180

For confidentiality purposes, B&B does not reveal exact sample sizes. Numbers in the table are approximate.
*Includes the base year survey in 1993.

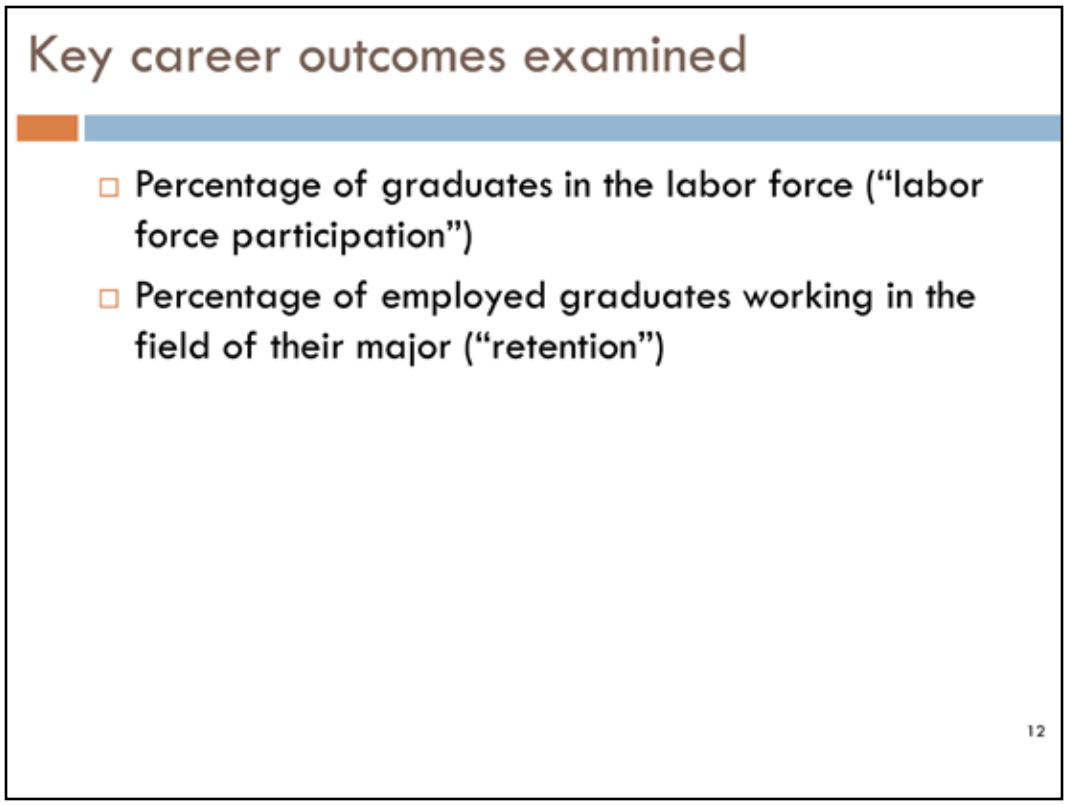
9

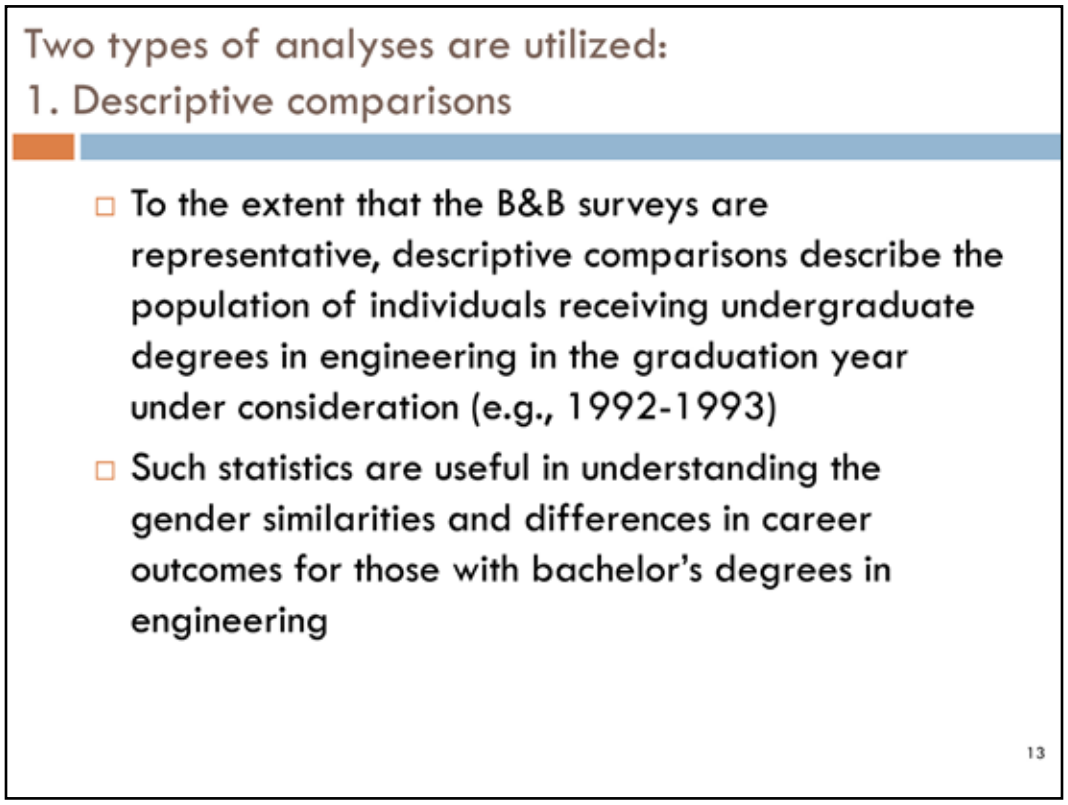
Another limitation of the B&B data

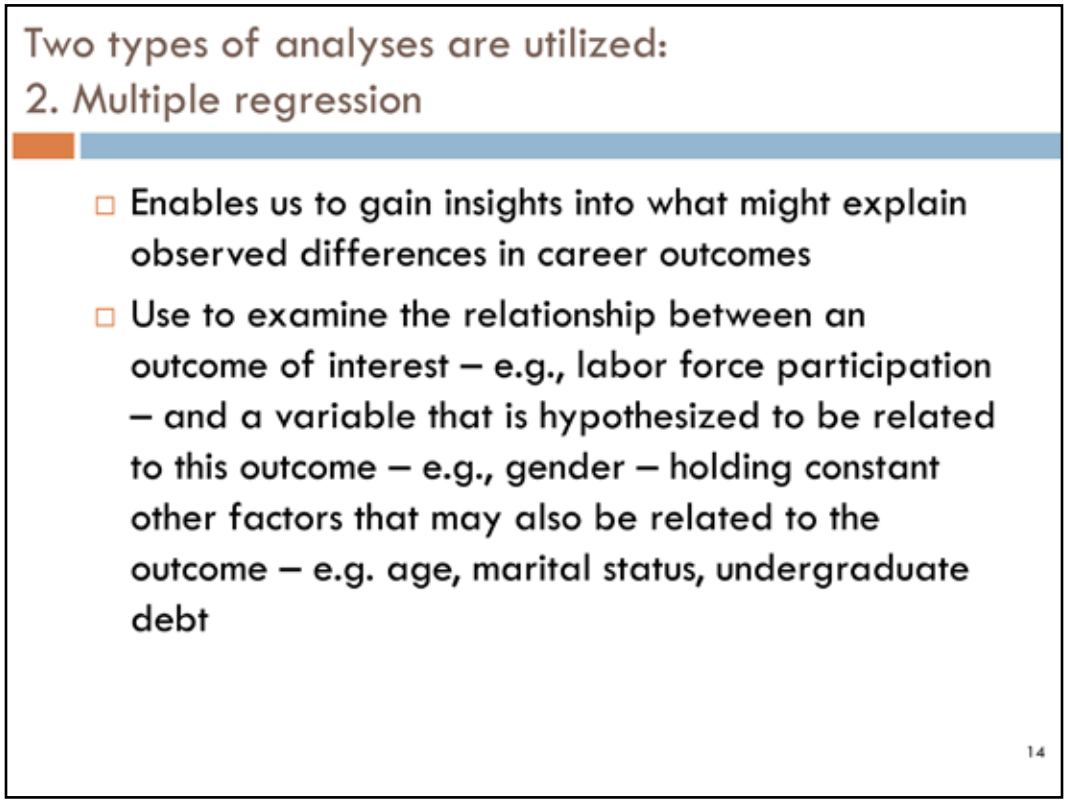
- Survey does not allow us to identify those who have progressed to engineering managers and supervisors
- Rather, individuals are recorded as managers or supervisors, with no information provided on the nature of the work overseen
- This limitation is most problematic for Cohort 1 since one might expect a sizable number of these graduates to have progressed to manager or supervisor by ten years after graduation

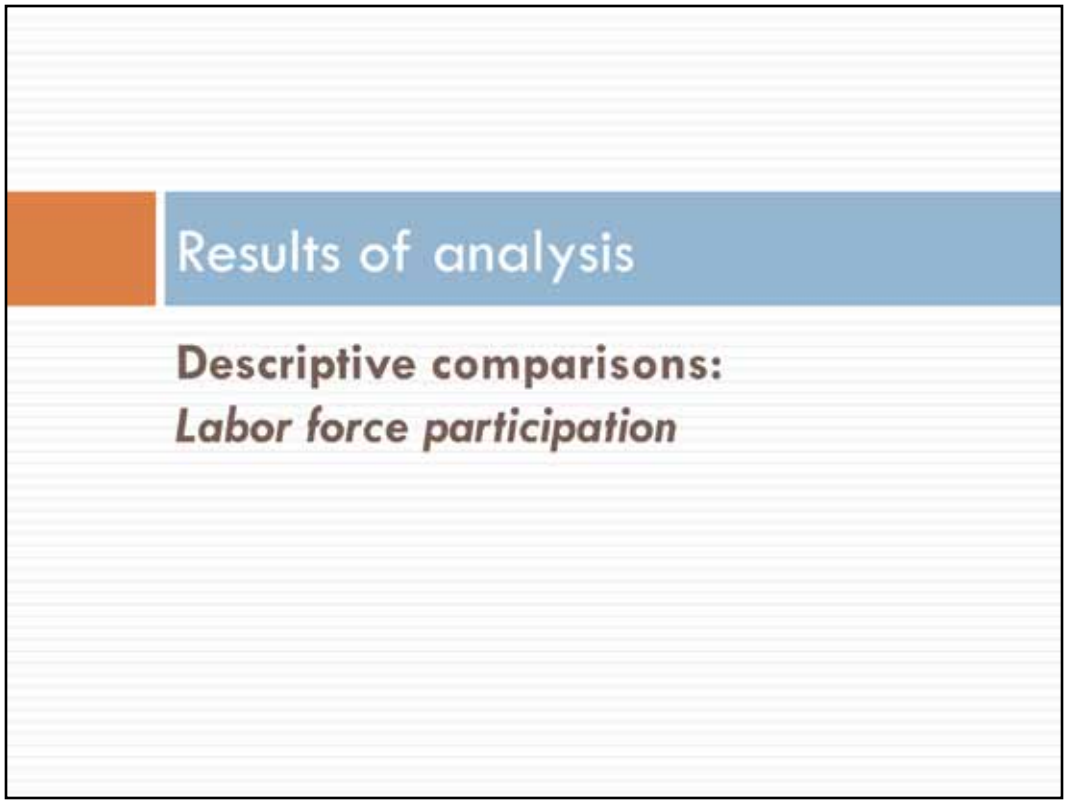
10

Methodology







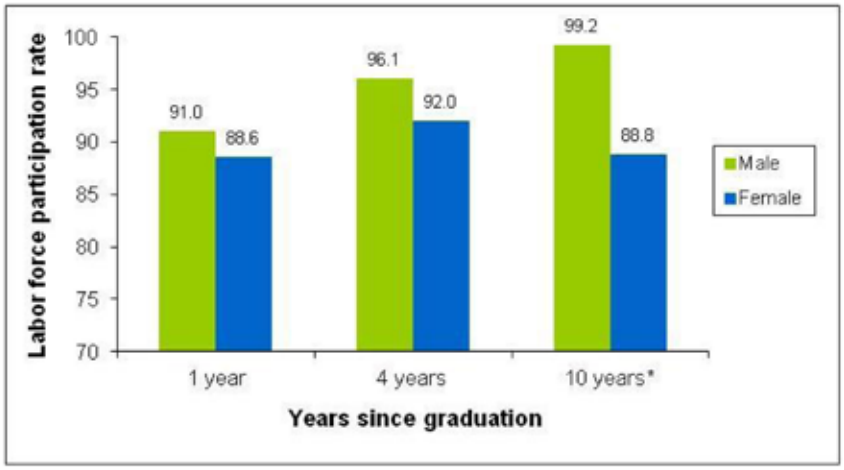


Labor force participation

- Upon graduating with a bachelor's degree, one key decision a graduate makes is whether to join the labor force
- Those who choose not to join the labor force do so for a variety of reasons, such as attending school, family responsibilities, health problems, and the like
- This section compares the labor force participation rates (LFPR) of male and female bachelor's degree recipients at various points after graduation

16

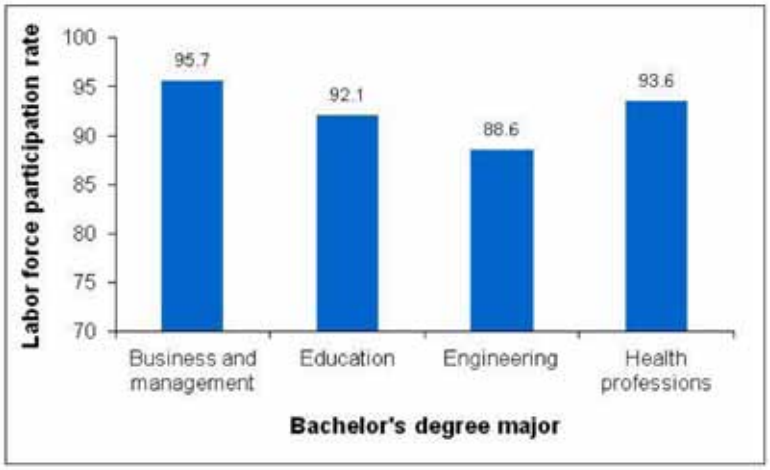
LFPR by gender for engineering bachelor's degree recipients, B&B Cohort 1



*Difference between male rate and female rate is statistically significant at the 5% level.
Note: The increases in LFPR over time for males are statistically significant at the 5% level.

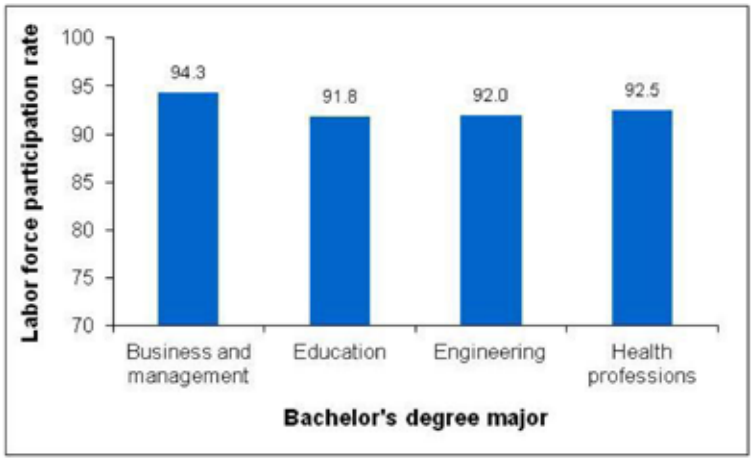
17

LFPR one year after graduation for female bachelor's degree recipients, B&B Cohort 1



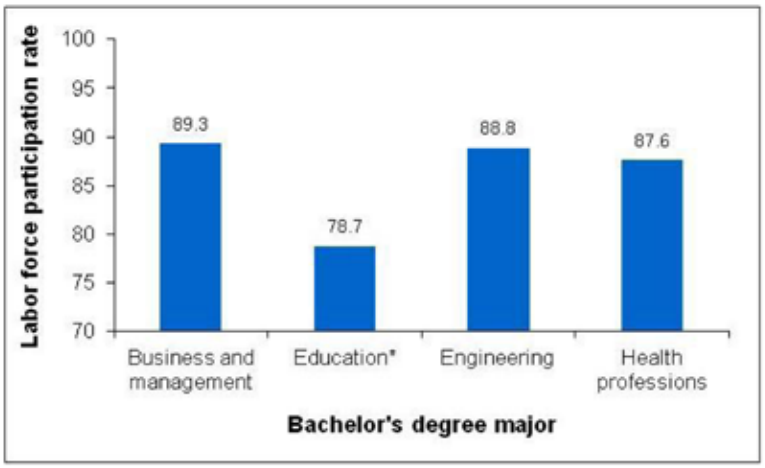
18

LFPR four years after graduation for female bachelor's degree recipients, B&B Cohort 1



19

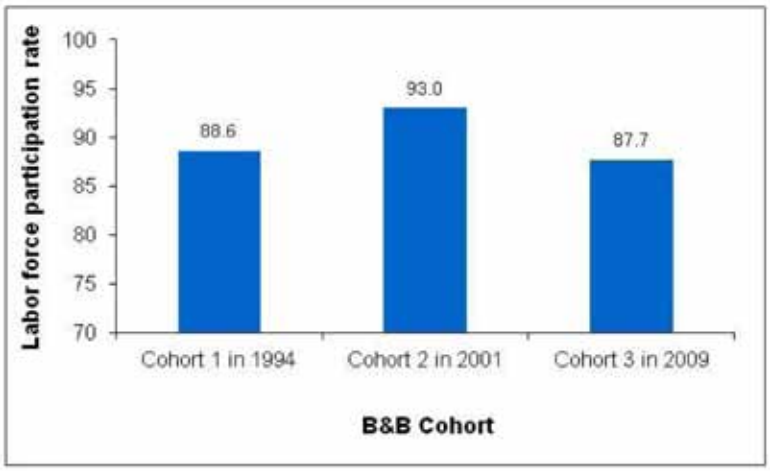
LFPR ten years after graduation for female bachelor's degree recipients, B&B Cohort 1



*Difference between this major and engineering major is statistically significant at the 5% level.

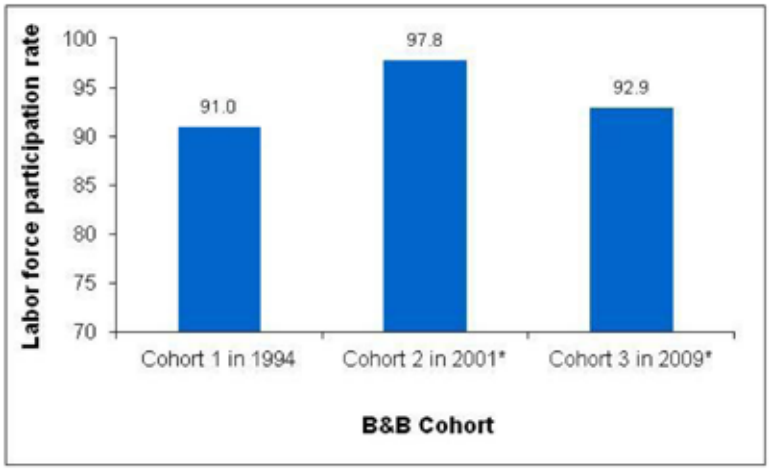
20

LFPR one year after graduation for female engineering bachelor's degree recipients, by B&B cohort



21

LFPR one year after graduation for male engineering bachelor's degree recipients, by B&B cohort



*Difference between this cohort and prior cohort is statistically significant at the 5% level.

22

LFPR summary of findings

- For engineering bachelor's degree recipients in Cohort 1, the male LFPR increases with increases in time since graduation; this pattern is not seen for female graduates
- Moreover, by ten years after graduation, the LFPR for females is more than 10 percentage points lower than the rate for males
  - However, the female LFPR ten years after graduation remains high (~89%)

23

LFPR summary of findings (continued)

- For this same cohort, the LFPR for female engineering bachelor's degree recipients is similar to the rates for female graduates with business/management and health-related majors
- Across B&B cohorts, the LFPR for male engineering bachelor's degree recipients one year after graduation increased from Cohort 1 to Cohort 2 and then fell from Cohort 2 to Cohort 3; a similar (but not statistically significant) pattern can be seen for female engineering bachelor's degree recipients

24

Results of analysis

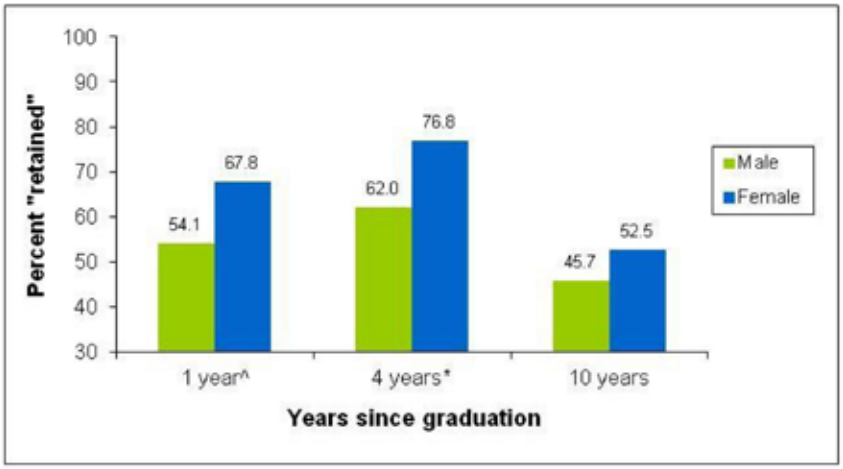
Descriptive comparisons:
Retention

Retention

- For those graduates who choose to be in the labor force, a key decision is whether to work in an occupation that is in the field of their major
- This section compares the "retention" rates of employed male and female bachelor's degree recipients at various points after graduation

26

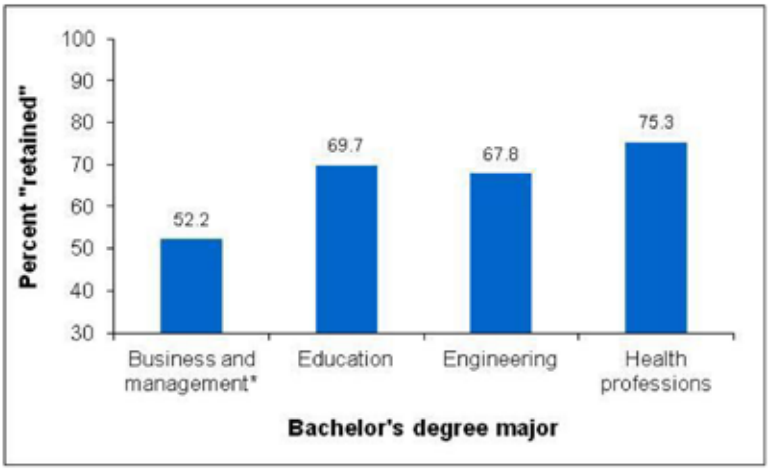
Employed engineering bachelor's degree recipients in an engineering/architecture occupation, B&B cohort 1



*Difference between the male and female figures is statistically significant at the 5% level.
^Difference between the male and female figures is statistically significant at the 10% level.
Note: The decline in the percent retained from four to ten years after graduation is statistically significant at the 5% level for both males and females.

27

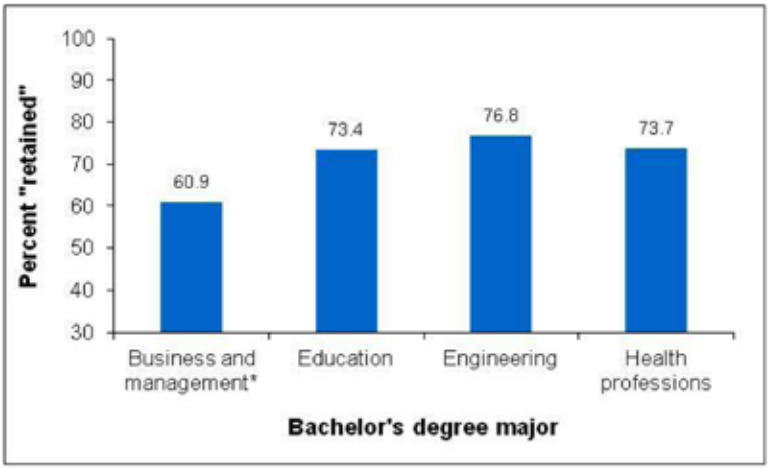
Employed female bachelor's degree recipients working in field of major one year after graduation, B&B cohort 1



*Difference between this major and engineering major is statistically significant at the 5% level.

28

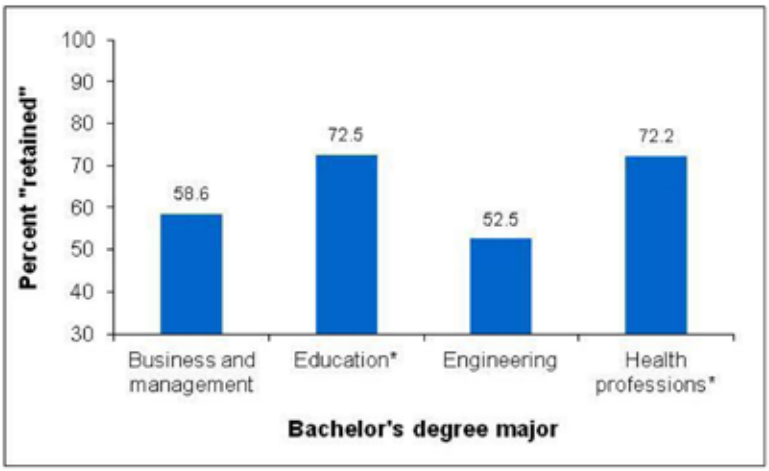
Employed female bachelor's degree recipients working in field of major four years after graduation, B&B cohort 1



*Difference between this major and engineering major is statistically significant at the 5% level.

29

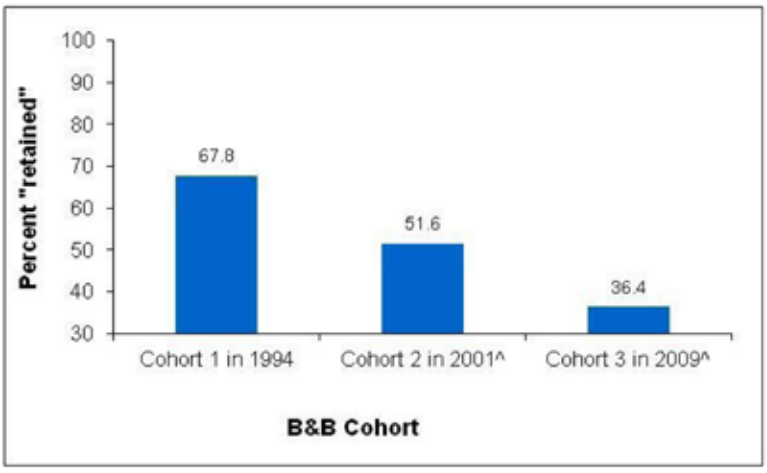
Employed female bachelor's degree recipients working in field of major ten years after graduation, B&B cohort 1



*Difference between this major and engineering major is statistically significant at the 5% level.

30

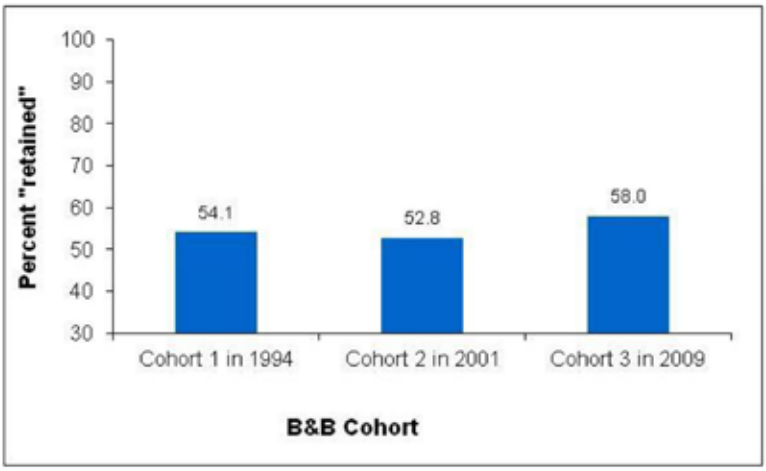
Employed female bachelor's degree recipients working in field of major one year after graduation, by B&B cohort



^Difference between this and prior cohort is statistically significant at the 10% level.

31

Employed male bachelor's degree recipients working in field of major one year after graduation, by B&B cohort



32

Cohort 3 engineering majors were asked for the primary reason for working outside their degree field

Females

- Job in field not available (47.6%)
- Change in career interests (16.6%)
- Job location (12.4%)
- Pay/promotion opportunities (11%)
- Working conditions (8.5%)
- Other factors (4.0%)
- Family-related reasons (0%)

Males

- Job in field not available (33.8%)
- Pay/promotion opportunities (32%)
- Other factors (25.1%)
- Change in career interests (4.6%)
- Job location (4.0%)
- Working conditions (0.5%)
- Family-related reasons (0%)

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Retention summary of findings

- For Cohort 1, the retention rate at each post-graduation follow-up is higher for female engineering bachelor's degree recipients than male engineering bachelor's degree recipients, although the difference is not statistically significant ten years after graduation
- Moreover, for both males and females, there is a statistically significant decline in retention rates between four and ten years after graduation

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Retention summary of findings (continued)

- Until ten years after graduation, the retention rate for female engineering bachelor's degree recipients is similar to the rates for education and health-related majors (and higher than that for management/business majors)
- However, by ten years after graduation , the retention rate for female engineering bachelor's degree recipients is significantly lower than the rates for education and health-related majors (and comparable to that for management/business majors)

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Retention summary of findings (continued)

- Across cohorts, the percent of female engineering bachelor's degree recipients "retained" has fallen significantly from one cohort to the next
  - The decline in the retention rate is more than 30 percentage points between Cohort 1 in 1994 and Cohort 3 in 2009
  - This same pattern of decline is not seen for male engineering bachelor's degree recipients, although both males and females in Cohort 3 report that the primary reason for working outside their degree field is because a job in their field was not available

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Results of analysis

Multiple regression results

Logistic regression

- Logistic regression is used when the outcome examined is categorical (e.g., yes/no; high/medium/low)
- Model predicts the likelihood of an outcome based on a series of explanatory or predictor variables
- Here two outcomes are modeled for Cohort 1:
  - Likelihood that a graduate is participating in the labor force ("participation")
  - Likelihood that a graduate is working in the field of their major ("retention")

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Predictors considered

- Gender
- Age at graduation
- Ethnicity
- Undergraduate GPA
- Undergraduate degree specialty/sub-field
- Undergraduate debt
- Undergraduate Carnegie code
- Parental education
- Marital status
- Parental status
- Citizenship status
- Spousal employment
- Spousal income
- Graduate degree
- Enrollment status

Not all predictors are included in the final set of models

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Characteristics of engineering bachelor's degree recipients, B&B Cohort 1

		Males	Females
Age at graduation	Average	24.3	23.6
Ethnicity	Minority (%)	19.5	26.1
Undergraduate GPA	Average	2.97	3.12
Undergraduate debt	Graduating with debt (%)	52.8	60.0
	Average debt ($)	10,583	10,534
Parental education	High school or less	23.5	23.5
	Post-secondary but less than Bachelor's degree	17.3	29.3
	Bachelor's degree	29.8	19.1 !
	Advanced degree	29.5	28.1

! Interpret data with caution because the standard error represents more than 30 percent of the estimate.

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Characteristics of engineering bachelor's degree recipients, B&B Cohort 1 (continued)

		Years since graduation					
		1 year		4 year		10 year	
		Male	Female	Male	Female	Male	Female
Marital status	Married (%)	28.6	29.3	47.4	51.3	75.0	77.7
*Parental status	Has children (%)	11.9	7.0 !	19.9	17.0 !	53.5	65.3
Spousal employment	Employed (%)	89.6	‡	80.4	87.0	66.7	96.5
Spousal income	Average ($)	16,470	‡	26,822	31,477	28,274	66,655
Graduate degree	Has graduate degree (%)	3.6	2.1	17.5	20.2	26.9	27.7
	Has graduate degree in engineering, math, or computer science (%)	2.9	1.1 !!	14.4	16.7 !	15.3	18.0 !
Enrolled in school	Enrolled in school (%)	20.8	23.7	18.7	15.2 !	7.4	8.1 !!

! Interpret data with caution because the standard error represents more than 30 percent of the estimate.
!! Interpret data with caution because the standard error represents more than 50 percent of the estimate.
*For 10 year survey, figure includes only dependent children under the age of 18.
‡ Reporting standards not met.

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Interpreting regression results

- If "P" is the probability that a graduate is in the labor force (or working in the field of their major), then the odds of the graduate being in the labor force are P/(1-P)
  - E.g., if P = .75, then the odds are .75/.25 = 3
- Results from these logistic regression models illustrate how a change in a predictor variable changes the odds of a graduate being in the labor force (or working in the field of their major), holding constant all other predictors in the model

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Key models examined

Outcome	Study population	Models								
		1 year after graduation			4 years after graduation			10 years after graduation		
		Males	Females	Males & Females	Males	Females	Males & Females	Males	Females	Males & Females
Participation	Engineering graduates	Too few males not in LF	Too few female grads	Too few males not in LF	Too few males not in LF	Too few female grads	Too few males not in LF	Too few males not in LF	Too few female grads	Too few males not in LF
	Engineering & other career-oriented graduates	■	■	■	■	■	■	■	■	■
Retention	Engineering graduates	■	Too few female grads	■	■	Too few female grads	■	■	Too few female grads	■
	Engineering & other career-oriented graduates	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

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Participation model: Female engineering and other career-oriented graduates, Cohort 1

A blank cell indicates that the predictor was not included in the model. A cell highlighted green indicates that the variable is statistically significant at the 10% level. Only a subset of predictors included in the models are shown in the table.

	Years since graduation		
	1 year	4 years	10 years
	Percentage difference in odds ratio	Percentage difference in odds ratio	Percentage difference in odds ratio
Age when received bachelor's degree	3%	4%	-1%
White, non-Hispanic (vs. minority)	148%	12%	-34%
Has children (vs. no children)	-67%	-73%	-74%
Married (vs. not married)	-19%		
Married with spouse not employed (vs. not married)		-40%	-36%
Spouse income from work < $50,000 (vs. not married)		18%	-30%
Spouse income from work ≥ $50,000 (vs. not married)		-50%	
Spouse income from work $50,000-$100,000 (vs. not married)			-83%
Spouse income from work ≥ $100,000 (vs. not married)			-93%
Incurred debt in undergrad (vs. no debt)	107%	51%	-10%
Undergraduate GPA is 3.0-3.5 (vs. <3.0 GPA)	-21%	66%	9%
Undergraduate GPA is 3.5 or higher (vs. <3.0 GPA)	-19%	7%	12%
Business and management (vs. engineering)	154%	73%	-26%
Education (vs. engineering)	60%	37%	-74%
Health professions (vs. engineering)	47%	82%	-34%
Enrolled (vs. not enrolled)	-89%	-61%	90%
Has graduate degree (vs. no graduate degree)	-44%	-8%	155%

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Participation model: Key findings

- Women engineering graduates are generally no more or less likely to be participating in the labor force than graduates in other career-oriented majors
- Women graduates in engineering and other career-oriented majors:
  - Are less likely to be in the labor force if they have children
  - Are less likely to be in the labor force four years and ten years after graduation if their spouse's income is relatively high

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Participation model: Key findings (continued)

- Women graduates in engineering and other career-oriented majors: (continued)
  - Are more likely to be in the labor force one year and four years after graduation if they incurred debt in college
  - Are less likely to be in the labor force one year and four years after graduation if they are enrolled in school, but are more likely ten years after graduation
  - Are more likely to be in the labor force ten years after graduation if they have a graduate degree

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Retention model: Employed male and female engineering graduates, Cohort 1

A blank cell indicates that the predictor was not included in the model. A cell highlighted green indicates that the variable is statistically significant at the 10% level. Only a subset of predictors included in the models are shown in the table.

	Years since graduation		
	1 year	4 years	10 years
	Percentage difference in odds ratio	Percentage difference in odds ratio	Percentage difference in odds ratio
Age when received bachelor's degree	1%	-1%	-3%
White, non-Hispanic (vs. minority)	87%	12%	26%
Has children (vs. no children)	-8%	-13%	19%
Married with spouse employed (vs. unmarried)		43%	17%
Married with spouse not employed (vs. unmarried)		16%	30%
Incurred debt in undergrad (vs. no debt)	10%	-6%	-4%
Undergrad GPA is 3.0-3.5 (vs. < 3.0 GPA)	30%	47%	47%
Undergrad GPA is 3.5 or higher (vs. < 3.0 GPA)	128%	35%	76%
Enrolled (vs. not enrolled)	-64%		-31%
Graduate degree in engr/math/cs (vs. no graduate degree)			-12%
Graduate degree in other FOS (vs. no graduate degree)			-81%
Female (vs. male)	88%	93%	47%

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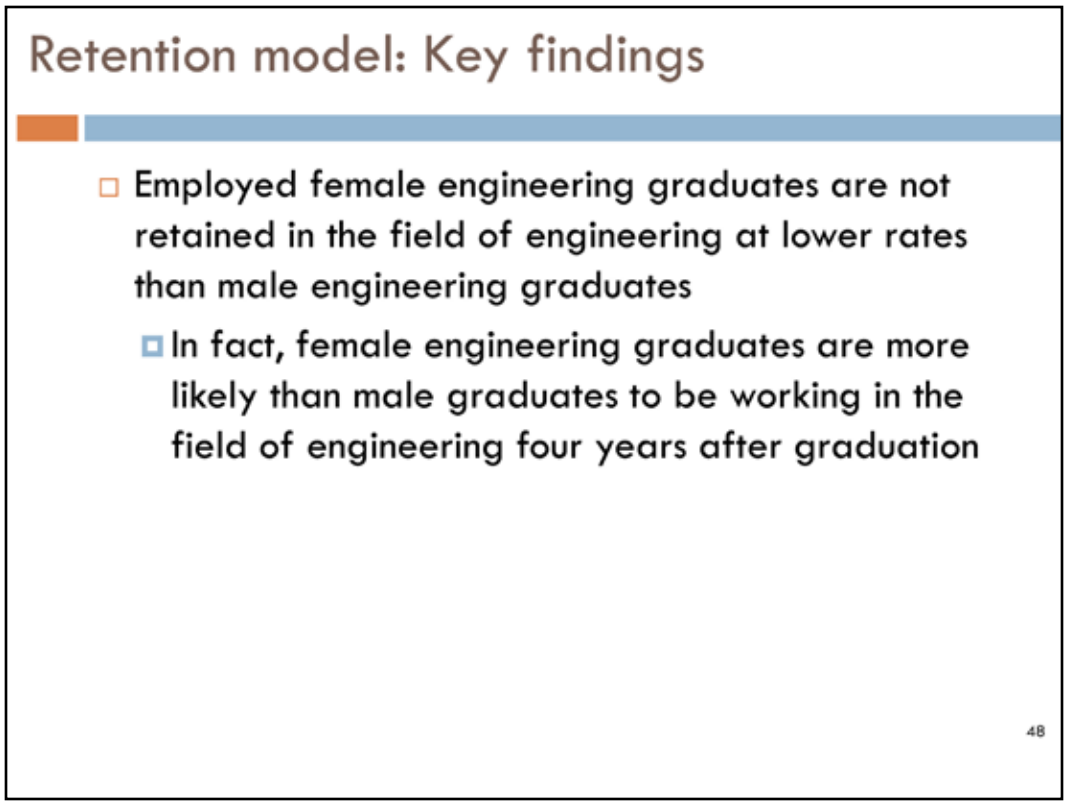

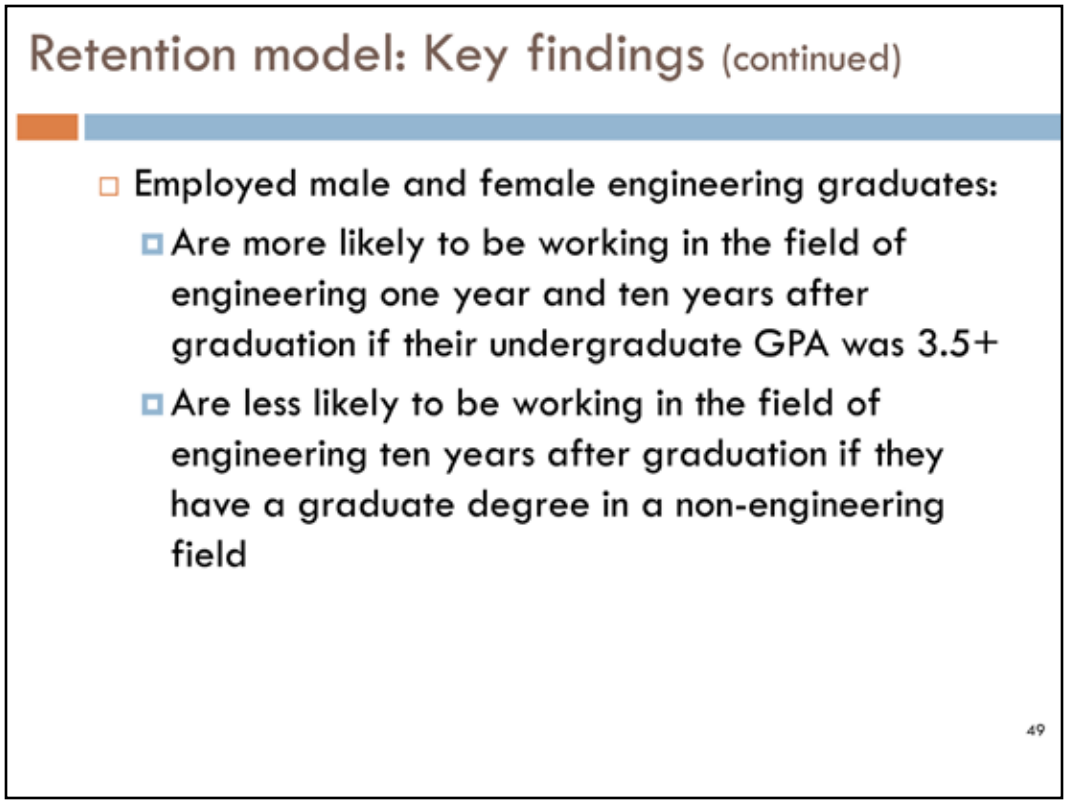

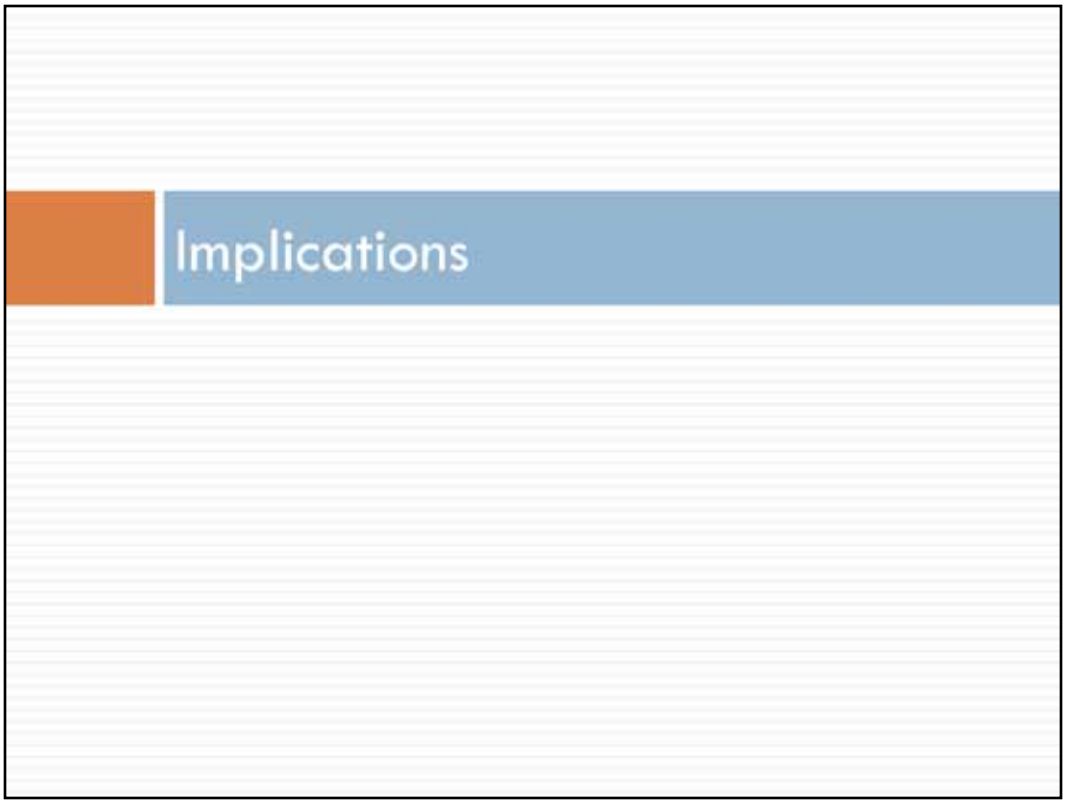

Implications

- It's not about participation in the labor force
  - Female engineering graduates in all three cohorts are participating in the labor force at high rates
- Retention in engineering appears to be an issue for both male and female graduates
  - Retention for male and female Cohort 1 graduates fell to around 50% by ten years after graduation
  - Male and female Cohort 3 graduates say that the primary reason for working outside engineering is a lack of jobs in their field

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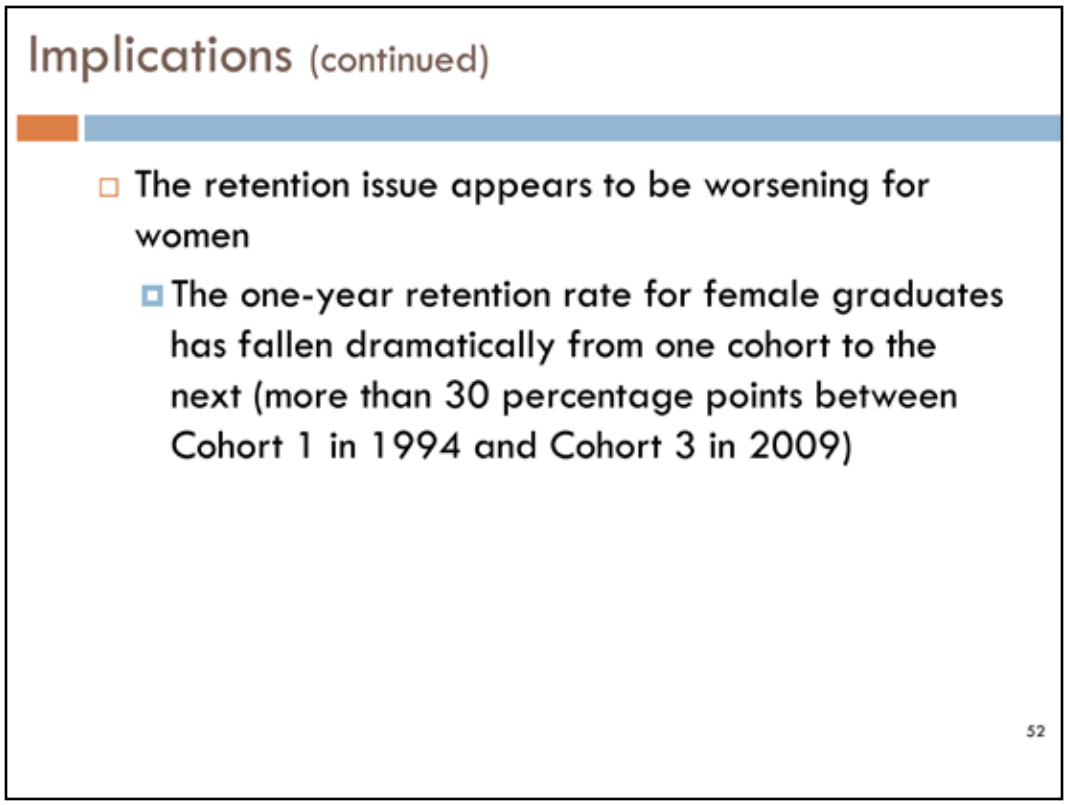
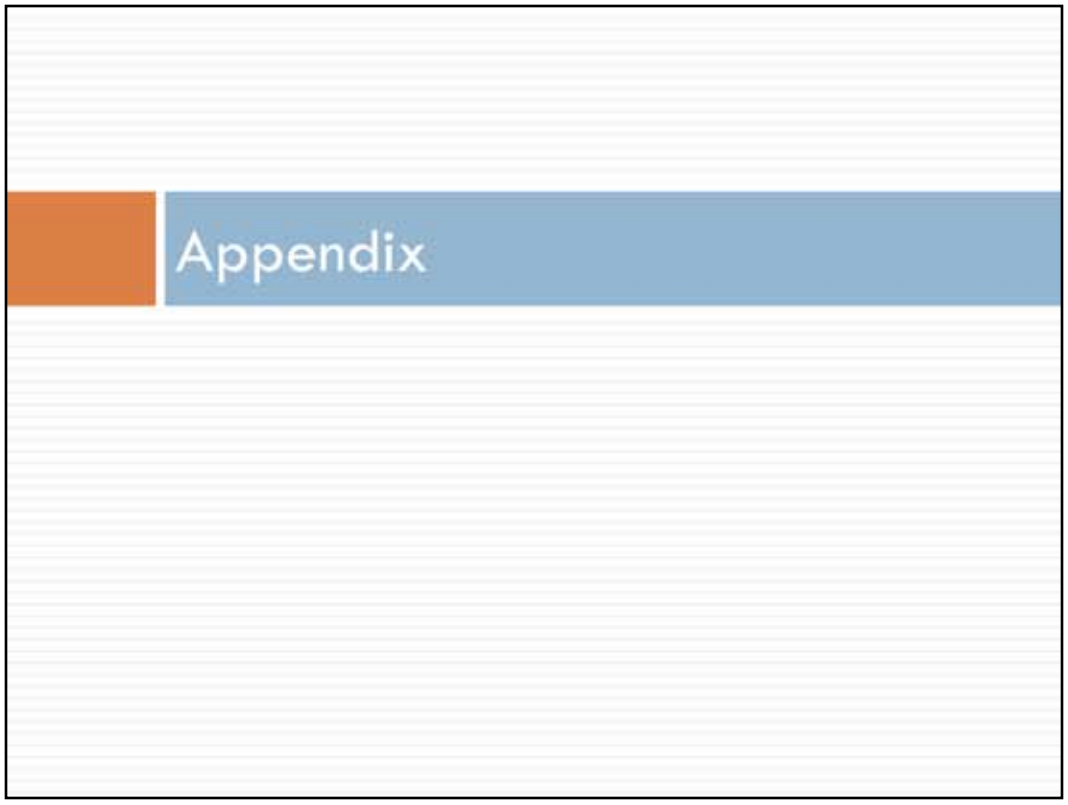
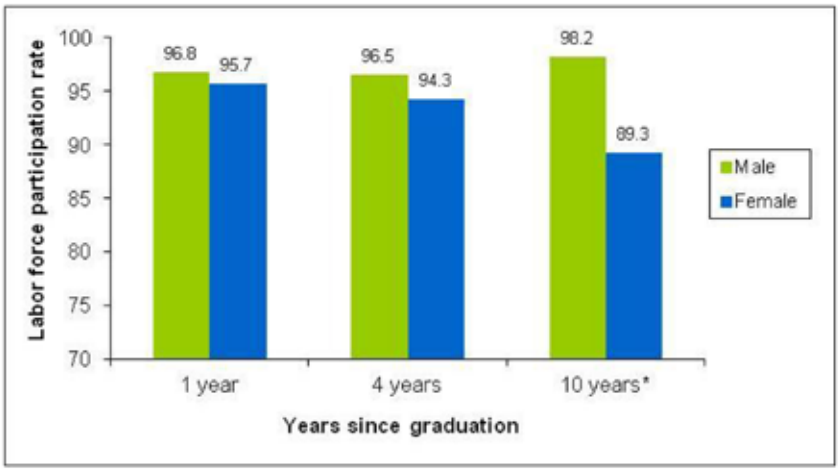




LFPR by gender for business/management bachelor's degree recipients, B&B Cohort 1



*Difference is statistically significant at the 5% level.

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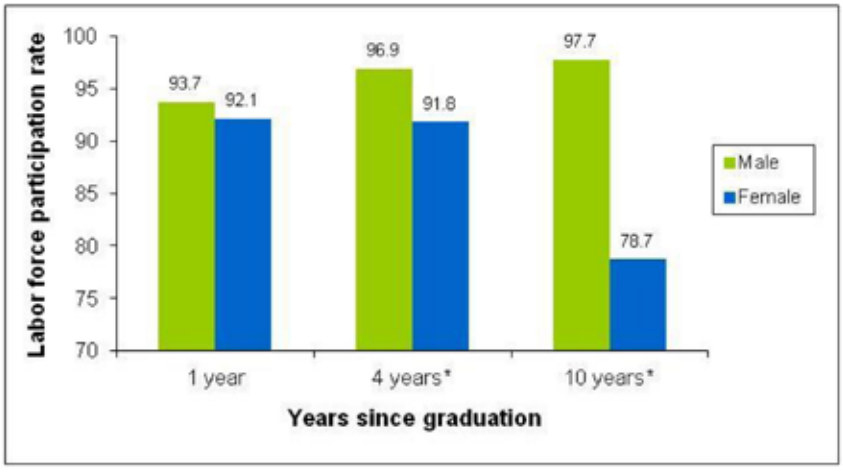
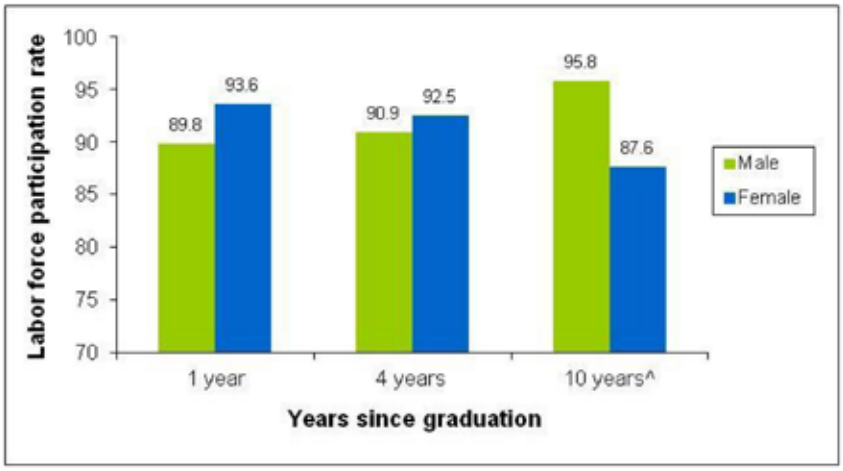
LFPR by gender for education bachelor's degree recipients, B&B Cohort 1



*Difference is statistically significant at the 5% level.

55

LFPR by gender for health-related bachelor's degree recipients, B&B Cohort 1



^Difference is statistically significant at the 10% level.

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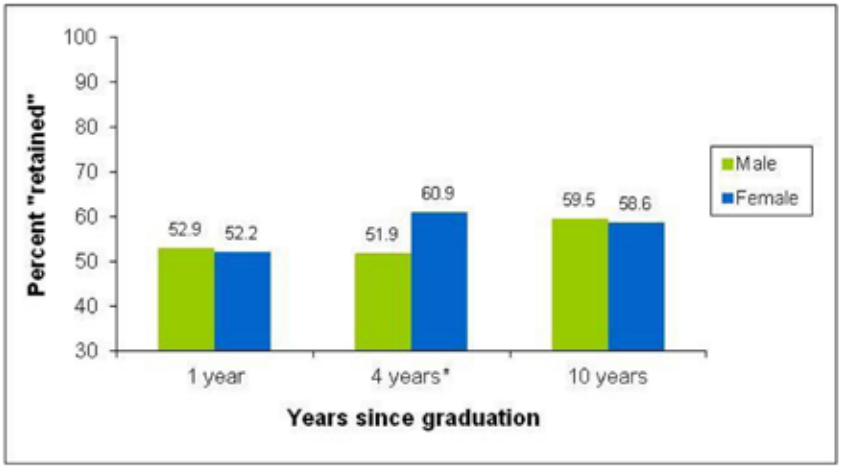
Employed bus/mgmt bachelor's degree recipients in a bus/mgmt occupation, B&B cohort 1



*Difference between the male and female figures is statistically significant at the 5% level.

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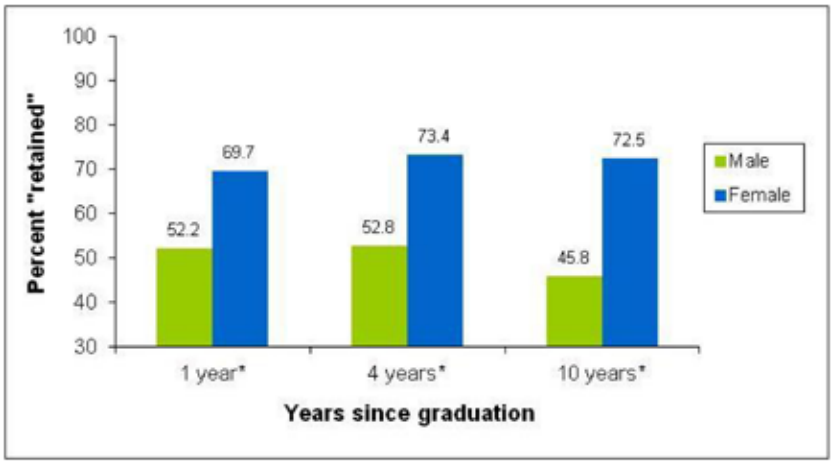
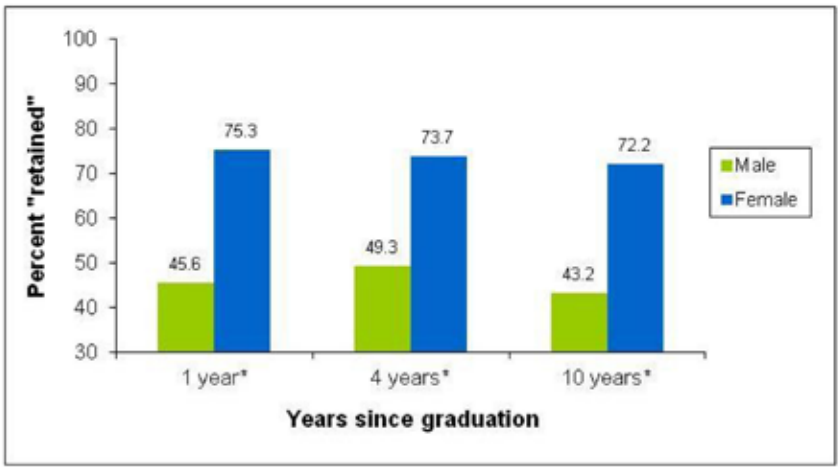
Employed education bachelor's degree recipients in an education occupation, B&B cohort 1



*Difference between the male and female figures is statistically significant at the 5% level.

58

Employed health-related bachelor's degree recipients in a health occupation, B&B cohort 1



*Difference between the male and female figures is statistically significant at the 5% level.

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