

Career Outcomes of Science and Engineering Graduates

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Abstract

In the last decade research on the undergraduate experiences of women and minorities in science, technology, engineering and mathematics (STEM) has expanded dramatically. Despite this expansion, little is known about post-baccalaureate career outcomes. Student support programs such as Women in Engineering and Women in Science and Engineering (WIE/WISE) and Minority Science and Engineering Program (MSEP), as well as student professional societies and Career Services provide assistance to undergraduates and may facilitate positive career outcomes. To fill the gap in knowledge about career outcomes of STEM graduates, the Center for Workforce Development at the University of Washington has conducted a series of surveys of graduating science and engineering majors (N=826).

Results suggest that there are career outcome differences between Career Service users and non-users, student professional society participants and non-participants, and WIE/WISE participants and non-participants. Career Service users, student society participants and WIE/WISE participants report a greater average number of interviews on-campus than non-participants from each group. WIE/WISE participants report higher levels of confidence in professional skills such as managing people and business ethics than non-WIE/WISE participants; Career Service users report greater confidence about working on a multi-disciplinary team and managing people; and student professional society participants report greater confidence in their technical (or other relevant major) skills. Students who participate in professional societies such as the Society of Women Engineers earn higher average starting salaries than those who do not participate in student professional societies. WIE/WISE participants report greater concerns that childcare, parental leave, and part-time work availability will affect their future educational and/or professional plans.

Introduction

Concerns about the lack of women in the science, technology, engineering and mathematics (STEM) workforce have reached a crises level in the aftermath of 9/11. Projected shortages of workers in STEM, international competition for scientists and engineers, and U.S. entry difficulties faced by foreign workers emphasize that the nation cannot afford to exclude half of its population from careers in STEM. Every citizen with an interest in STEM should be encouraged and supported to pursue that interest to the fullest, regardless of race or gender. The lack of women in STEM careers fuels supply-side arguments for increasing the number of women studying STEM in the nation's colleges and universities. The supply-side argument is certainly valid considering that in 2001 women earned about 57% of all baccalaureates degrees

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granted and only 20% of those in engineering, 32% of those in mathematics, and 42% of those in physical sciences (National Science Foundation, 2004). The emergence of Women in Engineering and Women in Science and Engineering (WIE/WISE) programs was a direct response to concerns about the small number of women studying STEM at the college level.

As WIE/WISE programs have matured and research on women in STEM has developed, it has become clear that increasing the number of women earning STEM degrees is not enough (Barber, 1995; Etzkowitz, Kemelgor, & Uzzi, 2000; Fox, 1998). For women, attrition from STEM continues to occur after a baccalaureate degree is earned. Women who earn STEM degrees are more likely than their male counterparts to choose to work outside STEM, especially in their early professional lives or the years right after college (Ellis & Babco, 2004; Long, 2001; National Research Council, 1994; Preston, 2004). In light of this talent loss after graduation, WIE/WISE and other student service programs in science and engineering are being called upon to work on both the supply-side issue and career preparation strategies to promote persistence in STEM beyond the baccalaureate.

In order to better understand the relationship between student services and career outcomes for students who participate in such programs, the University of Washington conducted a research study involving STEM baccalaureate degree recipients at the point of exit from college. Primary research questions for the study included: 1) Are there gender differences in career planning at the point of exit from STEM baccalaureate programs; and 2) Are the factors that influence persistence in STEM impacted by participation in undergraduate student services programs?

Persistence factors examined in the study include self-efficacy, work/life expectations, equitable pay and career advising. Schaefer *et al* (Schaefer, Epperson, & Nauta, 1997) found that academic ability, self-efficacy, support-barriers and interest congruence contribute greatly to persistence in engineering, for both men and women. In her study, Preston (2004) found that discontent with income and opportunity, lack of career guidance, family concerns and lack of interest in science contributed to attrition from STEM careers. Few studies, however, have sought to explore how these factors are affected by participation in undergraduate student services programs. The Women's Experiences in College Engineering (WECE) project examined the relationship between persistence and participation in student services, but the sample did not include men and was limited to students majoring in engineering (Goodman Research Group Inc., 2002).

Gender differences in self-efficacy are a significant factor in STEM entry and persistence. First theorized by Bandura (1977), self-efficacy has been defined as the confidence that a person has in his/her ability to successfully perform a specific career-related task or behavior (Betz, 2004). Numerous studies have shown that women exhibit lower levels of confidence in their math and science abilities which lead them to opt out of STEM majors in college (Brainard & Carlin, 1998; Goodman Research Group Inc., 2002; Sax, 2001; Seymour & Hewitt, 1994). Negative self-perceptions about their ability to perform on the tasks related to being a scientist and/or engineer have also been attributed to decisions to leave STEM careers after earning a STEM bachelor's degree (Davis, Ginorio, Hollenshead, Lazarus, & Rayman, 1996; Long, 2001; Preston, 2004).

It has been proposed that the time commitment required for STEM careers is incompatible with women's family responsibilities (Etzkowitz et al., 2000; Long, 2001; National Research Council, 1994). Preston (2004) argues that expectations about how to balance work and family influence women's career decision-making to a greater extent than men. She found that while 21.4% of the women in her study cited family issues as a reason for leaving science, only 4.5% of the men did so.

Gender differences in pay were also evident in Preston's study of exit from STEM careers (Preston, 2004). Interestingly, in her study more men than women cited better pay in non-STEM positions as their primary reason for leaving STEM careers (68% of the men compared to 33% of the women). A recent report on the STEM workforce indicates that on average the ratio of women's pay in STEM compared to men is 0.787 (Ellis & Babco, 2004). Gender differences in starting pay as undergraduates enter the STEM workforce adds up over time and can contribute greatly to decisions to leave STEM for other fields.

Expectations about job prospects and the actual work of scientists and engineers can be greatly influenced by career advising during the undergraduate years. Research suggests that better career advising can help students avoid bad matches due to uninformed expectations and incongruence between student personalities and the demands of scientific careers (Preston, 2004; Schaefer et al., 1997). Career advising during the job search and interview process can also help students acquire positions that fit their unique interests and situations.

Research studies have consistently shown that the four factors discussed above (self-efficacy, work/life expectations, equitable pay, and career advising) combine to explain much of the gender variance in STEM persistence. Given their important influence on persistence, it is imperative to know more about how these factors are related to participation in undergraduate student services programs.

Methodology

The University of Washington (UW) developed the Undergraduate Retention and Career Outcomes Exit Survey as part of a National Science Foundation grant to the Center for Workforce Development (CWD) to study undergraduate experiences and their effect on career outcomes for STEM majors. The survey is web-based on a secure server maintained by the UW Office of Educational Assessment (OEA). The survey includes forty-seven questions about educational climate, undergraduate outcomes, and post-graduate outcomes; including labor market and graduate education plans. Students were sent emails requesting their participation in the survey, and a link to the survey was included in the emails.

The sample includes STEM majors who applied to graduate in the target quarter, including all women, all minority men, and an equal number (or whoever is leftover) of Caucasian men as the number of all women. The survey sample varies from approximately 500 to 1200, depending on the quarter being surveyed (Spring and Winter quarters are the largest).

The survey has been administered at the University of Washington three times since CWD received the grant; August 2003, November 2003 and May 2004. Response rates for the first

three administrations of the survey are 21.8%, 36.3% and 35.9% respectively. A total of 826 students have participated in the survey resulting in an overall 30.7% response rate. Response rates by race and gender are shown below in Table 1.

Table 1. Response Rates by Gender and Race

	Sample		Respondents	
	Frequency	Percentage	Frequency	Percentage
Male	1665	61.9	448	54.8
Female*	1026	38.1	369	45.2
African American	39	1.4	6	0.7
Asian American	723	26.9	218	26.4
Pacific Islander	16	0.6	3	0.4
Hispanic/Latino**	0	0	21	2.5
Native American	18	0.7	1	.1
White American	1481	55.0	523	63.3
Unknown / Other	414	15.4	54	6.5
Total	2691		826	

* Nine students did not designate a gender. They constitute 1.1% of the respondents by gender. Also, students who designated Asian or Asian Indian ethnicity were combined into Asian American

** Due to coding inconsistency, Hispanic origin was not designated in the original sample

Variables

Student respondents were coded into three different student service groups on the basis of their answers to questions regarding their satisfaction with services rendered by the groups. A person is coded as a non-WIE/WISE participant if they marked “not applicable” on all 6 questions related to WIE/WISE programs. If they answered any one of the six questions with a valid response, they are coded as a WIE/WISE participant. Similarly with career services, a person is coded as a career services user if they indicated their satisfaction with either career services in their department or career services at the university. If a person marked “not applicable” to both of the career services questions, they are a career services non-user. Seven questions were used for coding the professional society participants. If a person marked “not applicable” on all seven societies, they are a professional society non-user. If they answered at least one of the questions about satisfaction with services provided by the seven societies, they are considered a professional society user. The seven student professional societies are: Science and Engineering Fraternity/Sorority, Science and Engineering Residential Living Center, Society of Women Engineers, National Society of Black Engineers, Society of Hispanic Professional Engineers, American Indian Science and Engineering Society, and other discipline specific professional society.

It is of note that the three student service groups examined here are not completely independent of one another. WIE/WISE users are more likely to use career services than non-WIE/WISE. WIE/WISE users are also more likely to be part of a professional society than non-WIE/WISE users. Professional society users are more likely to use career services than non-professional society users. The overlap between services helps to explain why some of the results seen below for each service provider are similar on some issues.

The factors affecting persistence in STEM careers are measured in the following ways. There were thirteen questions on the survey that asked about confidence in different areas. The question was worded, “In thinking about your post-baccalaureate goals, how confident are you that your undergraduate experience prepared you in the following areas?” The areas found to be significant and discussed below in the results section are: managing people, business ethics, ability to work on a multi-disciplinary team, and engineering (or other relevant major) skills. Students were also asked how many interviews they scheduled through on-campus services. For those who had already accepted jobs, they were asked the annual salary range for the job offer they accepted and were able to choose the appropriate category from a list of salaries in \$9,999 increments (eg. \$31,000 to \$40,999). The last four categories of salary were collapsed due to low frequencies into a new \$71,000 to \$100,000+ category. Answers to five questions about work and family balance were combined into a factor score using factor analysis. The question asked “To what extent do the following concerns affect your educational and/or professional plans: access to child care, generosity of parental (maternity/paternity) leave benefits, flexibility in work schedule to care for family needs, availability of telecommuting, and availability of part-time work”.

Results

Many different analyses were done on the data from the Exit surveys, but due to limited space, only the results from WIE/WISE, career services, and student professional society analyses are reported here with regard to a select set of variables that were hypothesized to affect career outcomes.

There are two questions in the survey that particularly speak to the issue of career outcomes and persistence in a STEM field. The first question asks what students are planning to do immediately after graduation. As reported in Table 2, the majority of students report that they are planning for full-time employment. Almost a third of students report that they are planning to attend graduate school, and 20% indicate that they will work for a while and then return to attend graduate school. There are significant differences between men and women on this question ($\chi^2 = 10.448$, $df=4$, $p = .034$). The adjusted residuals indicate that the categories of “full-time employment”, “part-time employment” and “other” are where the expected frequencies are very different from the observed frequencies for men and women. More men than women are expecting to be employed full-time, while more women than men are expecting to be employed part-time.

Table 2. Percentages reported for student plans immediately after graduation

Plans after Graduation	All	Male	Female	WIE/WISE	Non-WIE/WISE	Career	Non-Career	Society	Non-Society
Full Time Employment	47.1	50.3	42.8	50.3	45.3	51.5	32.4	48.1	43.4
Part Time Employment	1.7	.9	2.8	.7	2.1	1.8	1.9	1.7	1.3
Graduate School	27.5	27.0	28.7	20.3	29.1	21.0	45.1	27.1	24.5
Employment, then Grad. School	17.3	17.0	17.4	18.2	17.9	19.7	12.7	15.5	25.3
Other	6.4	4.8	8.3	10.5	5.7	6.0	8.0	7.7	5.4

* Totals differ for each column, so results are reported in percentages.

Women are more likely to say that they will be doing something “other” than employment or graduate school. Of the write-in answers to “other” there were 11 people who indicated they would be continuing their education, but in medical school, dental school, or pharmacy school rather than traditional graduate school. Four students indicated that they would be doing volunteer work, such as for the Peace Corps, and seven students indicated some type of employment. There were no significant differences between women who participated in WIE/WISE programs and those that did not.

To measure persistence in STEM, the following question was asked, “Will you be working in a field similar or related to the major in which you received your bachelor’s degree?” The percentages by group are reported in Table 3. For those students who answered the question, they seem fairly equally split between continuing in a STEM field or doing something different from their major. The only significant difference in Table 3 was for WIE/WISE and non-WIE/WISE students ($\chi^2=5.686$, $df=1$, $p = .017$). Contrary to the researcher’s expectations, students who participated in WIE/WISE services were less likely to say they would be working in a field related to their major. A possible post-hoc explanation would be that by virtue of being involved with WIE/WISE services, students become more aware of the difficulties of working in a STEM field, and this awareness ultimately is a factor in their decision to pursue work in a STEM related field. Also, WIE/WISE participants have greater concerns about work/family balance, and prior research indicates that these types of concerns affect persistence after graduation. It is also possible that WIE/WISE participants indicated that they would not be in a STEM field even though they will be doing technical work, but in an industry considered non-technical. However, the survey does not ask detailed information about their career, and so it is impossible to tell if this is part of the effect seen here.

Table 3. Percentages working in a field similar or related to their undergrad major.

Working in a Related Field	All	Male	Female	WIE/WISE	Non-WIE/WISE	Career	Non-Career	Society	Non-Society
No	49.6	48.2	50.9	61.5	47.7	49.9	50.9	53.9	61.1
Yes	50.4	51.8	49.1	38.5	52.3	50.1	49.1	46.1	38.9

WIE/WISE / Non-WIE/WISE Differences

WIE/WISE participants were found to have greater confidence than non-WIE/WISE participants on two confidence questions. They have greater confidence in their ability to manage people ($t = -2.968$, $df = 680$, $p = .003$) and greater confidence in their business ethics ($t = -2.206$, $df = 642$, $p = .028$). Respondents who took part in WIE/WISE services also had more interviews on campus ($t = -2.342$, $df = 180.59$, $p = .02$) reporting an average of 1.46 compared to .93 for non-WIE/WISE respondents. They were also more likely to be satisfied with career services in their department ($t = -2.677$, $df = 391$, $p = .008$) and at the university ($t = -2.238$, $df = 478$, $p = .026$) than respondents who had never used WIE/WISE services. Finally, WIE/WISE respondents were more concerned about balancing work and family than non-WIE/WISE respondents. WIE/WISE participants responded more often in the affirmative when asked whether things such as child care, parental leave benefits, flexible work schedules and the availability of part-time work would affect their future educational and professional plans ($t = -3.069$, $df = 664$, $p = .002$).

Career Service Differences

As expected, those who utilized career services on campus had more campus interviews (1.33 vs. 0.35), on average, than those who did not take part in any services offered by the career centers on campus ($t = -7.026$, $df = 579.9$, $p = .000$). Career services participants indicated higher levels of confidence about working on a multi-disciplinary team ($t = -2.232$, $df = 759$, $p = .026$) and managing people ($t = -2.106$, $df = 719$, $p = .044$) than survey respondents who had never used career services. Those who used career services also indicated that work/family balance concerns might affect their future plans to a greater degree than those who did not use career services ($t = -3.259$, $df = 700$, $p = .001$).

Student Professional Society Differences

Students who participated in at least one of seven different student professional societies indicated that they engaged in more on-campus interviews than students who were not involved in these types of societies ($t = -3.337$, $df = 219$, $p = .001$). Student professional society participants averaged 1.68 interviews compared to .87 interviews for students not involved in professional societies. Students involved with professional societies also have higher confidence levels than non-involved students regarding their engineering skills ($t = -3.268$, $df = 409.3$, $p = .001$), working on a team ($t = -2.240$, $df = 397.7$, $p = .026$), and business ethics ($t = -2.340$, $df = 492$, $p = .020$). In a cross tabulation analysis of salary categories and participation in a student professional society, it was found that reported salary and participation in student professional societies are not independent of one another ($\chi^2 = 38.678$, $df = 6$, $p = .000$). Analysis of the adjusted residuals indicates that student professional society members are less likely to report salaries in the \$21,000 to \$30,999 and \$31,000 to \$40,999 range, but they are more likely to report salaries in the \$41,000 to \$50,999 and \$71,000 and higher range.

Discussion

Four factors -- self-efficacy, work/family balance, earnings disparities, and career advising -- have been found in prior studies to be related to gender differences in STEM persistence. This study found that each of those four factors is related to participation in certain student services programs. Students involved in the three student programs discussed in this paper have been found to have higher self-efficacy on issues such as working on a multi-disciplinary team, managing people, and business ethics than students who were not involved with student services programs. While WIE/WISE students are the only ones significantly less likely to be working in a field related to their major, they do have higher confidence levels on career-related skills that are not taught in the undergraduate curriculum. More work is needed to help WIE/WISE students increase their confidence on skills those that are taught in the curriculum such as designing experiments, problem-solving, or using the relevant equipment/software.

Work/Family concerns have been linked to decreases in persistence in the research literature, and it should be worrying that WIE/WISE participants and career services participants experience greater anxiety about these issues than non-participants. It may be that students gain more knowledge about the culture of science and its incompatibility with family life through WIE/WISE programs and career services. This is definitely an area ripe for further exploration.

There is a pay disparity between students who are involved in professional societies and those who are not. Even though professional society participants do not differ from non-participants in their likelihood of staying in a STEM field after graduation, these pay differences should be examined to understand what is causing the difference and to help other students gain higher starting salaries. Perhaps student organizations could offer salary/compensation package negotiation seminars to help students bargain during the job offer process.

Respondents who received career advising reported higher than average on-campus interviews. More interviews enable students to better reflect on job prospects and the match with their own skills and interests. Such opportunities also allow students to learn more about differences between employers and compare workplace cultures, thus limiting incongruence in their early careers.

In our sample, almost half of the respondents (regardless of gender) report that they are not working in a field related to their undergraduate major. The difference between WIE/WISE and non-WIE/WISE participants is unexpected. This represents a serious loss of science and engineering talent at the point of graduation. More research must be done to figure out what is causing the difference and what should be done to mitigate it. Also, more research should be done to determine the actual careers the students are in. It is possible that WIE/WISE students are not actually leaving a field related to their major, but that the question asked in the survey does not allow enough detail to determine retention sufficiently. For example, a woman may take a position with a bank doing computer program writing. She may consider this position to not be in her field because she is not working at an engineering firm. But she is still using her degree to do technical work, and future research interviews with participants could probe more deeply to find out this information. Programs may need to re-think their focus in order to help students see STEM careers as exciting and plausible, and to assist students in their transitions from undergraduate programs to the STEM workforce.

The findings above raise interesting questions for WIE/WISE programs. WIE/WISE programs generally are focused on helping women cope with the culture and difficulties of working in a STEM field. This focus may be part of the reason fewer WIE/WISE participants go into STEM careers. Perhaps students are being given too much negative information in the effort to help them deal with their programs and future careers, and it is scaring them away. Student programs need to strike a balance between giving students realistic expectations about their careers in STEM and showing the fields as positive and a good fit for everyone. Student programs should seek to balance their programming by including more positive discussions of the benefits of a STEM career.

Limitations of the Study and Future Research

The findings from this study suggest that student services programs such as WIE/WISE programs can profoundly affect career planning and decision-making for STEM undergraduates, and ultimately their persistence in STEM careers. Further research needs to be conducted on the relationship between factors which influence persistence and the services provided to students through extracurricular activity. Such research can direct program activities and provide the means for assessing how well such programs address the demand for more diversity in the

STEM workforce. The reader should also take caution and consider that participants and non-participants might be different in other ways that might affect their participation levels, that those differences are actually what are causing the relationships seen here. The amount of overlap between participants in WIE/WISE programs, student societies and career services needs to be explored further. Findings from this study imply that by collaborating closely, these types of services and programs can better serve the STEM undergraduate student population.

Limitations for this particular study include its generalizability to other campuses and programs, the timing of the survey administration and the small number of responses from underrepresented students. The funding for this research study will soon be exhausted, so no further survey administrations will take place at the University of Washington after May 2005. The authors are currently seeking funding to follow up with study participants. The Exit survey was only administered at a major urban research institution and the findings may vary at different institutional types. Another limitation of the study might be the point at which students completed the survey. It was administered two months prior to graduation, a time of great transition for graduating seniors. It is possible that students would give very different answers after actually joining the STEM workforce. Finally, it is impossible to draw any conclusions about women of color based on this survey due to the paucity of responses from underrepresented students.

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