AC 2010-99: THE EFFECT OF GENDER ON SUPPORT AND SELF-EFFICACY IN UNDERGRADUATE ENGINEERING PROGRAMS

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The Effect of Gender on Support and Self-Efficacy in Undergraduate Engineering Programs

Abstract

This study is part of a larger research project, supported by a National Science Foundation Research on Gender in Science and Engineering program grant, designed to determine the effect of self-efficacy and other factors on the retention of women in undergraduate engineering programs. These data represent the first wave of the study completed in the 2008-2009 academic year of sophomores in the colleges of engineering from four participating universities: Northeastern University, Rochester Institute of Technology, Virginia Polytechnic Institute, and the University of Wyoming. The study examines the effect of gender on a range of contextual supports to explain three dimensions of self-efficacy: work, career, and academic within undergraduate engineering. Contextual support is defined as the institutional support provided to students through a number of mechanisms, such as financial aid, mentorship, and participation in living/learning communities.

The analyses revealed some significant differences by gender. With the exception of academic self-efficacy, which is significantly higher among males, every other significant difference favors the female population. As freshmen, women are not as confident as men in their likelihood of achieving success in their engineering major. However, they were found to have higher career self-efficacy, in contrast to what has been reported in the literature, and benefit far more from mentorship. They also exceed the scores of their male counterparts in five support dimensions: they report receiving more support from professional clubs and associations; they are more involved in campus life; they take more advantage of living/learning communities; and they report that they not only receive more support from their friends but that their friends really matter to them.

Introduction

Supported by a National Science Foundation grant (NSF #0827490), this study, using the first wave of data, was designed to determine the effect of self-efficacy and other factors on the retention of women in undergraduate engineering programs. The data pool represents all sophomores in the 2008-2009 academic year in the colleges of engineering at four universities. Students completed a 96-item survey, mostly done in class and in written form. The total number of respondents was 990 students, of which 216 were female. The combined response rate was 44%.

The overarching model for the study proposes that self-efficacy is based on the impact of students' demographic characteristics, the effect of work experience - in particular cooperative education, and the contextual support provided by the university. In this paper, we report on the effect of gender on self-efficacy through the impact of contextual support.

Self-efficacy was assessed through three measures – work, career, and academic – signifying the confidence that students have in succeeding within the workplace, within their chosen engineering career, or in the classroom, respectively. Contextual support was measured as the

support provided to students through a number of mechanisms, in particular, financial aid, mentors, advisors, family, friends, teachers, profession, campus life, and living/learning communities.

This paper will present the survey methodology, the results to date regarding the effect of gender on self-efficacy through the impact of contextual support, and the future plans of this ongoing study of pathways to retention among undergraduate women in engineering.

Background

The literatures from the fields of women in engineering and self-efficacy have established the importance of efficacy in the persistence and satisfaction of young women pursuing engineering careers. Women continue to be underrepresented in engineering, earning only 19.3% of bachelor's degrees in engineering in 2007[1] (having peaked at 20.6% in 2000[2]) and holding only 11% of engineering positions.[3] Although they are as academically prepared and as academically successful as men, women lag behind men in academic satisfaction, academy self-efficacy, and self-esteem.[4] Traditional assumptions about career options for women have been reinforced in society and have projected stereotypes that discourage talented women from continuing in engineering careers. This is evidenced by research that found a dramatic drop in women's self-efficacy throughout the course of engineering programs. In an in-depth study of students who switched out of science, math, and engineering majors, 77.9% of women cited discouragement and loss of self-efficacy as a factor in switching.[5]

Hackett and Betz[6] were the first to use self-efficacy to explain the career development of women, especially in male-dominated career domains. They suggested that societal factors have created gender differences in gaining access to primary sources of self-efficacy information in male-dominated career fields. In turn, lower self-efficacy beliefs about these careers have resulted in fewer women entering these fields. Since then, empirical studies supported these conclusions about efficacy and gender, finding that college-aged women's self-efficacy within male-dominated fields was significantly lower than their self-efficacy in traditionally female occupations.[7, 8] The one exception to this finding is when women declare an engineering major upon entering school; in this instance their career self-efficacy becomes equivalent to that of their male counterparts.[9]

If women face discouragement and lower or equivalent efficacy than men in their undergraduate studies, it stands to reason that universities can counteract this trend by providing both academic and non-academic forms of support. Tinto and others have shown that the provision of support in the form of counseling and mentoring can positively influence student retention.[10, 11] An explanation for the salutary impact of social support on retention is provided by studies demonstrating the effect of contextual support on both academic achievement and academic self-efficacy.[12, 13, 14]

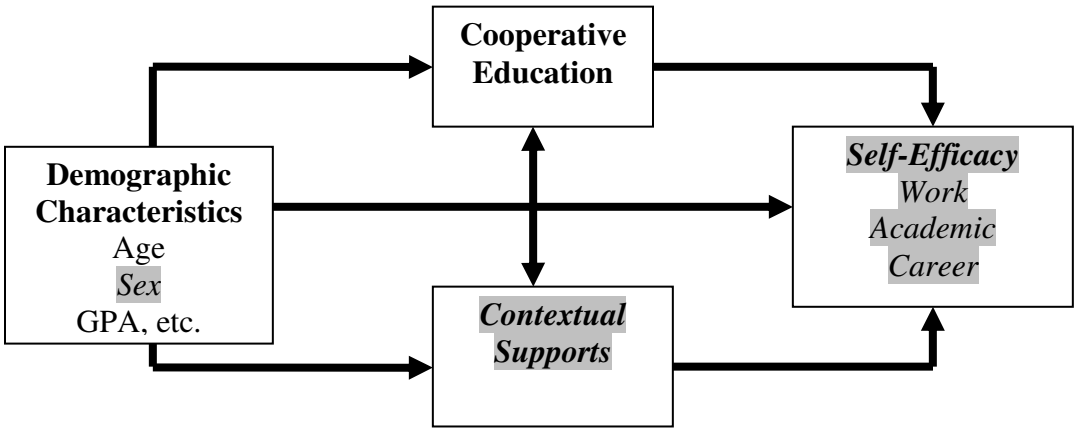
A pilot study was performed by two universities in 2005-2006 to discriminate the effect of cooperative education (co-op) versus other competing measures on three forms of self-efficacy: academic, career, and work.[15] Among the findings, co-op was found to significantly predict change in work self-efficacy; prior academic achievement predicted subsequent academic self-

efficacy; and academic support significantly enhanced all three forms of self-efficacy. Women undergraduates were more confident in obtaining occupational information and learning from their work experiences. While this preliminary study suggested the strong influence of co-op, additional variables constituting a more comprehensive model within larger populations needed to be considered. This larger research project, supported by the National Science Foundation, began in 2008, and the current study is a report of the first wave of findings.

Conceptual Framework

The framework for the study is depicted in Figure 1 as a series of pathways between four variable clusters. The determination of self-efficacy is based on the impact of students' demographic characteristics, the effect of work experience - in particular co-op, and the contextual support provided by the university. In this study, as is indicated in *highlighted italics* in Figure 1, the research team is interested in the effect of gender on self-efficacy through the impact of contextual support.

Figure 1
Conceptual Framework of the Study



Data

The data pool represents all sophomores in the colleges of engineering from the four participating universities. Students completed a 20-minute survey, mostly done in class and in written form, although some 26% of the respondents completed the survey online. As Table 1 reveals, the total number of respondents was 990 students, of which 216 were female - a proportion of 22%. The response rate for the full sample was 44%.

Besides gender, the sample is predominantly Caucasian (81%) and upper-middle and middle class (78%) in socioeconomic status (SES). The average SAT score is 1274 (Math plus Verbal), based on the original SAT version with a 1600 maximum score. The average GPA is 3.23 and the most popular major is mechanical engineering (at nearly a third of the sample) followed by civil, electrical, and chemical, in that order. It is noteworthy that in terms of these major demographic categories (race, SES, SAT score, GPA, and major), there are no significant gender differences.

Table 1
Overall Sample Statistics

School	# Students Completing Survey 1	# Women (in Prior Column)	% Women
Northeastern University*	398	86	22%
Rochester Institute of Technology*	177	29	16%
University of Wyoming	75	21	28%
Virginia Polytechnic Institute	340	80	24%
TOTALS	**990**	**216**	**22%**

*Signify the two universities with predominantly co-op engineering colleges.

Measurement

The measures of the principal study variables are as follows. The new work self-efficacy inventory, developed at the Center for Work and Learning at Northeastern University, measures a range of behaviors and practices that relate to the non-technical and social skills necessary to achieve success in the workplace. The inventory features seven subscales: problem-solving, sensitivity, communication, teamwork, learning, pressure, and politics. Academic self-efficacy (AS-E) was derived from the Self-Efficacy for Academic Milestones and Self-Efficacy for Technical/Scientific Fields surveys,[16] and career self-efficacy was obtained directly from the short-form of the Career Decision-Making Self-Efficacy Scale of Betz, Klein, and Taylor.[17] Among the contextual social support variables, most were derived from the contextual supports subscales of Lent et al.,[18] and the advisorship and mentorship scales from the rapport and apprenticeship subscales of the Advisory Working Alliance Inventory (AWAI) prepared by Schlosser and Gelso.[19] The survey instrument obtained the demographic data from the respondents directly or from their student record.

The first round of analyses confirmed the reliability of these measures. Each of the three self-efficacy scales as well as the subscales in the work self-efficacy (WS-E) and career self-efficacy (CS-E) scales produced high reliabilities, measured by Cronbach's alpha coefficient of internal consistency: [20, 21]

WS-E: .94
CS-E: .94
AS-E : .91

These general scales and all the embedded subscales are above the recommended 0.70. The advisor and mentor scales also performed well: advisorship at 0.95 and mentorship at 0.97. The three major self-efficacy scales were found to have a high degree of concurrent validity, measured initially by correlations that are high and significant but not so high as to be equivalent:

WS-E and CS-E = .68
AS-E and CS-E = .43
WS-E and AS-E = .38

Convergent validity was also established by significant correlations among discriminating variables. For example, mentorship, provided as part of programs to support women and underrepresented students, was significantly correlated with both work- and career self-efficacy. Meanwhile, GPA (measured at the end of the freshman year) was found to be highly and significantly correlated with academic self-efficacy. The latter was also significantly correlated with perceived teaching quality and prior SAT scores. It should be noted that the data were also tested for institutional effects, but none were found. The impact of mentorship, for example, did not vary by university.

Results

Bivariate Gender Differences: As can be seen in Table 2, there are some significant bivariate gender differences. With the exception of academic self-efficacy, which is significantly higher among the males, every other significant or near-significant difference (significance is conventionally determined at scores > 0.05) favors the female population. Women have higher career self-efficacy, in contrast to what has been reported in the literature, and benefit far more from mentorship (though this can be expected given that these programs, as noted previously, are designed exclusively for this purpose). They also exceed the scores of their male counterparts in four support dimensions listed in Table 2: they report receiving more support from professional clubs and associations; they say they are more involved in campus life; and they also report that they not only receive more support from their friends but that their friends really matter to them. Subsequent data provide one caution to these preliminary bivariate findings: some of these results may be moderated when controlling for socioeconomic status. For example, among the data that were significant, the value of friends, found to be relatively high among women, was not shared among women of the lowest socioeconomic strata.

Table 2
Significant Bivariate Gender Differences

	Academic Self-Efficacy	Career Self-Efficacy	Mentor-ship	Prof. Support	Friend Support	Friends Matter	Involve-ment
Males	**3.88***	3.67	3.98	3.54	4.25	4.19	3.60
Females	3.74	**3.74***	**4.24***	**3.75***	**4.49***	**4.43***	**3.78***
F-Ratio	5.60	2.42	2.23	6.07	12.51	14.60	4.57
Sig.	0.018	0.120	0.137	0.014	0.000	0.000	0.033

*Bold figures indicate higher value

Differences for Living/Learning Communities: The study also considered the impact of students choosing residence in selective living/learning communities, such as special floors or houses in engineering, honors, or leadership. Nearly half of the sample took advantage of these special residential arrangements, but women were significantly more likely to have chosen this

residential option. Specifically, 64% of women chose a living/learning community in their freshman year, compared to 43% of men. Furthermore, those who chose to live in living/learning communities reported greater effects among several of the study's support variables. In particular, they were more likely to receive financial and professional support, were more involved in campus life, and declared that both their friends and the university as a whole mattered more to them.

Regressions for the Efficacy Scales: The analysis of the data concludes by considering the impact of the study's independent variables on the three separate dimensions of self-efficacy (work, career, and academic). For this purpose, three regression equations were initially calculated. The purpose was to determine how much of the variance in each of these dependent variables can be explained at this early stage of the study by the demographic and support variables. Statisticians tend to refer to the statistic known as r-square – the coefficient of determination – which technically represents an index of the closeness of the plotted points to the regression line. At this stage, given that none of the students in our sample, as sophomores, had been exposed to formal university-sponsored work experience programs, such as co-op, the regression results for work self-efficacy were modest with only a r-square (equivalent to the variance explained) at 13%.

With respect to career self-efficacy, the regression analysis was run in two ways. In the first equation, the analysis was run without entering the variable, mentorship. As indicated earlier, mentorship constitutes a specialized variable because it applies to (and was only answered by) students who receive special support from programs for women and those otherwise underrepresented in engineering. Thus only 221 respondents answered this question (representing approximately 22% of the sample). Regression equation results run with rigorous properties, such as list-wise deletions, become more unstable when their degrees of freedom are attenuated in this way. Nevertheless, prior correlation analyses had revealed the possible effect of mentorship especially on career self-efficacy. Indeed, when the career self-efficacy regression was run without the addition of mentorship, only 21% of the variance was explained. When mentorship was entered, nearly 39 percent of the variance (a fairly robust R^2 with social science data) was explained and the degrees of freedom are sufficient in this case. Clearly, special mentorship helps to focus students on the value of an engineering career. This second regression model for career self-efficacy is depicted in Table 3. As can be seen, professional support and financial support, as well as teaching quality, are also significant predictors of career self-efficacy. Unexpected among these results is that the direction of financial support is negative. Those receiving financial aid appear to be less confident in pursuing an engineering career than those who fund their own college education.

Table 3
Regression for Career Self-Efficacy (CS-E) with Mentorship

Model Summary

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
2	0.624[a]	0.389	0.338	0.485

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
2	Regression	23.113	13	1.778	7.557	0.000
	Residual	36.229	154	0.235		
	Total	59.342	167			

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
2	(Constant)	1.009	0.495		2.039	0.043
	Mentorship	0.098	0.036	0.184	2.679	0.008
	Professional Support	0.139	0.048	0.225	2.900	0.004
	Financial Support	-0.070	0.032	-0.148	-2.153	0.033
	Teaching Quality	0.184	0.052	0.249	3.513	0.001

[a] Dependent Variable is Career Self-Efficacy (CS-E)

The last regression equation reported (see Table 4) is for academic self-efficacy (without the mentorship variable). A full 43.6% of the variance is explained. Not surprisingly, GPA accounts for the largest portion (note the standardized coefficient, known as the Beta weight, at 0.47). Some of the now familiar support variables are also present. What is most interesting for this study is that the negative numbers for gender signify that males account for a significant difference in academic self-efficacy, even when controlling for all the other independent variables. Compared to males, women as freshmen are not as confident in their likelihood of achieving success in their engineering major.

Table 4
Regression for Academic Self-Efficacy (AS-E)

Model Summary

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	0.661[b]	0.436	0.426	0.61

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	187.191	12	15.599	41.926	0.000
	Residual	241.846	650	0.372		
	Total	429.037	662			

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-0.938	0.314		-2.754	0.006
	Financial Support	0.083	0.038	0.081	2.188	0.029
	Professional Support	0.056	0.026	0.072	2.165	0.031
	College Matters	0.082	0.028	0.098	2.936	0.003
	Teaching Quality	0.249	0.031	0.255	7.986	0.000
	Gender	-0.253	0.058	-0.131	-4.383	0.000
	GPA	0.786	0.053	0.474	14.842	0.000

[b] Dependent Variable is Academic Self-Efficacy (AS-E)

Conclusion

This study sustains longstanding research results suggesting that women have lower academic self-efficacy than men at the point of entry in their undergraduate engineering education. As a result, women continue to be at risk of prematurely terminating their engineering careers. However, it appears that colleges of engineering are taking active steps to counteract this critical condition by providing support to women in their early college years. Some of the support mechanisms, such as the availability of professional and friend support, come at modest incremental costs to colleges. Furthermore, this study suggests that women are taking advantage of these support mechanisms. For example, their reliance on special mentorship opportunities

certainly enhances their career self-efficacy. Women also take full advantage of special opportunities afforded by universities to take up residences in specialized living/learning communities which, in turn, increases their connection to the university. Although not ascertained by this study, it can be speculated that the social support and resulting involvement of women might come more naturally to them than to their male counterparts.

In the next surveys to be conducted through this study, the research team hopes to determine whether formal work experiences offered to students in their sophomore and subsequent years might also contribute to equalizing the balance in academic self-efficacy among women undergraduates compared to men. Such work experiences might also contribute to enhancing both male and female work self-efficacy, which is likely to lead to subsequent positive experiences within the field and within the workplace. Finally, in the last phase of this study, the predictors of efficacy as well as efficacy itself will be viewed as potential contributors to retention both within the students' engineering major and within college in general.

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