AC 2008-148: A CROSS SECTIONAL STUDY OF ENGINEERING SELF-EFFICACY

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Title of the Paper:

A Cross-Sectional Study of Freshmen Engineering Majors' Self-Efficacy

Abstract

This is a quantitative study examining differences in 253 freshmen engineering majors' self-efficacy, ability to cope, and engineering outcome expectations by gender, ethnicity, engineering specialty, participation in freshmen interest groups [FIGS], and participation in undergraduate engineering organizations. All of the participants in the study were first-time freshmen and were enrolled in an introductory engineering course during the fall semester of 2007. This study was performed at a large research extensive Midwestern university. Men in the study showed statically significant higher engineering career outcome expectations and statistically significant higher abilities to cope than women. Women who were in undergraduate engineering organizations and women who were in undergraduate freshmen interests groups [FIGS] showed statistically significant higher engineering career outcome expectations than women who were did not participate in these programs.

Introduction

Bandura[1] defines self-efficacy as one's judgments of his or her abilities to accomplish specific tasks or objectives. Individuals' behaviors and motives are better predicted by what they believe they are able to do more so than what they are actually capable of doing [2]. Individuals with high efficacious beliefs think, feel, and act in such ways that they can actually create their own future rather than simply foretelling it [1]. Self-efficacy theory assumes that an individual is able to create internal models, imaginative scenarios, for various courses of action, and that an individual can predict the outcome for each course of action [3]. Self-efficacy theory also embraces the idea that individuals are self-reflective, and evaluate their decisions throughout their course of action; therefore, behavior is premeditated and is guided by intentions [3]. A person's decision upon a course of action is interrelated to his or her emotions, biological events, cognition, and environmental events. Self-efficacy influences behavior through five mechanisms. A person's level of self-efficacy determines his or her: a) goals; b) persistence in the face of obstacles [1]; c) strategies to attain goals; d) emotional responses; and e) selection of environments [3].

Self-efficacy theory proposes six sources for an individual's self-efficacy beliefs. These sources are: 1) a person's successes and failures (mastery experiences); 2) a person's ability to imagine possible situations and respective outcomes for performing successfully and unsuccessfully; 3) a person's ability to learn though observing others; 4) a person's influence by verbal persuasions from external sources; 5) psychological states; and 6) emotional states [3].

In the early 1980s and into 1990s, the self-efficacy construct was taken from Bandura's initial definition and tied to a person's confidence in passing a course, finishing an engineering degree program, or one's confidence in finding a job that he or she will like. In 1981, Betz and Hackett [4, 5] established field of occupational self-efficacy research, where a person's confidence in career related pursuits. Lent [6] established the first academic milestones measure of self-efficacy, a person's confidence in his or her ability to negotiate major hurdles in an academic program. This area of self-efficacy research is relevant with regards to retention of undergraduates in engineering degree programs.

The National Science Board [7] posits that one challenge in moving forward in engineering education is retention of engineering students. Some of the best undergraduate engineering majors are lost. The attrition of women and minorities in undergraduate engineering programs is significantly higher than White males. About 60 percent of individuals who enter engineering graduate in 6 years [7]. Adelman [8] posits that men have a 61.6 percent retention rate in undergraduate engineering programs. This retention rate over the course of his 11-year longitudinal study was 20 percent higher than women (61.6 percent versus 41.9 percent). Peak attrition for undergraduate engineering majors occurs during the freshmen and sophomore year [9]. The National Science Board [7] posits, "these groups most likely lack role models in engineering" (p. 3). Though this is comparable to other undergraduate programs, it is of specific concern to undergraduate engineering programs. The acquisition of skills and inflexible coursework in engineering means that the movement of undergraduates into engineering is nearly impossible. While other academic majors can compensate for the 40% loss of individuals who enter, engineering cannot [7]. Attrition in undergraduate engineering programs is a factor when considering the low representation of minority and women engineers in the workforce. In 2003, there were approximately 1,554,800 engineers in the United States workforce: 1,382,500 were men, less than 80,000 were Hispanic, and less than 60,000 were Black [10]. Under representation of women and minority groups in science and engineering is stressing the nation's economic capacity and growth in a time of global competitiveness [11].

Body

Review of the Literature

Engineering Self-Efficacy: Gender

Women enter college engineering programs with high mathematics test scores take the same engineering prerequisite high school courses as men, and they are just as confident as men in their academic abilities [12]. Unfortunately, females report negative feelings [12] and lower self-confidence in mathematics than men [9]. Seymour and Hewitt [13] interviewed students that switched majors and persisted in majors from several disciplines among seven campuses showed that there is no evidence that those who dropped out of engineering lack preparation, have a lower ability, or are unwilling to work. Rather, "problems which arise from the structures of the education experience and the culture of the discipline[s] (as reflected in the attitudes and practices of the S.M.E. faculty) make a far greater contribution to S.M.E. attrition than individual inadequacies of students or the appeal of other majors (p. 392). The main reason why women switch out of engineering is because they felt alienation, isolation, and loss of confidence. This is primarily a result of women's perception of educators at the college level as being rigid, closed, and condescending[13].

Betz and Hackett[4] examined gender and ethnic differences in career self-efficacy and the relationship of career self-efficacy to a person's range of career options. College students were asked to rate their confidence in completing the education requirements for 20 occupations (10 male-dominated and 10-female dominated), and to rank their confidence for performing the respective job duties. Overall, there were no differences in career self-efficacy among the 20 occupations; however, when Betz and Hackett divided the occupations as male or female dominated, women's career self-efficacy was significantly lower than men in the male dominated domains. Career self-efficacy was found to be a significant predictor for the range of occupations the students considered while ACT scores were not.

Hackett et al. [5] examined the relationship of social cognitive variables to academic achievement in engineering programs. The sample consisted of 218 student enrolled in the School of Engineering. Hacket et al. measured: 1) self-efficacy, measured as two subscales (a student's confidence in their ability to complete the education requirements for various science and engineering occupations, and student's confidence in their ability to complete the degree requirements); 2) outcome expectations, measured using 12 items asking students to respond from strongly agree to strongly disagree to statements pertaining to the outcomes of completing the degree; and 3) stress, strain, and coping. Women in the study reported significantly lower positive outcome expectations than men, but there were no statistically significant differences in engineering self-efficacy.

Lent et al. [6] measured 75 men and 30 women engineering majors' academic milestones and occupational self-efficacy in relation to interests and performance. Academic milestones, defined as an individuals confidence to complete specific education requirements, was found to be the greatest predictor for academic achievement, and occupational self-efficacy for engineering careers was significantly correlated with scientific/technical interests; however, academic milestones was not. Academic milestones were significantly correlated to the participants' prior high school performance. There were no statistically significant differences for both academic milestones and occupational self-efficacy between men and women.

Schaefers, Epperson, and Nauta [14] sampled 236 men and 348 male students who were declared engineering majors and who directly entered college from high school. The final sample in the study consisted of 278 participants (49% women and 51% men). The engineering majors identified themselves as being in their first, second, third, fourth, and fifth year of study. The following variables were measured: 1) ability measured by GPA; 2) mathematics self-efficacy; 3) occupational self-efficacy; 4) lifestyle expectancy; 5) outcome expectations; 6) supports and barriers; 7) student's pre-college interests; and 8) persistence. Men and women in the study showed similar persistence rates (69% women; 73% men), and no differences in self-efficacy were found between genders. Regression analysis of engineering major's first semester GPA was found to be the most significant predictor for persistence.

Engineering Self-Efficacy: Ethnicity

Ethnicity is a term used to refer to a social group of people who have defining characteristics. These characteristics may include nationality, culture, ancestry, language and physiology [15]. Rotheram & Phinney [16] refers to ethnic group identity as "one's sense of belonging to an ethnic group and the part of one's thinking, perceptions, feelings, and behavior that is due to group membership" (p. 13). To clarify this summary of self-efficacy literature, the following studies

focus upon ethnicity, not ethnic identity. There are concerning statistics of African Americans, Hispanic Americans, and Native Americans in undergraduate engineering. In 2005, 76, 003 bachelors degrees were awarded in engineering [7]. The ethnic breakdown was: 51,302 whites, 10,033 Asian Americans, 3,756 African Americans, 4,890 Hispanic American; 378 Native American; and 5,644 foreign nationals [2].
As mentioned in the earlier section, Hackett et al. [5] examined the relationships of measures of career self-efficacy, academic self-efficacy, vocational interest, outcome expectations, perceived stress, perceived supports, and coping self-efficacy of 197 ethnically diverse men and women undergraduate engineering majors. Hacket et al. found that when using dichotomous coding for ethnicity, Mexican-Americans had lower outcome expectations.

Marra and Bogue [17] developed the Longitudinal Assessment of Engineering Self-Efficacy [LAESE] to measure engineering self-efficacy using a pre-/post- self-efficacy intervention. This instrument was developed to measure the effectiveness of engineering self-efficacy interventions. Marra and Bogue used LAESE to identify longitudinal differences across students of different ethnicities. They found that African American students showed a lower mean score for feelings of inclusion. This may be the factor for the higher attrition rate of African Americans in engineering degree programs.

Fewer negative outcome expectations, wider interests, lower levels of faculty discouragement, positive outcome expectations, coping, and fewer stressors significantly predicted academic self-efficacy. Hackett et al. [5] reports no statistically significant differences between genders; however, they did find significant differences in self-efficacy among ethnicities. In regression analysis, Euro-Americans showed higher predictability for academic self-efficacy than those coded as Mexican-Americans.

Mau [18] studied 24,599 eighth graders career aspirations over a six year period. In the original sample, 827 eighth graders aspired to science and engineering careers. Six years later, 176 students retained their science and engineering aspirations. The two measures that showed to be strong predictors for retained science and engineering career interest were mathematics self-efficacy and academic self-efficacy. This parallels Eccles [19] finding that mathematic self-efficacy is the strongest predictor for continued science and engineering aspirations. According to Mau, the women who were initially interested in science and engineering careers were more likely than men to switch their career aspirations to a different domain. Mau also reported that women perceive a heightened amount of institutional barriers. Examining across ethnicities shows that Asians had the highest percentage for persistence (35.3%), whereas Blacks had the lowest (18.3%).

Engineering Self-Efficacy: Support Groups

Academic support groups are defined by an individual's help-seeking behaviors. These behaviors include: meeting with a class professor, faculty advisors, and research mentors; forming peer study groups; being active in student organizations; and taking a studies strategies course. Tate and Linn [20] interviewed five upper-level African American women studying engineering at a large university to explore their help-seeking behaviors and the corresponding support system that they sought. The interviews consisted of questions targeting academic support systems, social support systems, interest in engineering, and reasons for persistence. Interestingly, one interviewee posits, "structured study groups do a good job providing you with help when you're in you lower division" (p. 486). The interviewee noted that it gets more difficult because there are fewer study groups and that each person tends to go their separate way. This may have contributed as to why self-efficacy has been found not to increase across academic levels. Four of the five individuals explain that they had to form their own peer study groups in the later years. This most frequent support system cited was contacting class professors during office hours. The interviewees, when commenting about what type of support system they wish they had early in their academic track include: 1) having other Black individuals in the program to form study groups; 2) early knowledge of women in engineering programs; 3) and ethnic minority mentors who have "survived" similar situations.

Engineering Self-Efficacy: Engineering Specialties

Over the past 10 years there has been a drop in women receiving bachelor's degrees chemical engineering [21]. There is limited literature pertaining to engineering students' self-efficacy across engineering specialties; however, there is literature pertaining engineering majors' perceptions of all engineering specialties, including chemical engineering. Shivy and Sullivan [22] studied 129 (99 males, 28 females, 2 missing) undergraduate engineering students among 11 engineering specialties. The majority of the participants in the study were Caucasian who had completed between 2 and 7 semesters of coursework. The instruments for the study obtained the participants: 1) familiarity with engineering specialties; 2) perceptions of the similarities among engineering specialties; 3) perceptions of prestige associated with the engineering specialties; 4) perceptions of the engineering specialties with regards to the degree that people working the specialty deal with people, data, ideas, things, and open to women; 5) commitment to their career choice; and 6) career decision-making self-efficacy. Career decision-making self-efficacy assesses individuals' goal selection, career planning, and career problem-solving. They concluded that: 1) minority students believed that engineering was working with ideas; 2) students who had over 4 years of engineering coursework had a statistically significant higher career decision-making self-efficacy; 3) females rate engineering specialties more prestigious than men; 4) participants believed that engineering specialties in high demand (e.g. chemical, nuclear, and bioengineering) are most prestigious; 5) petroleum, materials, and chemical engineering deal with micro-level things; 6) industrial, computer, mechanical and aerospace engineering deals macro-level things; and 7) some engineering specialties are perceived to have a better path to management (e.g. industrial, computer, and electrical).

Gaps in the Literature

Prior studies by Pajares [23-27], Lent [6, 28-34], Lopez [35], Betz and Hackett [4, 5] have shown how social-cognitive constructs relate to persistence of individuals in undergraduate engineering programs. These studies have emphasized statistical methodologies that examine the correlation and predictability among the constructs. Lent et al. [34] and Lent et al. [33] posit that coping self-efficacy, career outcome expectations, and academic milestones are all significant predictors of undergraduate engineering majors' persistence in their degree programs. The questions that now need to be examined, specifically in regards to coping self-efficacy and engineering career outcome expectations among freshmen engineering students are:

- Are there differences among these social-cognitive constructs: by gender, ethnicity, between students who live in an engineering Freshmen Interests Group versus those who do not, students who participate in undergraduate engineering organizations versus those who do not, and by engineering specialty?

Methodology

Variables

The dependent variables in the study are: academic milestones self-efficacy one [SE1], academic millstones self-efficacy two [SE2], career outcome expectations, and coping self-efficacy. The independent variables in this study are: a) gender (male or female); b) engineering specialty (e.g. biological); c) students' involvement in freshmen interest groups and collegiate engineering organizations; and d) ethnicity.

The first dependent variable [SE1] is intended to measure a student's confidence in obtaining an A or a B in a difficult course and his or her confidence succeeding in the engineering curriculum. This is somewhat different than the second academic milestones variable [SE2]. SE2 measures student's confidence in completing the undergraduate engineering requirements when comparing him or herself to students in all other engineering specialties. Engineering career expectations are an individual's perceptions of the benefits of working as an engineer. The four dependent variable, coping self-efficacy, is a person's ability to manage stressful circumstances to decrease internal stress [36].

Instrument

LAESE [17] is a 7-point Likert instrument developed from NSF grant #0120642 to allow for the measurement of engineering self-efficacy (www.aweonline.org) and outcome efficacy. The instrument is divided into six separate subscales, each was found to be reliable and valid for undergraduate engineering majors. Validity of the subscales was ensured through expert reviews and factor analyses. Results of the validity and reliability showed that the survey adequately measures self-efficacy. Cronbach's Alpha for the six subscales ranges from 0.72 to 0.87. The six subscales are: engineering career success expectations (7 items, alpha = 0.84), engineering self-efficacy one (5 items, alpha = 0.82), engineering self-efficacy two (6 items, alpha = 0.82), feeling of inclusion (4 items, alpha = 0.73), coping self-efficacy (6 items, alpha = 0.78), and math outcome expectations (3 items, alpha = 0.84). Four of the six subscales are used in this study. The four subscales are: engineering self-efficacy 1 (academic milestones one), engineering self-efficacy two (academic milestones two), engineering career outcome expectations, and coping self-efficacy. Marra and Bogue [17] posit, LAESE "identifies the typical *barriers* that stand between the individual and her or his success in the domain. Thus, this self self-efficacy instrument is designed to identify the sources of barriers or obstacles in the task of obtaining an engineering degree and ascertain how capable a person feels in those situations" (pp. 1-2). The first two subscales, engineering self-efficacy one and engineering self-efficacy two, measures a person's ability to reach academic milestones.

Each respondent's survey contained items belonging to only four subscales from LAESE. The four subscales are: 1) engineering self-efficacy I (academic milestones one): 2) engineering self-efficacy II (academic milestones two); 3) engineering career expectations e; and 4) coping self-efficacy. The survey items are consistent with the original LAESE 7-point Likert items, but have been altered slightly. The two subscales containing altered items, academic milestones one and academic milestones two, both have a Cronbach's Alpha of 0.82.

Participants

The participants of the study (N=253) were undergraduate freshmen men and women (211 men, 42 women) across several ethnicities (9 African-American, 7 Asian, 220 Caucasian, 8 Hispanic, 1 Native American, 4 Middle-Eastern, and 4 unreported) majoring in several different engineering specialties (36 biological, 5 chemical, 19 civil, 65 computer/electrical, 20 industrial, and 108 mechanical/aerospace engineering). At the time of the survey, the participants were enrolled in a freshmen engineering course during the Fall Semester 2007 at a Research I university.

Data Analysis

This study uses a two factor experiment with repeated measures for one factor (engineering self-efficacy). The four measures that are repeated include SE1, SE2, career outcome expectations, and coping self-efficacy. A multiple analysis of variance was used to determine if there are differences among self-efficacy subscale scores for levels of factor A, levels of factor B, and if there is an interaction between the levels of factor A and factor B on the self-efficacy subscale scores. The assumptions concerning the nature of the data are: 1) both factors show normally distributed data for the dependent variables; 2) independent samples; 3) independent subjects; 4) compound symmetry; and 5) homogeneity of variance.

Results

Table 1 illustrates how the subscales differ for the entire freshmen sample. The third subscale, engineering career outcome expectations, has the highest mean.

Table 1
FS 2007 freshmen means, variances, standard deviations, and range for the dependent variables (n=253).

			Standard	Range	
Variable	Mean	Variance	Deviation	Min.	Max.
Self-Efficacy One	5.434	.981	.990	1.40	7.00
Self Efficacy Two	5.625	.890	.943	2.20	7.00
Career Outcome Expectations	6.121	.519	.720	3.43	7.00
Coping Self-Efficacy	5.875	.481	.693	4.00	7.00

Tables 2, 3, and 4 examine differences among the subscale scores between men and women. There are statistically significant differences between men and women's subscale scores in the sample. Table 3 explains that there are differences between men and women engineering majors' self-efficacy. Looking more closely among the four subscales, Table 4 shows that freshmen men have statistically higher coping self-efficacy [t (251) = 2.099, p<0.05] and engineering career outcome expectations subscale scores [t (251) = 2.252, p<0.05] than freshmen women.

Table 2
FS 2007 freshmen means, variances, standard deviations, and range for the dependent variables by gender.

Variable	Mean	Variance	Standard Deviation	Range Min.	Range Max.
Men (n= 211)					
Self-Efficacy One	5.473	.948	.973	1.40	7.00
Self Efficacy Two	5.646	.858	.926	2.40	7.00
Career Outcome Expectations	6.166	.479	.704	3.43	7.00
Coping Self-Efficacy	5.915	.470	.685	4.00	7.00
Women (n= 42)					
Self-Efficacy One	5.238	1.128	.990	1.40	7.00
Self-Efficacy Two	5.190	1.058	.943	2.20	7.00
Career Outcome Expectations	5.894	.582	.720	3.43	7.00
Coping Self-Efficacy	5.671	.495	.693	4.00	7.00

Table 3
Repeated measures ANOVA of engineering self-efficacy between freshmen men and freshmen women.

Factor	df	Sums of Squares	Mean Square	F-Value
Between Genders	1	6.80	6.758	3.71*
Engineering Self-Efficacy Subscales	3	35.03	11.679	34.05**
Interaction (AxB)	3	.42	.141	.74

* p< .05; ** p< .01

Table 4
Independent t-tests of self-efficacy subscale scores between freshmen men (mean 1) *and freshmen women* (mean 2).

Variable	df	Mean 1 (n= 211)	Mean 2 (n= 42)	Mean Difference	t-statistic
Self-Efficacy One	251	5.4730	5.2381	.23489	1.406
Self-Efficacy Two	251	5.6464	5.5190	.12740	.799
Coping Self-Efficacy	251	5.9156	5.6714	.24421	2.099*
Career Outcome Expectations	251	6.1666	5.8946	.27200	2.252*

p< .05; ** p< .01

Table 5, 6, and 7 illustrates how the subscale scores differ between students who are in undergraduate engineering freshmen interest groups [FIGS] and students who are not. Table 6 shows that when comparing these two groups for the entire sample, there is no statistically significant difference; however, when women are separated from the sample, and then compared by FIG status, there is a statistically significant difference in their engineering career outcome expectations (Table 7). Women who participate in a FIG have statistically significant higher engineering outcome expectations than women who do not.

Table 5

FS 2007 freshmen means, variances, standard deviations, and range for the dependent variable by freshmen interest group status.

Variable	Mean	Variance	Standard Deviation	Range Min.	Range Max.
Member (n= 71)					
Self-Efficacy One	5.481	.830	.911	2.80	7.00
Self-Efficacy Two	5.735	.744	.862	3.40	7.00
Career Outcome Expectations	6.171	.709	.842	3.43	7.00
Coping Self-Efficacy	5.856	.527	.725	4.00	7.00
Non-member (n= 182)					
Self-Efficacy One	5.415	1.044	1.021	1.40	7.00
Self-Efficacy Two	5.582	.944	.971	2.20	7.00
Career Outcome Expectations	6.102	.447	.668	3.71	7.00
Coping Self-Efficacy	5.882	.465	.681	4.00	7.00

Table 6

Repeated measures ANOVA of engineering self-efficacy between freshmen students who are members of FIGs versus freshmen who are not.

Factor	df	Sums of Squares	Mean Square	F-Value
Member of FIG	1	.877	.877	.474
Engineering Self-Efficacy Subscales	3	53.046	17.682	51.641**
Interaction (AxB)	3	.818	.273	.797

* p< .05; ** p< .01

Table 7

Independent t-tests of self-efficacy subscale scores between freshmen women who are members of FIGS versus freshmen women who are not.

Variable	df	Mean 1 (n= 9)	Mean 2 (n= 33)	Mean Difference	t-statistic
Self-Efficacy One	40	5.4000	5.1939	.20606	.511
Self-Efficacy Two	40	5.6667	5.4788	.18788	.481
Career Outcome Expectations	40	6.3492	5.7706	.57864	2.098*
Coping Self-Efficacy	40	5.8000	5.6364	.16364	.614

* p< .05; ** p< .01

Students in undergraduate engineering organizations have a statistically higher engineering career outcome expectations scores [t = 2.289, p<0.05]. When the sample is divided by gender (Table 11), women who are in undergraduate engineering organizations have a statistically significant higher self-efficacy one (academic milestones one), self-efficacy two (academic milestones two), and career outcome expectation scores than women who do not participate in organizations.

Table 10
Independent t-tests of self-efficacy subscale scores between freshmen who are members of an undergraduate engineering organizations (mean 1) *versus freshmen who are not* (mean 2).

Variable	df	Mean 1 (n= 34)	Mean 2 (n= 219)	Mean Difference	t-statistic
Self-Efficacy One	251	5.6000	5.4082	.19178	1.051
Self-Efficacy Two	251	5.8471	5.5909	.25619	1.477
Career Outcome Expectations	251	6.3824	6.0809	.30147	2.289*
Coping Self-Efficacy	251	5.9882	5.8575	.13070	1.023

* p< .05; ** p< .01

Table 11
Independent t-tests of self-efficacy subscale scores between freshmen women who are members of an undergraduate engineering organizations (mean 1) *versus freshmen women who are not* (mean 2).

Variable	df	Mean 1 (n= 12)	Mean 2 (n= 30)	Mean Difference	t-statistic
Self-Efficacy One	40	5.7667	5.0267	.74000	2.125*
Self-Efficacy Two	40	6.0167	5.3200	.69667	2.060*
Career Outcome Expectations	40	6.2500	5.7524	.49762	1.980*
Coping Self-Efficacy	40	5.7333	5.6467	.08667	.357

* p< .05; ** p< .01

Table 12
Correlations among the four subscales and persistence for freshmen women.

Variable	2	3	4	5
Self-Efficacy One	.866**	.513**	.350*	.416**
Self Efficacy Two	1.000	.617**	.326*	.536*
Career Outcome Expectations		1.000	.256	.744**
Coping Self-Efficacy			1.000	.166
Persistence				1.000

*p<.05; **p<0.01

Table 13

Correlations among the four subscales and persistence for freshmen men.

Variable	2	3	4	5
Self-Efficacy One	.874**	.477**	.351**	.437**
Self Efficacy Two	1.000	.449**	.372**	.451**
Career Outcome Expectations		1.000	.595**	.423**
Coping Self-Efficacy			1.000	.201**
Persistence				1.000

*p<.05; **p<0.01

Table 14

FS 2007 freshmen means, variances, standard deviations, and range for the dependent variables by participants engineering specialty.

			Standard	Range	
Variable	Mean	Variance	Deviation	Min.	Max.
Biological (n= 36)					
Self-Efficacy One	5.333	1.067	1.033	2.20	7.00
Self-Efficacy Two	5.594	.943	.970	2.20	7.00
Career Outcome Expectations	5.952	.535	.731	3.71	7.00
Coping Self-Efficacy	5.833	.483	.695	4.20	6.80
Chemical (n= 5)					
Self-Efficacy One	5.560	.388	.622	4.60	6.20
Self-Efficacy Two	5.520	1.352	1.162	4.20	6.80
Career Outcome Expectations	5.914	.598	.773	5.14	7.00
Coping Self-Efficacy	6.320	.332	.576	5.60	7.00
Civil (n= 19)					
Self-Efficacy One	5.210	2.229	1.492	1.40	6.80
Self-Efficacy Two	5.242	1.527	1.235	2.40	6.40
Career Outcome Expectations	6.150	.427	.653	5.00	7.00
Coping Self-Efficacy	5.726	.552	.743	4.00	7.00
Computer/Electrical (n= 65)					
Self-Efficacy One	5.384	.997	.990	2.80	7.00
Self-Efficacy Two	5.510	.999	.999	3.00	7.00
Career Outcome Expectations	6.041	.522	.722	3.71	7.00
Coping Self-Efficacy	5.833	.483	.695	4.20	7.00
Industrial (n= 20)					
Self-Efficacy One	5.530	.338	.581	4.40	6.60
Self-Efficacy Two	5.770	.313	.559	4.80	7.00
Career Outcome Expectations	6.371	.149	.386	5.71	7.00
Coping Self-Efficacy	5.810	.385	.620	4.40	7.00
Mechanical (n= 108)					
Self-Efficacy One	5.130	.894	.945	2.60	7.00
Self-Efficacy Two	5.750	.772	.878	3.20	7.00
Career Outcome Expectations	6.183	.583	.763	3.43	7.00
Coping Self-Efficacy	5.931	.492	.701	4.00	7.00

Table 15

Repeated measures ANOVA of engineering self-efficacy by engineering specialty.

Factor	df	Sums of Squares	Mean Square	F-Value
Engineering Specialty	5	8.677	1.735	.940
Engineering Self-Efficacy Subscales	3	29.558	9.853	28.774**
Interaction (AxB)	15	4.917	.328	.957

* p< .05; ** p< .01

Table 14 examines the differences in mean subscale scores across engineering specialties. Looking at Table 15, there are no statistically significant differences in any subscale score among the engineering specialties; F (5, 247) = 0.940, p>0.05.

Table 16

FS 2007 freshmen means, variances, standard deviations, and range for the dependent variables by ethnicity.

Variable	Mean	Variance	Standard Deviation	Range Min.	Range Max.
African American (n= 9)					
Self-Efficacy One	5.266	.710	.8280	4.00	6.60
Self-Efficacy Two	5.400	.740	.8602	4.20	7.00
Career Outcome Expectations	6.333	.168	.4103	5.60	6.40
Coping Self-Efficacy					
Asian (n= 7)					
Self-Efficacy One	5.771	.686	.8280	4.40	6.80
Self-Efficacy Two	6.114	.598	.7733	4.80	7.00
Career Outcome Expectations	6.061	.516	.7183	5.00	7.00
Coping Self-Efficacy	5.628	.672	.8199	4.60	6.60
Caucasian (n= 220)					
Self-Efficacy One	5.442	.984	.9919	1.40	7.00
Self-Efficacy Two	5.617	.873	.9343	2.40	7.00
Career Outcome Expectations	6.133	.493	.7019	3.43	7.00
Coping Self-Efficacy	5.884	.474	.6885	4.00	7.00
Hispanic (n= 8)					
Self-Efficacy One	5.200	2.000	1.4142	2.20	6.60
Self-Efficacy Two	5.350	2.363	1.5371	2.20	7.00
Career Outcome Expectations	5.982	1.180	1.0864	3.71	6.86
Coping Self-Efficacy	5.925	.742	.8614	4.60	6.60
Other (n= 4)					
Self-Efficacy One	5.7000	.120	.3464	5.20	6.00
Self-Efficacy Two	5.6500	.117	.3415	5.20	6.00
Career Outcome Expectations	5.0714	1.327	1.1517	3.71	6.29
Coping Self-Efficacy	5.1000	.920	.9591	4.20	6.20

Table 16 illustrates that there are a few number of African-Americans (n=9), Asians (n=7), Hispanics (n=8), and other (n=4). For statistical purposes, these groups have been clustered and compared to the 220 Caucasians in the sample (Table 17). There are no statistically significant differences between Caucasians and ethnic minority students' subscale scores in the sample.

Table 17
Independent t-tests of self-efficacy subscale scores between freshmen engineering majors who are Caucasians (mean 1) *versus ethnic minorities* (mean 2).

Variable	df	Mean 1 (n= 220)	Mean 2 (n= 33)	Mean Difference	t-statistic
Self-Efficacy One	251	5.4427	5.3758	.06697	.362
Self-Efficacy Two	251	5.6173	5.6788	-.06152	-.349
Career Outcome Expectations	251	6.1338	6.0390	.09481	.704
Coping Self-Efficacy	251	5.8845	5.8121	.07242	.559

* p< .05; ** p< .01

Discussion

This investigation of freshmen engineering majors found statistically significant gender differences in engineering career outcome expectations and coping self-efficacy scores. Men in the freshmen engineering sample were found to have a significantly higher mean for both subscales (Table 4). This finding supports Hackett et al. [4] that women have significantly lower positive outcome expectations than men, and no statistically significant differences in engineering self-efficacy. Going beyond Hackett et al. [4], this study (Table 12) found women's engineering career outcome expectations strongly correlate to persistence in obtaining an undergraduate engineering degree ($r = 0.744$, $p<.01$). Though differences were found between men and women's coping self-efficacy scores (Table 4), the correlation of this subscale to persistence is not significant (Table 12). After dividing the sample by gender, we found that women who are in undergraduate engineering freshmen interest groups and women who are undergraduate engineering organizations have higher engineering career outcome expectations. Author [38] suggests in his empirically-based social-cognitive model (*Figure 1*) that there are three primary sources that drive individual's to persistence in undergraduate engineering programs. These three sources are 1) reaching academic milestones; 2) coping self-efficacy; and 3) career outcome expectations.

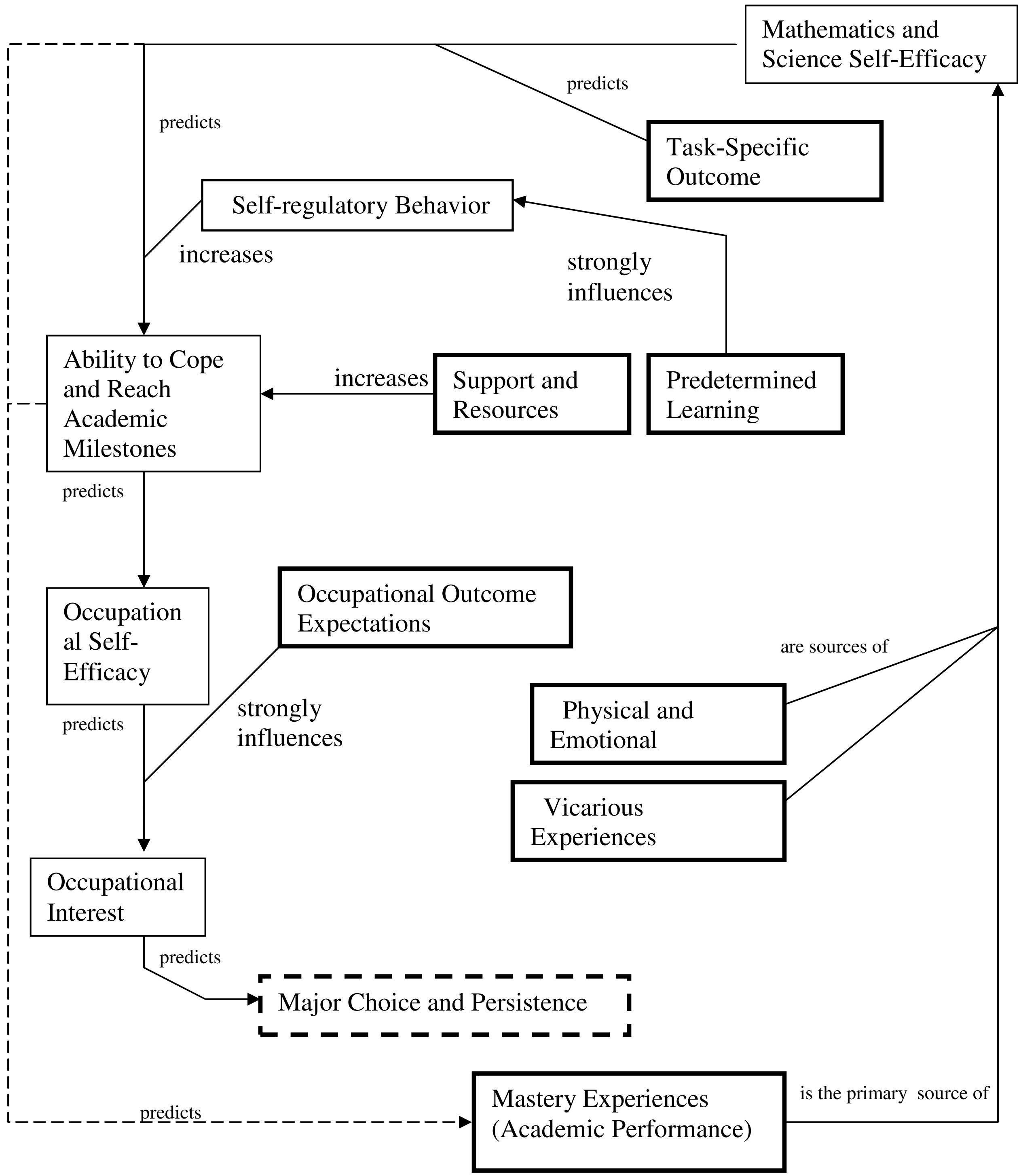

Figure 1. Concept map showing empirical relationships of social-cognitive constructs (Author, 2008).

Based on this model, this study suggests that the significantly lower persistence of females compared to males in undergraduate engineering organizations is due the gap between the genders' perceived engineering career outcome expectations.

In this study, no statistically significant differences were found among engineering specialty or by ethnicity for all four subscale scores. Oppositely, Marra and Bogue [18] did find significant differences across ethnicities. African-Americans exhibited a lower mean for feelings of inclusion. This subscale, feelings of inclusion, which is present on LAESE, was not considered as a dependent variable in this study.

Marra and Bogue [18] found no statistically significant differences when comparing women's engineering self-efficacy scores across academic grade levels. One reason that can explain this is that the individuals who persist in undergraduate engineering programs initially have high academic confidence [9]. One to two years into the program some students show a scattering pattern of drop out; subsequently, those individuals who stay in the program maintain a high degree of engineering self-efficacy [18]. Follow-up studies using the LAESE survey should not only address women, but also differences among self-efficacy constructs for both genders. Though this study did find statistically significant differences in engineering outcome expectations and coping self-efficacy by gender, it fails to examine engineering self-efficacy across all undergraduate engineering grade levels.

Follow -up studies should also focus upon differences among these self-efficacy variables between transfer and native students. Transfer students coming into an engineering program as a junior experience a much different environment than native students. Townsend and Wilson [39] posit that transfer students exhibit higher levels of stress. Stress stems from students inflexible schedule if they wish to graduate in four to five years. Secondly, the participants received less help than incoming freshmen with regards to campus tours, advice as to where to park their vehicle, how to add or drop a class, how to file for a graduation plan, and where to go to register. These experiences may result in statistically significant differences among the self-efficacy subscales.

Conclusion

The results of this study show: 1) there are no statistically significant differences among engineering self-efficacy scores by engineering specialty; 2) there are no statistically significant differences between engineering self-efficacy scores by ethnicity (majority vs. minority status); 3) men exhibit statistically significant higher engineering career outcome expectations and coping self-efficacy scores than women; 4) there are no statistically significant differences between engineering self-efficacy subscale scores for students who are in FIGS versus students who are not in FIGS; 5) women in undergraduate engineering FIGS show a statistically significant higher engineering career outcome expectation score than women who do not participate in FIGS; 6) women in undergraduate engineering organizations show statistically significant higher career outcome expectations and academic milestones self-efficacy scores than women who do not participate in undergraduate engineering organizations.

Implications

Undergraduate engineering students, particularly women, need career placement services, and are aware that there is a career placement office. A career placement office needs to take an active role, interacting with the students as early their freshmen year. The career placement office should advertize in formal and informal learning environments that they will help engineering students find a job that pays well, that students think they will like, that allows students to use their talents and creativity, where students think they will be apart of a team, and where students expect to be treated fairly.

The last two implications of this study are: 1) incoming freshmen engineering majors should be encouraged to join an engineering freshmen interest group and to join a professional engineering organization; and 2) due to the rigorous coursework, and the time and energy required from students, Colleges of Engineering need to provide students outreach services that address strategies for coping in the presence of academically related obstacles, such as failing a test or receiving a lower grade in a course than what was expected.

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