STUDENTS' DECISIONS TO ENTER ENGINEERING: HOW MEN AND WOMEN DIFFER

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Interest in engineering careers among college freshmen reached a 20-year low in 1995 when 13.6% of men and 2% of women planned on a career in engineering[1]. In 1999, only 6.2% of the men and 2.2% of the women entering college planned to major in engineering[2]. Roughly 34 to 40 percent of high school graduates change their minds about pursuing science, math or engineering majors at or before college enrollment, constituting the biggest "leak" in the pipeline producing these professionals[3].

Women and minorities continue to be underrepresented in engineering. Women constituted only 18.6% of those awarded bachelor degrees in engineering in 97-98[4]. Underrepresented minorities (African American, Hispanic, and Native American) accounted for only 11.75% of the bachelor degrees in engineering[4]. Minority women are the least represented in engineering, receiving only 3.2 percent of the bachelor degrees in engineering in 1998[4]. Why are these numbers so low for engineering when women and minorities are entering other previously European-American, male-dominated fields, including all other scientific disciplines, in record numbers[5]?

Although early studies demonstrated a tendency for girls to self-select out of advanced math and science courses in high school[6], current research indicates that this is no longer the case[7]. Differences in enrollment in math, chemistry and physics persist, however, for underrepresented minority students[7]. Meta-analyses used in previous research had also shown gender differences in mathematical abilities[8,9], however, current research has found that gender differences for math and science achievement are decreasing[7].

Despite the gains that have been made in terms of girls' enrollment and achievement in the areas of math and science, women continue to be underrepresented in engineering. Other research has focused on gender differences in attitudes toward math and science. One study found that early on girls tend to value math less than boys do[10]. However, results from the 1995 international TIMSS study found that girls and boys in 4th and 8th grades were similar in their attitudes toward science and mathematics. Among 8th graders, females and males were about equally likely to like mathematics. Some differences were apparent by subject area, however. Eighth grade males and females differed little in liking of biological science or earth science, but male students in most countries were more likely to like physical science than were females[7].

The U.S. Department of Education and The National Institute for Science Education recently published Women and Men of the Engineering Path[11]. The study reviews longitudinal data from the High School and Beyond, Sophomore Cohort Longitudinal

Study in hopes of determining what attracts and keeps male and female students in the engineering pipeline. In determining which factors are responsible for students choosing engineering majors, the study considered monetary rewards, parental support, socio-economic standing, and high school preparation (courses taken, school ranking, mini-SAT score percentile). In sum, the study concluded that males who had originally decided to major in engineering, and then changed their minds between 12th grade and college were "curricularly challenged", however, this was not the case for women. The author goes on to state that "neither grades nor SES add anything to the explanatory power of the model", and that "for women, something else is at work that no regression equation will uncover" (p. 61). Although the Women and Men of the Engineering Path study does include how the culture of engineering affects women's choice to enter, or not enter, engineering majors, the study comes short of integrating the more nebulous factors of culture into the model for statistical analysis.

Hackett and Betz[12] suggested that women's socialization provides them with less exposure to the information that allows individuals to develop strong self-efficacy, beliefs concerning a person's ability to successfully perform a given task or behavior, for traditionally male occupations. This social cognitive hypothesis proposes that low self-efficacy for the tasks required to enter and succeed in engineering may be one of the primary reasons women continue to be underrepresented in engineering. If women have less confidence in their abilities to successfully complete engineering programs, irrespective of their actual capabilities, they will be less likely to enter engineering.

A number of other studies have seized upon the application of self-efficacy to women's career development. Research has shown a number of factors explain women's low self-efficacy for engineering-related tasks, including a lack of science and math preparation[12,13,14,15,16], a lack of role models[17,18,19], and the perception of engineering as incompatible with women's roles[9]. While little research has focused on the career development of minority women, existing findings suggest that many of these same factors are responsible for minority students' low self-efficacy for engineering-related tasks[20,21,22]. A handful of studies have examined specifically which factors interact to predict math or science-related college major choice for men and women[23,24,25,26,27,11]. Only the Women and Men of the Engineering Path study focuses specifically on predictors of majoring in engineering.

The present study examined how social cognitive theory explained which high school students entered engineering majors. This study is unique in that it is a longitudinal design, tracking students through the transition from high school to college. The study focuses on engineering, an area that is different from other math- and science-related majors in some important ways, including the continued low involvement of women.

METHOD

High school students participating in recruiting events for an engineering college participated in the study. Students from 48 public and private high schools throughout the state, representing inner-city, suburban and rural communities, were in attendance. A

total of 507 students returned the study questionnaires. Listwise deletion to eliminate missing data resulted in a sample of 245. Of this remaining sample, 62.2% were male, 37.3% were female, 77.3% were Caucasian, and 22.7% were ethnic minorities.

Participants completed a Career Expectations Questionnaire. The Career Expectations Questionnaire consisted of the following subsections: Demographic Information (gender, year in school, ethnicity and parental occupations), Educational Background (school rank based on Stanford 9 scores, GPA, and math and science classes taken), Academic Confidence [based on Betz and Hackett's[28] Mathematics Self-Efficacy - College Courses Scale, Lent, Brown and Larkin's[29] Academic Milestones Self-Efficacy Scale, and Hackett, Betz, Casas and Rocha-Singh's[30] Coping Self-Efficacy Scale], Occupational Interests [based on Betz and Hackett's[31] Career Interest Scale and Lopez and Lent's[16] Math/Science Interests Scale], Outcome Expectations [Hackett, Betz, Casas and Rocha-Singh's[30] and Lent, Lopez and Bieschke's[25] Outcome Expectations Scales], and Career Plans.

Participants were mailed follow-up questionnaires at one year intervals over the next two years to determine what career decisions they had made at that time. Data were analyzed using logistical regression equations.

RESULTS AND DISCUSSION

The results of the logistical equation model explained roughly 40% of the variance for choosing an engineering versus a science or non-science major. However, not all of the independent variables (the Career Expectations Questionnaire subsections) contributed to the variance being accounted for.

The self-efficacy variables included in this model were engineering self-efficacy, coping self-efficacy, and milestones self-efficacy. Only Engineering Self-Efficacy emerged as a significant predictor of majoring in engineering when entered in a model along with gender. When Career Interest in Engineering was added to the model, Engineering Self-Efficacy ceased to be significant, indicating that Career Interest in Engineering is capturing Engineering Self-Efficacy's contribution to predicting majoring in engineering. Although social cognitive theory states that self-efficacy is a more powerful predictor of career choice than interests[21,32,33], this is not the case when individuals have sufficient exposure to a particular domain, comparable ability levels, and efficacy-building experiences.

This sample was selected from an engineering recruiting event. The majority of the students at the event were presumably at least somewhat interested in pursuing an engineering degree, and most were selected to attend by their teachers from higher-level math and science courses. Although gender remained a significant predictor in the present study, it may be that this relatively homogeneous group did have sufficient exposure to the engineering domain, comparable ability levels, and similar efficacy-building experiences.

Given that self-efficacy did not emerge as a significant predictor of choice of an engineering major, it is important to underscore that gender differences for self-efficacy continue to persist. Women in the present study took slightly higher levels of math and science than the men and earned a significantly higher ($p = .001$) GPA than the men. However, a T-test comparison of mean scores for engineering and academic milestones self-efficacy revealed a significantly lower score for women. This is comparable to Betz and Hackett's original study where 70% of the males, but only 30% of the females, felt they could successfully complete engineering educational requirements[31].

Finally, the demographic variable, SES, also failed to significantly predict choice of an engineering major. This is in keeping with Rotberg, Brown and Ware's[34] finding that socio-economic status (SES) was not predictive of the range of occupations considered by their community college sample. However, Post-Kammer and Smith[35] found that among economically-disadvantaged students aged 16-24, females had extremely low self-efficacy for engineering and drafting careers. Hannah and Kahn's[36] study on Grade 12 students in Canada found that high SES females were more likely than low SES females to choose male-dominated occupations. Also, the study found that the low SES group reported significantly lower self-efficacy than the high SES group, regardless of the occupational prestige level. In fact, low SES students in the present study did have significantly lower Milestones Self-Efficacy scores than high SES students.

Gender consistently entered as a significant predictor of choice of an engineering major. Not surprisingly, this indicates that men were significantly more likely to enroll in an engineering major than women. Not until the final equation where gender significantly interacted with both intent to major in engineering and outcome expectations did gender cease to be significant on its own. This means that when female students in the sample planned to be an engineering major while in high school, and had high positive expectations for the results of obtaining a degree in engineering, their gender no longer affected their chances to become an engineering major.

Gender interacted significantly with intent to major in engineering so that women who intended to major in engineering during high school were much more likely to do so than women who did not intend to major in engineering during high school. On the other hand, men who intended to major in engineering during high school were only somewhat more likely to major in engineering than if they did not intend to major in engineering during high school.

This result is not surprising when one considers the rarity of a female high school student intending to major in engineering. Female high school students are often unaware of what engineering is, the variety of options within engineering, and the socio-economic benefits of being an engineer[37,38]. Those females who do get this information must often battle subtle and outright discouragement by peers, educators, counselors, parents and others before proclaiming their intent to major in engineering[37,38,6]. For those few females who do intend to major in engineering while still in high school, their resolve appears to carry them through the obstacles that they meet up against. This appears not to be the case for males, however, for whom it is more common to intend to major in engineering

during high school. So even though males were more likely to major in engineering if they intended to major in engineering than males who did not intend to major in engineering, this intention was not as significant for males as it was for females.

This finding has significant implications for efforts to recruit more women into engineering fields. It suggests that interventions during or before high school that would result in young women intending to major in engineering during high school would be the most effective technique for recruiting women into engineering majors. Encouraging young women to resolve to enter a non-traditional career such as engineering early on in her academic career may provide her with the vision and resolve to achieve that goal.

Women with high positive outcome expectations were more likely to enroll in engineering than men with high positive outcome expectations of the results of obtaining an engineering degree. The surprising finding for this gender by outcome expectations interaction is the fact that for males, the more positive their outcome expectations for obtaining an engineering degree, the less likely they were to enroll in engineering. It may be that as the male students perceived the rewards of obtaining an engineering degree increasing, they felt it was less likely obtainable. What may also be an important consideration is the fact that the women in this sample had a statistically higher GPA than the men, although there were no gender differences for levels of math and science classes taken. (Neither level of math and science classes taken nor GPA emerged as a significant predictor of choice of an engineering major.)

An even more surprising finding was that ethnicity as a main effect never entered into the equation as a significant predictor of choice of an engineering major. Furthermore, other than the interaction with intent to major in engineering, ethnicity failed to result in any other significant interactions. Even when each of the regression models was rerun testing only Caucasian (majority) against African American, Native American, and Hispanic/Mexican-American (minority), selecting out Asian-American and other ethnicities, ethnicity failed to emerge as a significant predictor of engineering majors.

It may be that the low number of minority students in the sample (58, 11.2%) did not allow for a valid comparison between minority and majority students. An alternative hypothesis is that the minority students involved in this sample, which was selected from an engineering recruiting event, were not representative of the minority student population. In other words, by their very presence at the event, these students were unique in some important ways from the general population of high school minority students. Hackett et al found that when academic preparedness was controlled for, ethnicity differences for academic and career self-efficacy disappeared[30].

In any event, it is clear that, at least with this sample, the variables that explain why women do not choose to major in engineering are different from the variables that explain why minority students do not choose to major in engineering. Further research needs to be conducted in this area.

A comparison between mean differences underscores the relative importance of gender over ethnicity as a predicting factor for which students enter into engineering majors. Men in this sample scored significantly higher on measures of engineering self-efficacy, milestones self-efficacy, career interest in engineering, outcome expectations, intent to major in engineering, and actually majoring in engineering. Women had significantly higher GPAs than men. The only significant difference between majority and minority students in this sample was that majority students were significantly more likely to intend to major in engineering. In fact, for this sample, minority students were not significantly less likely than majority students to choose to major in engineering. As discussed previously, these results may be due to sample effects.

As with the interaction between gender and engineer, the interaction between ethnicity and intention to major in engineering indicates that minority students have a much greater likelihood of pursuing engineering if they intend to do so during high school as compared to minority students who do not intend to major in engineering during high school. On the other hand, a majority student only has a moderately better chance of pursuing engineering if they intend to do so during high school compared to majority students who did not intend to major in engineering during high school. This appears to be the same phenomenon as was witnessed with the gender by engineer interaction: So few minority students actually intend to pursue an engineering major while in high school that those who do are resilient enough to overcome obstacles that might lie between them and their goal, or they have already overcome great obstacles to have formed this intention.

Hackett et al[30] and Byars and Hackett[26] suggested that outcome expectations are especially pertinent to the career choices of minority women because these women may perceive more potential discrimination, and therefore less positive outcomes, in such a homogeneous field. In fact, Byars and Hackett found that outcome expectations and perceptions of barriers were significant predictors of science-related choices for minority women. When a regression was performed to determine what factors predicted choice of an engineering major for the 23 minority women in the present sample none of the selected variables, including outcome expectations, emerged as significant predictors. However, it may be that the n for this sub-sample is too small to produce meaningful results.

CONCLUSIONS AND IMPLICATIONS FOR RECRUITMENT

The present study examined social cognitive predictors for which students would ultimately choose to major in engineering versus other fields. Results of the study indicate that minority male students who intended to major in engineering during high school were the most likely to choose to major in engineering. Women with low positive outcome expectations for engineering who did not intend to major in engineering were among the least likely to enter into engineering as a college major.

These results indicate that in order to increase the number of women majoring in engineering efforts should focus on increasing girls' positive expectations of what an engineering degree would do for them, and targeting interventions early so that the intent

to major in engineering takes place during high school. Increasing girls' positive outcome expectations for engineering necessitates first discovering what they want to accomplish from a career and then demonstrating how engineering can fulfill those values. This strategy could be implemented through individual or group outreach programs specific to young girls, or through large-scale media campaigns to increase the social desirability of engineering in general.

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