

Leaving Engineering: A Multi-Year Single Institution Study

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Abstract

This paper describes the results of a multi-year study designed to uncover the reasons why students choose to leave engineering. The authors collected profile information hypothesized to be factors in retention or attrition (e.g. academic preparation, reasons for choosing engineering, participation in academic support and extracurricular activities) and measured the factors that influenced students' decision to switch out of an engineering degree program. The reported results are from data collection over three years at a large engineering degree granting institution in the eastern U.S.

Introduction

The U.S. Bureau of Labor estimates that the number of jobs to be filled in engineering and science will grow at more than three times the rate of other professions. However, a recent study found that the number of high school seniors planning on entering engineering careers has dropped more than 35 percent in the past 10 years (Santovec, 2004).

Additionally, recent figures (Board, 2006; Gibbons, 2005; NSF, 2004) show that attrition rates in undergraduate engineering are still an area of concern. Retention numbers are notoriously hard to pin down due to variability in how the data are collected. Cohort studies, in which individual students are tracked for retention, are the most effective; they indicate that engineering students experience relatively high attrition and underrepresented students are retained at a lower rate than majority students (Smith, 2000). A National Center for Educational Statistics (NCES) longitudinal study of first-year S&E students in 1990 found that fewer than 50 percent had completed an S&E degree within five years (NSF, 2004).

Understanding why some students leave engineering is an important step in addressing low retention. This study examines the factors that influenced the decision to leave engineering for students from a large engineering degree granting institution in the eastern United States.

Background and Related Literature

Retention and Engineering

Two landmark studies have both informed the engineering education community and influenced research retention in engineering. Seymour and Hewitt's (1997) qualitative work identified two categories of students who leave science / engineering programs: those who become bored or disappointed with the curriculum and those who feel they must leave because of a loss of academic self-confidence in the competitive environment. Adelman (1998) analyzed actual behavior of men and women studying engineering and described the path that engineering students followed to both cross an initial "threshold" of studying engineering as well as completing an engineering degree. His study did find gender differences (such as scores on SAT/ACT) between "Migrants" – those students who began an engineering curriculum but left before completion. Of those that leave, a disproportionate number of these students are women, ethnic minorities, or both. Consequently, much recent work has especially focused on the barriers to success and retention for students who fall into one of these groups (e.g., Blickenstaff, 2005; Marra, Rodgers, Shen & Bogue, 2009; May & Chubin, 2003).

Bean and Eaton (2000) proposed a psychologically based model of retention in which a reciprocal relationship of commitment existed between students and the institutions that they attended. Institutions demonstrated their commitment to their students by being sensitive to the needs of the particular students that it served and by offering its students academic and social

support. The primary way that students demonstrate their commitment to their university is by remaining through to the end of their degree programs. Such decisions to continue to degree completion are influenced by things such as campus climate and feelings of belongingness. Focusing specifically on STEM fields, the Bean and Eaton (2000) suggest that a key component of increasing overall retention and especially that of underrepresented students is to demonstrate to students a commitment to their comfort and success in their programs.

Blickenstaff (2005) lists nine explanations for the lower participation and retention rates among girls and women pursuing STEM related careers. Among them, the author includes male-oriented curricula, a “chilly climate” towards women in the sciences, as well as lack of preparation for success. Indeed, each of these may serve as potential barriers to success in STEM fields for all students. However, research indicates that their influence may be particularly damaging in the retention of under-represented students. Each of potential barriers to retention in engineering and other STEM fields will be discussed in the following sections.

Engineering “climate”

Perhaps especially applicable to students from underrepresented groups, the perceived “climate” in engineering programs contributes to students’ feelings of belongingness and is potentially detrimental to their retention in those programs. Campus “climate” refers to the attitudes, perceptions and expectations associated with an institution (Rodgers & Summers, 2008). In engineering education, however, the term climate often refers to work from Sandler et al. who coined the term “chilly climate” to describe educational practices and environments that treated women and men differently and that had an adverse impact on women. Chilly climate comprises “the myriad small inequities that by themselves seem unimportant, but together create a chilling environment.” (Sandler, Silverberg & Hall, 1996, p. 1). Cabrera, Nora, Terenzini,

Pascarella and Hagedorn (1999), in their explanation of the student-institution fit perspective, propose that perceptions of an unwelcoming climate in an academic setting creates a barrier between students and the institution. This is a key point because this barrier obstructs students from feeling comfortable accessing academic and social support resources available. This discomfort becomes reiterative in that, in times of academic or personal struggle, the isolated students become less likely to seek help and consequently are often rendered even more isolated and at an academic disadvantage.

In engineering, or STEM fields in general, students may perceive a chilly climate either implicitly or explicitly. de Pillis and de Pillis (2008) examined gender-biased undertones in engineering school mission statements and found definite masculinized sentiments that devalued personality traits usually associated with women, including being soft-spoken and likeable. In a research methods course, Diangelo (2006) observed faculty exclusion of women and students of color in a class that was comprised mostly of Asian students. Instead, the most vocal students, mostly male, were most acknowledged by the professor, despite being in the considerable minority in the course. Connections between students and faculty are crucial particularly in STEM fields, where faculty write the recommendations and offer research opportunities necessary for advancement and success in the area. Consequently, those students left behind the barrier imposed by the chilly climate may find themselves locked out of future opportunities as well (Johnson, 2007).

Preparation for difficult course material

Concerns regarding students' level of preparation for engineering programs have been long considered in the literature (particularly as they pertain to women and minorities (e. g. Jacobs, 2005; Nauta, Epperson, & Kahn, 2003). Seymour and Hewitt's (1997) study that

compared science students who persist and those who do not found that there were no real differences in the factors of high school preparation, ability, or effort expended in their coursework between students who remain and those who switch. Additionally, these results have been confirmed to apply to women science engineering students by other studies (Brainard & Carlin, 1998; Seymour & Hewitt, 1997), and particularly, recent data has shown that the gender gap in high school math and science achievement has nearly been eliminated and what gender differences remain are small (Hyde & Linn, 2006).

Mau's (2003) six-year study offers different findings; he followed eight graders who professed intent to pursue science and engineering careers, found that the only reliable predictors for persistence across race/ethnicity and gender were academic preparation and math-self efficacy. Looking at conditions that occur during engineering curricula, studies from Felder et al. (1993) and more recently, Suresh (2006) both found that performance in key introductory undergraduate courses – “barrier” courses – courses that are required for degree but have high withdraw or failure rates (e.g. calculus, physics) – are related to engineering persistence.

Pedagogical Style

Blickenstaff (2005) cites pedagogical style as a possible deterrent to engineering students, and particularly for women and students from particular ethnic backgrounds. The lecture format that dominates many engineering courses, especially at the lower levels can be detrimental in that it potentially creates a barrier between students and instructor. Thus, it is easier to become disconnected from one's engineering program, as voiced by the women in Johnson's (2007) study of how science professors inadvertently discouraged women of color. These women indicated that, not only did the lecture format distance them from the professor, but the general competitive nature of their courses was not conducive to the comfort level they needed for

success. Similarly, the female participants in Robinson and McIlwee's (1991) study the culture of engineering also indicated the detrimental effects of the competitive engineering "culture."

Typical pedagogical style in STEM majors may also be incompatible with students' personal approaches to learning course material. Bernhold, Spurlin and Anson's (2007) recent path study followed a first year engineering cohort for three years and analyzed how learning styles relates to GPA, performance in first year courses, gaining entry into an engineering major and staying in engineering. Their results show that students who display a learning style that focuses on "Why" and "What if" issues exhibit both lower grades and have higher attrition rates than the other two learning styles that are characterized by "What" and "How".

Motivation & Self-efficacy

Eccles et al. (1983) described motivation to engage in a task as the result of the interaction of expectancy of success and the value placed on the task. That is, $Motivation = Expectancy \times Value$. *Task value* has four components: cost (what one must give up in order to engage in a task), interest value, utility value (usefulness of the task) and attainment value (value placed on the results of completing the task). The authors' definition of *expectancy for success* suggests a primary focus on self-efficacy.

Self-efficacy was defined by Bandura (1977) as "the beliefs in one's capacity to organize and execute the courses of action required to produce given attainments" (p. 3). Further, Pajares (1996) contends that self-efficacy affects one's task choice, how long one persists at a task in the face of struggle, and how much effort is put into the task. Akin to self-confidence, self-efficacy is task specific, wherein one can believe positively in the likelihood of success in one domain while lacking efficacy in performing well in another. Thus, a student can have a high self-efficacy in the task of completing a degree in a humanities field, for example, while maintaining

low self-efficacy in their ability to meet the requirements for a degree in engineering. The task-specific characteristic of self-efficacy explains, in part, why some students (*migrants*; Adelman, 1998) simply leave engineering and go into another program, rather than leaving their institutions altogether.

According to Bandura, students receive information regarding their likelihood of success from four major sources: mastery experiences, social persuasion, vicarious experiences and emotional and physiological states. In the case of mastery experiences, as discussed in a previous section of the present discussion, students' perceptions and actual preparation for success in engineering and other STEM fields affects their perceptions of their chances of completing their engineering degree, particularly if they appear less prepared than their classmates. For the women in Nauta, Epperson and Wagoner's (1999) study of attributions for success and failure and persistence in engineering, non-persisters tended to attribute their struggles in engineering to *lack of ability* to master the material. Conversely, persisters largely attributed their successes and failures to their *ability* to master the material.

The value of social persuasion and vicarious experiences appears in the engineering literature regarding the importance of social support and role models to success in STEM fields. As a source of efficacy expectation, *social persuasion* refers to one's feelings of efficacy as the result of the encouragement of significant others, such as parents, friends and faculty. Similarly, *vicarious experiences* can positively affect self-efficacy in a task through observation of relevant others successfully completing the task. These "relevant others" must be models with whom one identifies and viewed as similar in relevant attributes (e.g. age, race/ethnicity, gender, ability level). While such support is important for all engineering students, given their considerable underrepresentation, social support and availability of mentors is crucial for women and ethnic

minorities pursuing engineering careers. Rask and Bailey (2002) determined that a correlation existed between the number of female students pursuing STEM careers and the number of female faculty in those programs. Investigating the importance of mentors for high school girls, Packard and Nguyen (2003) found that contact with female mentors in STEM fields allowed girls to visualize themselves in these fields, thus creating “possible selves.” Similar findings regarding the impact of mentoring and social support on students’ self-efficacy in engineering and other STEM fields can be found in the present literature (e. g. Bettinger & Long, 2005; Downing, Crosby, & Blake-Beard, 2005).

Finally, *emotional and physiological states* as a source of efficacy expectation are evidenced in the disruptive anxiety associated with phenomena such as *stereotype threat* (Steele & Aronson, 1995). Stereotype threat occurs when an individual is aware of a negative stereotype in a specific realm that exists about a group to which she or he belongs, and the knowledge of this stereotype incites anxiety which can hinder performance. This phenomenon has been extensively studied as it applies to women and minorities in the sciences (e. g. Bergeron, Block, & Echtenkamp, 2006; Kellow & Jones, 2008; Ryan & Ryan, 2005).

However, even without the existing stereotype, anxiety that results from students’ attributions for their failures (i.e. to natural ability vs. hard work), their comfort level with the pedagogical tendencies of many STEM disciplines, the feelings of lack of belonging and their perceptions of how prepared they are for success can hinder the performance, and ultimate retention of all students, regardless of gender or ethnic background. Compatibility with the predominant pedagogical style, comfort with approaching faculty for academic and social support and personal learning styles also contribute to students’ overall assessments of their sense of belonging in their engineering programs, and ultimately, students’ likelihood of

persistence.

Current research literature provides insights into different factors (e.g. learning styles, performance in key courses) – some of which are curricular related – that may impact engineering persistence. Valuable as these resources are, the need for further studies comes from both the lack of consistent research results and the changing nature of students (e.g. shrinking gender gap in math and science achievement (AAUW, 2008)). This paper begins to address this need via a multi-year study of male and female students who left engineering at one of the largest producers of engineers in the U.S.

Research Questions

1. What are the factors that influence their decision to transfer out of engineering as perceived by students? How do these differ by gender and ethnicity?
2. Do high school preparation, period of time in engineering and original confidence when beginning an engineering degree predict the factors that influence students to transfer out of engineering, and in what way?
3. What is the influence of the three factors on GPA, confidence in completing a new major and major choosing?

Methodology

Subjects were undergraduate engineering students at a large eastern U.S. institution. Of the 113 responses that were collected in 2004, 2007, and 2008, there were 75 males and 38 females. The majority of the participants (91, 80.5%) were Caucasian, and most of them came directly into their undergraduate program from high school (93, 82.3%). Table 1 shows the demographic information of participants including gender, ethnicity status, school year information, and where they were before they attended this institution.

Table 1.
Description of Participants

Demographic Variables	N	%
Gender		
Male	75	66.4
Female	38	33.6
Ethnicity/Citizenship		
African/Black American	5	4.4
Asian American & Pacific Islander	5	4.4
Latino/Hispanic American	4	3.5
Caucasian/White American	91	80.5
Other	2	1.8
No Response	6	5.3
Where were you before your first semester/term at this institution?		
High School	93	82.3
Two-Year College	2	1.8
Four-Year College	5	4.4
Military	5	4.4
Working a Full-time Job	1	.9
No Response	7	6.2
Total	113	

Academic advising officers receive notification with a student transfers out of engineering. These students received an email explaining that the institution wished to gather data on their decision to transfer out of engineering and a link to the online survey.

The AWE Students Leaving Engineering (SLE) instrument (see aweonline.org for instrument and Marra, Rodgers, Shen and Bogue (2007) for details) is a quantitative instrument to collect data on the reasons engineering students decide to transfer out of engineering. In addition to gathering basic demographic data the instrument includes items on the reasons for initially pursuing engineering, high school preparation, intended transfer destination, career plans, participation in extracurricular activities, factors that impacted respondents' decision to leave engineering

Results

Data were analyzed using SPSS 15.0. We conducted an exploratory factor analysis (EFA), correlation, chi square analysis and regression analysis to answer the research questions. The results are organized around the study research questions: Factors that influence students' decision to transfer out of engineering, input variables that may predict the factors, and the relationship of the three factors to outcome variables.

RQ1: What factors influence students' decision to transfer out of engineering?

Exploratory Factor Analysis

We asked students to report how much a variety of factors contributed to their decision to leave engineering. The factors we presented were based on our review of the literature. Students responded with their degree of agreement to sixteen factors on a scale of 1 to 5 where 1 indicated the factor had “no influence” on their decision and 5 a “significant influence”. An exploratory factor analysis with the Principle Axis Factoring extraction method with Varimax rotation was performed. Five factors emerged from the 16 factors presented. Using the cut-off value of .15 for cross loading, six items were deleted and three factors remained with Eigenvalue greater than one. The three factors explained 65.92% of the total variance, and each explained 35.61%, 18.72%, and 11.59% of the variance, respectively. The three factors can be described as poor teaching and advising, curriculum difficulty, and lack of belonging. Table 2 shows the factor loading, and Table 3 displays the description of the three factors.

Table 2.

Factor Loadings for items on decision to leave engineering

Factors	Factor 1 (F1)	Factor 2 (F2)	Factor 3 (F3)
Factor 1 – Poor Teaching & Advising (Eigenvalue = 3.56; 35.61% of variance explained)			
Poor teaching by engineering faculty members or graduate assistants	.717	.302	.135
Poor teaching by math/science faculty members or graduate assistants	.539	.285	.226
Foreign language accents of faculty or graduate assistants made it difficult to understand course material	.628	.436	-.013

Faculty advisers gave me poor advice on courses to take or were not responsive to my needs	.754	.036	-.144
Factor 2 Curriculum Difficulty (Eigenvalue = 1.87; 18.72% of variance explained)			
Engineering classes were unfriendly	.211	.457	.060
I am unhappy with my grades in engineering	.344	.762	.079
Overall curriculum was too difficult or too lengthy	.100	.826	.113
Factor 3 Lack of Belonging (Eigenvalue = 1.16; 11.59% of variance explained)			
A non-engineering career would be more fulfilling to me	-.015	-.112	.733
Did not feel as if I belonged in engineering	-.032	.163	.791
Engineering curriculum is too narrow; it isn't applicable to my other interests	.095	.150	.441

Table 3.

Descriptive statistics of factors

Factors	Overall Mean (SD)	Reliability (# of items)
Factor 1 -Poor Teaching & Advising	2.38 (1.17)	.79 (4)
Factor 2 - Engineering curriculum was too difficult (Curriculum Difficulty)	2.36(1.16)	.75(3)
Factor 3 - Lack of Belonging in engineering	3.21(1.22)	.68(3)

RQ1 – continued -How do these factors differ by Gender and Ethnicity?

Three independent sample t-tests were performed to examine factor response differences between male and female students; no significant differences were found, $t(95) = .81$, $t(95) = .68$, and $t(95) = -.95$, $p > .05$, respectively. Table 4 shows the result of the t-test.

Table 4. t-test results by gender on three factors

Variable	Male (n=63) M (SD)	Female (n=34) M (SD)	t-test				
			90% C.I.		t	df	Sig. (2-tailed)
			Lower	Upper			
Poor Teaching & Advising	2.45 (1.13)	2.25 (1.25)	-.29	.70	0.81	95	0.42
Curriculum Difficulty	2.43(1.21)	2.26 (1.08)	-.33	.66	0.68	95	0.50
Lack of Belonging	3.13 (1.27)	3.37 (1.10)	-.76	.27	-0.95	95	0.35

Three independent sample t-tests were used to examine the differences between Caucasian (N = 79) and minority (N = 15) respondents. At the $p > .05$ level, no significant differences existed for two of the factors - poor teaching and advising and lack of belonging, $t(92) = -.02$, $t(92) = -1.77$, $p > .05$, however there did exist a trend towards significance for lack of

belonging with minorities perceiving this factor as more of a contributor to their decision to leave engineering than Caucasians. Further, minority respondents reported significantly higher scores for curriculum difficulty, $t(92) = -2.15, p < .05$ indicating they perceived curriculum difficulty as a greater factor that made them transfer out of engineering than Caucasian respondents. Table 5 shows the t-test results.

Table 5. t-test results by ethnicity on three factors

Variable	Caucasian (n=79) M (SD)	Minority (n=15) M (SD)	t-test				
			95% C. I.		t	df	Sig. (2-tailed)
			Lower	Upper			
Poor Teaching & Advising	2.41 (1.18)	2.42 (1.20)	-.66	.65	-0.02	92	0.99
Curriculum Difficulty	2.26 (1.14)	2.96 (1.08)	-1.36	-.05	-2.15*	92	0.03
Lack of Belonging	3.17 (1.19)	3.76 (1.10)	-1.25	.07	-1.77	92	0.08

Note. * $p < .05$

How does high school preparation, period of time in engineering and original confidence when entering engineering predict the factors (RQ2)?

Other data collected in SLE may help explain students' responses to the three identified factors. High school preparation, the period of time students stayed in engineering, and how confident they were when they began their engineering program were examined to explore the formation of the three factors.

High School Preparation as a contributor to the three factors

Students were asked if their high school coursework adequately prepared them to be successful in their engineering program. High school preparation is related to the factor results. Those who reported their high school degree *did not* adequately prepare them for studying engineering reported significantly higher scores for curriculum difficulty, $t(95) = -4.24, p < .001$ and poor teaching and advising", $t(95) = -2.51, p < .05$ than respondents who indicated their high school work had prepared them. There were no significant differences for lack of belonging

between the students who reported their high school course work prepared them adequately and those who did not. Table 6 displays the result of these t-tests.

Table 6
t-test results by high school course preparation on three factors

Variable	Yes (n=57) M (SD)	No (n=40) M (SD)	t-test				
			95% C. I.		t	df	Sig. (2-tailed)
			Lower	Upper			
Poor Teaching & Advising	2.14 (1.00)	2.73 (1.21)	-1.06	-.13	-2.51*	95	.013
Curriculum Difficulty	1.98 (1.05)	2.92 (1.10)	-1.38	-.50	-4.24***	95	.000
Lack of Belonging	3.11 (1.27)	3.37 (1.12)	-.76	.24	-1.04	95	.30

Note. * $p < .05$, *** $p < .001$

Time in Engineering as a contributor to the three factors

The respondents reported they had stayed in engineering for about 13.5 months ($M=13.51$, $SD = 8.40$). Using a simple linear regression, we found the number of months students stayed in engineering was a predictor of two factors – poor teaching and advising and curriculum difficulty. Specifically, as a student’s stay in engineering increased by one month, his or her perception of poor teaching and advising as a factor that influence the decision to leave engineering was estimated to increase by .05 on the one to five scale (95% CI: 02, .08; Beta = .360). Similarly, as a student’s stay in engineering increased by one month, his or her perception of curriculum difficulty as a factor is estimated to increase by .04 (95% CI: 01, .07; Beta = .28).

Table 7 shows the regression results.

Table 7.
Regression between three factors on months in engineering

Variable	AdjR ²	B	SE B	β	95% CI		t	df	Sig.
					lower	upper			
					Poor Teaching & Advising	.12			
Curriculum Difficulty	.07	.04	.01	.28	.01	.07	2.75**	91	.00
Lack of Belonging	.00	-.00	.02	-.03	-.04	.03	-.24	81	.81

Note. ** $p < .01$, *** $p < .001$

Original Confidence as a contributor to the three factors

Using a simple linear regression, we found students’ reported initial confidence level for completing their engineering degree (1 = not very confident; 4 = very confident) significantly predicted the lack of belonging factor. The analysis indicated showed a negative relationship; specifically that as confidence level in completing an engineering degree increased by one, students’ perception of lack of belonging as a factor was estimated to decrease by .43 on the one to five scale for influence of factors (95% CI: -.69, -.18; Beta = -.34). Table 8 presents the regression results.

Table 8.
Result of regressing three factors on original confidence level

Variable	AdjR ²	B	SE B	β	95% CI		t	df	Sig.
					lower	upper			
Poor Teaching & Advising Curriculum	-.01	.00	.13	.00	-.25	.25	-.004	93	.99
Difficulty	-.01	.08	.13	.07	-.17	.33	.62	92	.54
Lack of Belonging	.10	-.43	.13	-.34	-.69	-.18	-3.44**	93	.001

Note. **p < .01

Influence of Three Factors (RQ3) on GPA, Confidence to complete degree and Major Choosing

Having identified the factors that influenced students’ decision to leave engineering we examined how these factors related to future behaviors and outcomes – specifically cumulative GAP, their confidence in completing a degree and their choice of a new major.

Three Factors and GPA

About 44.2% students reported they had lower than a 3.0 GPA when they were in their engineering program, and 44.3% reported they had 3.01-4.00 GPA. Table 9 shows the GPA information.

Table 9.
Cumulative GPA of Participants

GPA Ranges	Frequency	Percent
2.00 or below	4	3.5
2.01 - 2.50	15	13.3
2.51-3.00	31	27.4
3.01-3.50	28	24.8
3.51-4.00	22	19.5
4.01-4.50	1	.9
Not reported	12	10.6
Total	113	100.0

Using a two-tailed Pearson correlation analysis we found that GPA was significantly correlated with poor teaching and advising, $r = -.28, p < .01$, indicating a weak yet negative relationship. GPA was also significantly correlated with factor two – perception of engineering curriculum as being too difficult, $r = -.45, p < .01$, indicating a moderate and negative relationship. GPA did not significantly correlate with lack of belonging, however this was the only one of the three factors that was positively related to GPA. Table 10 shows the correlations between GPA and three factors.

Table 10.
Correlation of GPA and Three factors

	1	2	3	4
1. Cumulative GPA	-			
2. Poor Teaching & Advising	-.28**	-		
3. Curriculum Difficulty	-.45**	.53**	-	
4. Lack of Belonging	.073	.093	.163	-
Mean	3.04	2.41	2.34	3.20
SD	.58	1.18	1.17	1.21

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

Multiple regression analysis was used to examine how the three factors explained students' cumulative GPA. The three factors together accounted for approximately 20.7% of the variance in GPA ($R_{adj}^2 = .207$), $F(3, 88) = 8.93, p < .001$. Curriculum difficulty was a significant predictor for GPA, $t(88) = -3.91, p < .001$, which accounted for 13.3% of the variance in months

in engineering not accounted for by other variables ($pr = -.365$) and uniquely accounted for 13.6% of the variance in months in engineering ($sr = -.365$). Holding other variable consistent, as curriculum difficulty increased by 1, GPA was estimated to decrease by about .22 (95% CI: -.33, -.11, Beta = -.44). Poor teaching and advising and lack of belonging were not significant predictors for GPA. Table 11 displays the result of the multiple regression.

Table 11.
Result of Multiple Regression

Variable	<i>B</i>	<i>SE B</i>	β	<i>sr</i>	<u>95% CI</u>		<i>t</i>	<i>df</i>	<i>Sig.</i>
					<i>lower</i>	<i>upper</i>			
Poor Teaching & Advising	-.03	.06	-.06	-.049	-.14	.08	-.53	88	.598
Curriculum Difficulty	-.22	.06	-.44	-.365	-.33	-.11	-3.91***	88	.000
Lack of Belonging	.08	.05	.16	.159	-.01	.17	1.71	88	.091

Note. *** $p < .00$

Three factors and Confidence of Completing a Degree

We examined how the three factors were related with students' self-reported confidence in completing current or future degree program. Pearson correlation was performed and there was no significant correlation between the three factors and confidence about completing a degree. Table 12 shows the result of correlation analysis.

Table 12.
Correlation of Three Factors and Confidence

	1	2	3	4
1. Poor Teaching & Advising	-			
2. Curriculum Difficulty	.53**	-		
3. Lack of Belonging	.09	.16	-	
4. Confidence	-.03	-.13	-.10	-

Note. ** $p < .01$

Three factors and Future Major

We were also interested to know if the factors were related with the new majors that students chose to pursue – which students indicated on the survey (see Table 13). We classified

these majors as being either technical (e.g. Computer / Information Science) or non-technical (e.g. Art / Fine Arts). Fifty students (44.2%) reported they would pursue a technical degree and 45 (39.8%) reported they would pursue a non-technical degree.

Table 13.
New Majors being Pursued

Major	Frequency	Percent
Technical	50	44.2
Non-Technical	45	39.8
Transferring to another institution	1	.9
Undecided	4	3.5
Not reported	13	11.5
Total	113	100.0

A logistic regression analysis was performed on major choosing as outcome and the three factors as the three predictors (see Table 14). Only lack of belonging was a significant predictor for major choosing, $X^2=5.483$, $df=1$, $N=113$, $p < .05$. For every one unit increase in lack of belonging, the odds for choosing technical majors (versus non-technical majors) decrease by 37.9%. Please see table 14 for the results of logistic regression.

Table 14.
Results of Logistic Regression

	B	Wald X^2	p	Odds Ratio
Poor Teaching & Advising	-.033	.022	.881	.967
Curriculum Difficulty	.013	.003	.955	1.013
Lack of Belonging	-.476	5.48*	.019	.621

Note. * $p < .05$

Discussion and Conclusions

This study of male and female students who transferred from engineering resulted in several findings of note. We organize our discussion around the factors themselves, and the constructs that are related to the factors

Factors that Influence Decision to Leave – Overall, Ethnicity and Gender

Our study showed that three factors influenced students' decision to transfer out of engineering: Poor teaching and Advising (F1), Difficulty Level of the Engineering Curriculum

(F2) – meaning it is too difficult, and a feeling Lack of Belonging in engineering (F3) (see Table 2). Conceptually these factors represent two types of influences for leaving engineering – influences that are academic in nature (F1 and F2) and influences (F3) related to students’ beliefs or feelings about their place in engineering. We note as well that the means for these factors cluster by these two categories with the academic factor means for F1 and F2 being 2.3 and 2.4 respectively and the mean for F3 – the beliefs factor – lack of belonging – being 3.2. Further, paired t-tests between these factor means showed that the lack of belonging factor mean was significantly higher than either of the two academic factors ($p < .01$). On the 5-point response scale this is a notable difference between the two sets of means, implying that this factor based in beliefs may be more of an influence towards students’ decisions to leave engineering than the academic factors.

As previously discussed, feelings of self-efficacy (or the lack of efficacy in a discipline) and the perception of stereotype threat – both of which can be classified as being based in ones beliefs – can contribute to students’ decisions to persist in difficult courses of study (Bettinger & Long, 2005; Downing, Crosby, & Blake-Beard, 2005). Our finding of Lack of Belonging as a factor contributing to students’ decision to leave engineering may be related to these constructs in that all three are related to self-beliefs. Our data do not provide the basis for knowing the nature of this relationship if it exists, however it is possible that these students lacked a sense of efficaciousness (due to one of the four sources of efficacy) that contributed to an overall sense of not belonging in engineering.

Although lack of belonging was the highest rated factor of all three for all students, some of that strength may be related to minority student experiences. The relative strength of the lack of belonging factor as compared to the “academic” factors is of further interest when one views it

together with the differences in the factors for minority and Caucasian students. Recall that minorities viewed curriculum difficulty as being significantly more of an influence on their decision to leave engineering than Caucasians (see Table 5) and there was a trend towards significance for lack of belonging – again with minorities reporting this as more of an influence. These differing perceptions for minority students – which may result from students experiencing stereotype threat or not being satisfied with their course grades – could lead to an overall sense that they do not belong in engineering. A further study that examined whether the curriculum difficulty factor predicts the lack of belonging factor could help better understand this potential relationship. Further studies – perhaps qualitative in nature – would be required to verify these hypotheses, however our results viewed in light of these prior works provides preliminary support for these ideas.

In contrast to our results for minority students, there were no differences by gender for the factors. These results are also in contrast to the academic based gender differences found by Blickenstaff (2005) and Adelman (1998). Adelman's study, however, focused on behaviors that defined the academic paths students followed and he did find gender differences such as SAT and ACT scores. All of our factors are based on self-report data; we found no gender differences for the lack of belonging factor, a factor not addressed in Adelman's study, or for the academic factors. This latter result is where our results are inconsistent with Adelman. However, the Adelman study is ten years old now and student populations have changed. The lack of gender differences for the academic factors, may be largely explained by differences closing in the preparation gap – specifically the closing gender gap in math and science preparation (AAUW, 2008; Hyde & Linn, 2006). Our subsequent analysis of the cumulative GPAs students reported does indicate the relative academic strength of the female students who chose to leave. A paired

t-test between male and female students' cumulative GPAs showed female students ($M = 3.20$, $SD = .52$) had significantly higher cumulative GPA than male ($M = 2.95$, $SD = .59$) students ($p < .05$).

Comparisons of this quantitative study to Seymour and Hewitt's (1997) qualitative study are less precise. Seymour and Hewitt's present the data on male and female students for the issues that were factors in their decision to switch out of engineering (Seymour and Hewitt, 1997, Tables 5.1, 5.2). The top ten factors for men and women differ with men listing three academic factors – curriculum overload, poor teaching, discouraged due to low grades -- as contributing to their switching decision and women listing five academic factors – the three just listed plus inadequate advising and conceptual difficulties in coursework. Although not analyzed for statistical differences, clearly there were differences in the reasons that contributed to each set of students' decision to leave engineering – results not evidenced in our current study. The remaining factors in the Seymour and Hewitt lists align more closely with our “lack of belonging” factor (e.g. “turned off science, non S.M.E major more interest). Again their study found observable gender differences in the frequencies for these factors while we found that these differences are prevalent for both male and female students.

Further, regarding the Lack of Belonging factor, we may infer that our findings are in contrast to related studies on the climate of the engineering classroom where researchers have reported that engineering schools communicate masculine themes via their mission statements (De Pillis and de Pillis, 2008) or that faculty more frequently excluded women in their class interactions (Diangelo, 2006). One would infer that such female negative messages and actions – if they existed at our subject institution – would result in women feeling a greater lack of

belonging than men. While the means did show women reporting a higher lack of belonging ($M = 3.37$ versus $M = 3.13$) the difference was not significant.

Relationship between the Factors and Input Variables

As educators we are not only interested in what precipitated the decision to leave but also what variables or conditions may help us understand how these factors come to exist, or how students come to perceive engineering in the ways that lead to their decision to leave. We have classified the factor found in this study as academic (F1 and F2 - poor teaching and advising and curriculum difficulty) and beliefs based (F3: lack of belonging in engineering). Our analysis found that the factors when viewed in these two categories are predicted by like types of inputs.

For instance, we found that the number of months spent in engineering before transferring out was positively related to both of the academic factors (see Table 7). Engineering curricula are accepted by students and faculty as being challenging, so that the fact that the difficulty of the engineering curriculum becomes more of a factor that influences a student's decision to leave the longer a "leaver" stays in engineering is not surprising. However that same relationship with the "poor teaching/ advising" factor is somewhat more disturbing. The authors recognize that the "leavers" perception of teaching and advising may be influenced by the very fact that they decided to leave, however, if we are serious as educators about our desire to retain students then we should consider examining more closely these students' teaching and advising experiences.

Similarly, we found that an academic preparation variable -- high school preparation was related to the two academic factors. Specifically the means for the academic factors for respondents who indicated that their high school education had *not* adequately prepared them for their engineering studies were significantly higher than for those who indicated high school had

prepared them (see Table 6). Thus for those who felt high school had not prepared them for engineering, poor teaching and advising and the perception of a difficult engineering curriculum were more significant factors for influencing their decision to leave engineering than for those who felt prepared by high school. These same academic related conditions did not predict the non-academic factor lack of belonging; however initial confidence in completing an engineering degree did (see Table 8). We posit that the conceptual consistency between the types of variables that predict the three factors and the factors themselves provides further support for the validity of these factors.

Beyond the strengthening of the three factors conceptually, there are other noteworthy aspects of these relationships. The perception that high school preparation is related to the academic factors is in alignment with prior research that shows the importance of students' preparation for studying engineering (Adelman, 1998; Mau, 2003). Seeing the trend for this relationship implies that engineering educators may wish to use this variable as a way to predict those who may be in danger of leaving engineering and offer early interventions.

Stereotype threat and self-efficacy also come into play for such students, who may interpret their lack of preparedness as a personal failure rather than a failure of their high school education. To support students' success in engineering, it is important to identify those students with inadequate preparation and provide ways and means for them to catch up. Educators must go beyond standardized placement tests and subsequent placement in courses stereotyped by prepared students as "bonehead", to provide effective tutoring resources and clear communications to students about why catching up is necessary.

Relationship between the Factors and Future Behaviors

Our analysis showed some relationships between the factors and how students behaved as they progressed through their new college majors. Again the lack of belonging factor shows up as being an important aspect of these relationships. The relationship of the factors to self reported cumulative GPA provides further evidence that we may need to further explore the non-academic reasons these students leave engineering. Table 10 shows that there are significant negative correlations between cumulative GPA and the two academic factors – curriculum difficulty and poor teaching and advising. Students with higher GPAs found the academic factors to be less of an influence in their decision to leave. In contrast, there is a positive correlation (but not significant) between cumulative GPA and the non-academic factor lack of belonging. This again suggests that regardless of academic ability, students are influenced to leave engineering by non-academic factors – e.g. lack of belonging.

The lack of belonging factor was also the only factor to be significantly related to the type of major students chose after leaving engineering (e.g. technical or non-technical). The more lack of belonging was a factor in their decision to leave, the less likely students were to choose a new major that was technical. The potential hypothesis of this result is that once students feel a lack of belonging in the very technical engineering major, that belief may generalize to other technical majors leading these students to gravitate towards non-technical majors. Clearly more data would need to be collected in order to ascertain students' complete reasons for their next major choice.

Lastly we examined the relationship between the factors and students' self-reported confidence in completing any major at this institution. There was no significant correlation between any of the three factors and students' reported confidence in completing their future majors. While initially puzzled over this result, we realized on reflection that the overall

institutional retention rate at this campus is high and standard for admission and matriculation across all university programs are rigorous. Thus, regardless of these students' decision to leave *engineering* it is not surprising that these students would intend to complete some degree at this institution.

Conclusions

This study examined the factors that students reported as being significant influences in their decision to transfer out of engineering. Two types of factors were found: two academic related factors, poor teaching and advising and the difficulty of the engineering curriculum; and one beliefs factor, lack of belonging in engineering. No gender differences were found for the factors however we did find differences between minority and Caucasian students for the curriculum difficulty factor and a trend towards significance for lack of belonging. In both cases the minority respondents indicated these factors were a greater influence on their decision to leave than Caucasian respondents.

Further, in subsequent analysis the lack of belonging factor seemed to emerge as the factor that may deserve the most attention. Intuitively, we may relate a sense of lack of belonging to under-represented students – however our data suggests this factor is the strongest of all three – in terms of influences on students' decision to leave engineering. In fact, the lack of belonging factor mean was significantly higher than the means for the academic factors. Overall – the results may suggest that academics are less of a reason for leaving engineering than the less tangible feelings and beliefs side of the equation. This idea is supported, for instance, by the regression result that shows that lack of belonging is negatively predicted by one's confidence in completing an engineering degree. That is, when a student is more confident in completing an engineering degree when he or she starts the program, the less a factor is lack of belonging is less

influential in the decision to leave engineering. This may imply that a positive feeling – confidence – can outweigh a negative feeling – belonging – in the decision to leave engineering. Also, lack of belonging seems to be resilient to relationships with the academic factors we tested for – specifically, the factor was not predicted by students’ perception of how well their high school degree prepared them for studying engineering, nor did it predict students’ cumulative GPA.

We recognize the limitations of the study. These students that did transfer out of engineering which may have influenced the portion of the data that is self report. We do not have students’ official academic records from their engineering classes, for example. Thus it is possible that the lack of belonging items that produced that factor are easier to agree with as a factor that influenced their decision to leave than the more concrete items that compose poor teaching and advising, and curriculum difficulty. Future versions of the instrument should be revised to attempt to unpack where this feeling of lack of belonging originates. Is it a product of poor academic performance, or a product of issues related to engineering climate – as some prior research suggests?

We also recognize the possibility of a reporting bias – these students left engineering and we do not have much control over who responds. However, the cumulative GPA data show a wide range of academic performance and indicate these are not universally students that we would predict would fail to succeed in engineering.

We are continuing to collect data on students who have left engineering using this instrument and plan to expand our data collection to other institutions. To better understand “leavers” data we are collecting comparative data, using a companion instrument, from students who persist in engineering. These results will help to develop a composite of typical persisters

and non-persisters that will, in turn, allow engineering educators, administrators and other stakeholders develop more effective retention and development strategies.

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