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Leaving Engineering: A Multi-Year Single Institution Study

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BACKGROUND
As estimates continue to indicate a growing demand for engineering professionals, retention in engineering remains an issue. Thus, the engineering education community remains concerned about students who leave engineering and must work to identify the factors that influence those students' decisions.

PURPOSE (HYPOTHESIS)
Our purpose was to identify a set of factors describing the experiences of students' in a college of engineering that are strong influences on decisions to leave and study how those factors are related to both predictor variables (e.g., high school preparation) and future behaviors (e.g., new major chosen).

DESIGN/METHOD
We solicited survey data from students who had recently transferred out of a large engineering college. We conducted exploratory factor analysis to determine the main factors for leaving engineering and then used these factors to answer the research questions.

RESULTS
Results indicate that both academic (e.g., curriculum difficulty and poor teaching and advising) and a non-academic factor (lack of belonging in engineering) contribute to students' decisions to leave engineering. We did find differences for some factors between majority and non-majority students; however, there were no gender differences.

CONCLUSIONS
Both academic and non-academic factors contribute to students' decisions to leave engineering; however, our sample indicated the non-academic factors may be a stronger influence. Implications for educators focus on addressing both academic and the belonging factor and include examining pedagogical activities that may be less welcoming to a wide variety of student groups, providing opportunities for meaningful faculty interaction and other activities designed to support students pursuing engineering degrees.

KEYWORDS
academic factors, diversity, retention

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. In contrast, a recent study found that the number of high school seniors planning on entering engineering careers has dropped more than 35% in the past 10 years (Santovec, 2004). Additionally, African American, Hispanic, and Native American students received only 5%, 7.8 %

and .5% of engineering degrees granted in 2007 while garnering 8.9%, 8.1% and .70%, respectively, of the total number of bachelor's degrees awarded that year (NSF, 2008). At the same time, the gap in *attrition* rates between men and women in engineering has narrowed and nearly disappeared. In 2007, men and women represented 82.6 and 17.4% of undergraduate enrollment in engineering programs (Engineering Workforce Commission, 2008), corresponding closely to the 81.4% of engineering degrees awarded to men and 18.5% awarded to women that same year (NSF, 2008).

Retention numbers are notoriously hard to pin down in part due to variability in how the data are collected. Cohort studies, in which individual students are tracked for retention, are the most effective; past studies indicate that engineering students experienced relatively high attrition and underrepresented students are retained at a lower rate than majority students (Smith, 2000). However a recent study using data from a multi-institution database of engineering students showed that engineering students overall are retained at rates similar to other majors (Ohland et al., 2008). Nevertheless, in large part due to the continued demand for engineers, attrition rates in undergraduate engineering are still an area of concern (National Science Board, 2006; Gibbons, 2005; NSF, 2004). Further, individual colleges of engineering have an interest in understanding why sometimes highly qualified engineering students choose to leave for another course of study. This study examines the factors that influenced the decision to leave engineering among students from a large engineering degree granting institution in the eastern United States.

Background and Related Literature

Retention and Engineering

Two landmark studies have informed the engineering education community and influenced research on 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) and those who persisted. Of those who left, a disproportionate number were women, ethnic minorities, or both.

Consequently, much recent work on engineering retention has focused specifically on the barriers to success and retention for students who fall into one of these groups (e.g., Marra, Rodgers, Shen & Bogue, 2009; May & Chubin, 2003). Another line of research has focused specifically on attrition issues for first year students (Besterfield-Sacre, Atman & Shuman, 1997; Shuman, Delaney, Wolfe, Scalise & Besterfield-Sacre, 1999) and proposes that the first semester is critical for these students' success and that most students who left reported disliking engineering. Further, a recent longitudinal study of persisters and non-persisters has added to the research base finding that although the two groups did not differ on most factors in a "persistence in engineering" survey, pre-college and positive parental influences and confidence in math and science skills were positively correlated with persistence (Eris, et al., 2010).

Blickenstaff (2005) lists nine explanations for the lower participation and retention rates among girls and women pursuing STEM related careers. Among them are

male-oriented curricula, a "chilly climate", and a lack of preparation for success. Indeed, each of these may serve as potential barriers for all students seeking success in STEM fields. Each of these potential barriers to retention in engineering is discussed in the following sections.

Engineering "climate" and belonging. The perceived "climate" in engineering programs contributes to students' feelings of belongingness and can be either detrimental or enabling to their retention in those programs. Climate may be described in several ways. Campus climate refers to the attitudes, perceptions, and expectations associated with an institution (Rodgers & Summers, 2008). However *classroom* climate focuses on the interactions within classroom settings among students and between students and faculty. In engineering, Sandler, Silverberg, and Hall (1996) used the term "chilly climate" to describe educational practices and environments that treat women and men differently and that have an adverse impact on women and others.

For all students, student to faculty interactions are an important aspect of climate and ultimately student success. For instance, Vogt (2008) studied student-faculty relationships and found that "distant" faculty relationships lowered self-efficacy, academic confidence, and GPA; all of which can impact student retention. Seymour and Hewitt (1997) linked the high attrition rates in STEM fields, in part, to the lack of faculty guidance. As the chilly climate research suggests, faculty interactions with students may be perceived as inequitable between different student groups. For instance, Diangelo (2006) observed faculty exclusion of women and students of color in a class comprised mostly of Asian students. Additionally, in their qualitative study of immigrants into engineering, Walden and Foor (2008) found that seven women, compared to three men, cited a welcoming climate as a significant influence on their decision to transfer into industrial engineering from another STEM field. Lastly, connections between students and faculty are crucial in STEM fields where faculty write the recommendations and offer research opportunities necessary for advancement and success (Johnson, 2007).

Preparation for difficult course material. Concerns regarding students' level of preparation for engineering programs have been long considered in the literature (Jacobs, 2005; Nauta, Epperson, & Kahn, 1998, Shuman, et al., 1999). For instance, Astin and Astin (1992) found that preparation in quantitative and analytical skills in high school was a strong indicator of interest in an engineering career. Zhang, Anderson, Ohland, and Thorndyke (2004) found that high school grade point average and quantitative scores on the SAT predicted engineering graduation rates, while the effects of gender, ethnicity, citizenship, and verbal SAT scores on graduation varied by institution. Looking at engineering curricula, studies from Felder et al. (1993) and, more recently, Suresh (2006) both found that performance in key introductory undergraduate courses ("barrier" courses required for the degree but that have high withdraw or failure rates (e.g., calculus, physics)) are related to engineering persistence. Course difficulty continues to play an important role in engineering persistence (Araque, Roldan, & Salguero, 2009).

For women students, Seymour and Hewitt (1997) and Brainard and Carlin (1998) both found there were no real differences in the factors of high school preparation, ability, or effort expended in coursework between science and engineering students who remained and those who switched. More recent data have shown that the gender gap in high school math and science achievement has nearly been eliminated and that the gender differences remaining are small (Hyde & Linn, 2006). However, Mau's (2003) six-year study offers different findings. He followed eighth graders who professed intent to pursue science and

engineering careers and found that the only reliable predictors for persistence across race/ethnicity and gender were academic preparation and self-efficacy in math

Pedagogical, Learning Styles and Retention

Blickenstaff (2005) cites pedagogical activities as a possible deterrent to the success of engineering students. 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 instructors. 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 their success. Similarly, the female participants in Robinson and McIlwee's (1991) study of the culture of engineering indicated the detrimental effects of the competitive engineering "culture;" a culture which was further analyzed by Godfrey and Parker (2010).

Typical pedagogical activities in STEM majors may also be incompatible with students' personal approaches to learning course material. Bernold, Spurlin and Anson's (2007) recent path study followed a first year engineering cohort for three years and analyzed how learning styles relate 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 in engineering coursework than the other two learning styles that are characterized by "What" and "How." 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.

Summary and Research Questions

The research literature provides insights into different factors (e.g., learning styles, performance in key courses) that may impact engineering persistence. Li, Swaminathan, and Tang (2009) proposed that such factors can be categorized and described as being one of external (external to the student, i.e., curriculum, institutional environment), internal (students' affective or cognitive characteristics), or demographics (age, race, socioeconomic status). Although past studies provide some understanding of engineering retention, 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) (American Association of University Women (AAUW), 2008). Further, this study's focus on identifying attributes of an engineering (versus pre college or student background characteristics) college experience that may contribute to students' decisions to leave engineering can provide educators with specific guidance on potential changes to improve retention. Our research questions are as follows:

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. Does 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 and students' choice of a new major?

Methodology

Subjects

Subjects were 113 undergraduate engineering students at a large eastern U.S. institution who left engineering during the academic years 2004, 2007, and 2008. In 2008, the institution ranked second in the U.S. in the number of engineering bachelor's degrees awarded. The institution enrolls approximately 8000 students per year, and offers 19 engineering majors, and since 2000 has six-year retention/ graduation rates of approximately 45%. The majority of the participants (91 or 80.5%) were Caucasian, and most of them came directly into their undergraduate program from high school (93 or 82.3%) (see Table 1). Seventy-five respondents were male and 38 were female. Our sample's representation of females is higher than the institution's 18% of women enrolled in undergraduate engineering. The average time respondents stayed in engineering was 13.5 months. Time in engineering is analyzed and reported on further in research question two. This institution's engineering college is similar to many others in terms of students' paths towards an engineering degree. When students enter this institution, they declare engineering as a major but are not formally admitted to a particular engineering discipline until the end of their sophomore year. In these first few semesters, students complete a first year engineering design course, pre-requisite courses in math and science, and sophomore level general engineering courses such as engineering mechanics (statics, dynamics strength of materials), and entry level electrical engineering and computer science courses. Students then progress towards their particular engineering disciplinary degree by meeting the requirements for that particular major.

We sent an exit survey to 585 students who had left the college of engineering during the academic years 2004, 2007, and 2008. Thus the 113 responses represent a response rate of approximately 19%. More details on our data collection procedures are described in the next section.

We are aware of the concern of a potential negative response bias of those who did respond. In particular, these respondents may have had a particular complaint or perhaps were less qualified academically than those who persisted. To address this concern, we conducted *t*-tests between the respondent leavers and persisters from the same years. Specifically, we looked to see if there were differences between the two groups on common academic indicators of success: entering SAT math and verbal scores and their cumulative GPA (from the semester when the leavers transferred out of engineering). All three *t*-tests found no significant differences between the leavers and the persisters. This result provides positive evidence that our sample is similar to persisters academically and lends credence to our results on why this set of students left engineering.

Procedures and Instrumentation

The institution's academic advising personnel provided lists of leaving students based on notifications that the office receives when students officially change colleges. Identified students received an email explaining that the college wished to gather data on their decision to transfer out of engineering and providing a link to an online survey. The AWE

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	

Students Leaving Engineering (SLE) instrument (see aweonline.org for instrument), is a primarily quantitative instrument designed to collect data on the reasons engineering students decide to transfer out of engineering (Marra, Rodgers, Shen and Bogue, 2007).

In addition to gathering basic demographic data (e.g., engineering major student intended to complete, University GPA, etc.) the instrument includes items on the reasons for initially pursuing engineering, high school preparation, college to which they will transfer, career plans, participation in extracurricular activities, a substantial number of items on the reasons that affected respondents' decisions to leave engineering and open-ended items soliciting other comments about their experiences in engineering.

To create the portion of the instrument on the reasons why students left engineering, we reviewed existing instruments designed for students switching majors or leaving college altogether (e.g., ACT "Withdrawing/Non-returning Student Survey", n.d.) and the interview protocols that were used in qualitative studies such as Seymour and Hewitt's (1997) landmark study on college science students' reasons for leaving. Reasons that were addressed in these protocols and instruments (e.g., financial, adequacy of departmental and university services) were included in our instrument together with other hypothesized reasons from the literature that may be unique to

18. The following is a list of factors that may have influenced your decision to transfer out of engineering. For each factor choose a number between **0** and **4** to indicate the degree to which that factor influenced your decision to leave engineering where **0** = **Not a Factor** and **4** = **A Significant Factor.**

	Not a Factor		A Factor But Not Significant		A Significant Factor
a. Money: loss of scholarship, financial aid, or other financial reasons	0	1	2	3	4
b. A non-engineering career would be more fulfilling to me	0	1	2	3	4
c. Did not feel as if I belonged in engineering	0	1	2	3	4

FIGURE 1. Question excerpt: reasons influencing decisions to leave engineering.

engineering students (Adelman, 1998; Blaisdell, 1995; Brainard & Carlin, 1998). Sample questions related to the reasons influencing a decision to leave engineering are shown in Figure 1. Students responded to each of the 16 items on a five-point scale from 0 (not a factor that influenced a decision to leave) to 4 (a significant factor). The results of an exploratory factor analysis on these items is presented in the next section as part of research question one.

RESULTS

Using SPSS, we conducted an exploratory factor analysis, correlation, chi square analysis, and regression analysis to answer the research questions. The results were organized around the study research questions: What are the factors that influence students' decisions to transfer out of engineering, input variables that may predict the factors, and the relationship of the three factors to outcome variables?

Research Question 1: What Factors Influence Students' Decision to Transfer Out of Engineering?

Exploratory factor analysis. We conducted an exploratory factor analysis with the Principle Axis Factoring extraction method with Varimax rotation on the item that addressed students' reasons for leaving engineering. Five factors emerged from the 16 reasons presented. Using the cut-off value of .15 for cross loading, six items were deleted and three factors remained with Eigenvalues 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 (see Table 2). We labeled the three factors as poor teaching and advising, curriculum difficulty, and lack of belonging (see Table 3) and used them in our subsequent research question analysis.

Research question 1 (continued): How do these factors differ by gender and ethnicity? We conducted three independent sample *t*-tests 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.

Because of the small frequencies for individual minority groups (see Table 1), we grouped respondents into Caucasian and non-Caucasian, which includes all underrepresented minorities in engineering, to examine differences by ethnicity. Note that with the exception of the five respondents classified as Asian, all others in the non-Caucasian group can be considered underrepresented minorities in engineering. Three independent

TABLE 2
Factor Loadings for Reasons 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

sample *t*-tests were used to examine the differences between Caucasian ($N = 79$) and non-Caucasian ($N = 15$) respondents (see Table 4) for the three factors. At the $p > .05$ level, non-Caucasians 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. There were no significant differences for poor teaching and advising and lack of belonging, $t\,(92) = -.02$, $t\,(92) = -1.77$, $ps > .05$; however, there did exist a trend towards significance for lack of belonging ($p = .08$) with non-Caucasians perceiving this factor as more of a contributor to their decision to leave engineering than Caucasians.

Research Question 2: How Does High School Preparation, Period of Time in Engineering and Original Confidence When Entering Engineering Predict the Factors?

Other data collected in SLE may help explain students' responses to the three identified factors. We examined high school preparation, the period of time students stayed in

TABLE 3
Factor Descriptive Statistics

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)

TABLE 4
T-Test Results by Ethnicity on Three Factors

			t-test				
Team	Caucasian (n = 79)	Non-Caucasian (n = 15)	95% C. I.		t	df	Sig. (2-tailed)
Variable	M (SD)	M (SD)	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. *$p < .05$.

engineering, and how confident they were when they began their engineering program 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. *T*-test results show that high school preparation is significantly related to the factor results (see Table 5). Those who reported their high school education *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 did respondents who indicated their high school work had prepared them. There were no significant differences for lack of belonging.

Time in engineering as a contributor to the three factors. The respondents reported they had stayed in engineering for an average of 13.5 months ($M = 13.51$, $SD = 8.40$). Using a simple linear regression, we found that the number of months students stayed in engineering was a predictor of two factors: poor teaching and advising and curriculum difficulty (see Table 6). Specifically, as a student's stay in engineering increased by one month, his or her perception of poor teaching and advising or curriculum difficulty as a factor that influenced the decision to leave engineering was estimated to increase by .05 and .04 (respectively) on a one to five scale (95% CI: 02, .08; $\beta = .360$, and *curriculum difficulty* 95% CI: 01, .07; $\beta = .28$).

TABLE 5
T-Test Results by High School Course Preparation on Three Factors

			t-test				
Team	Yes (n = 57)	No (n = 40)	95% C. I.		t	df	Sig. (2-tailed)
Variable	M (SD)	M (SD)	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. *$p < .05$. ***$p < .001$.

TABLE 6
Regression Between Three Factors on Months in Engineering

					95% CI				
Variable	$AdjR^2$	B	SE B	β	lower	upper	t	df	$Sig.$
Poor Teaching & Advising	.12	.05	.01	.36	.02	.08	3.70***	92	.000
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 in completing engineering degree 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 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 the influence of the factors (95% CI: −.69, −.18; $\beta = -.34$) (see Table 7).

Research Question 3: Influence of Three Factors on GPA and Choice of New Major

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

Three factors and GPA. About 44.2% students reported they had a GPA lower than 3.0 when they were in their engineering program, and 44.3% reported they had a GPA between 3.01 and 4.00; 12 respondents did not report an engineering cumulative GPA.

Using a two-tailed Pearson correlation analysis we found that GPA was significantly correlated with the poor teaching and advising factor, $r = -.28$, $p < .01$, indicating a weak yet negative relationship (see Table 8). 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 7
Result of Regressing Three Factors on Original Confidence in Completing Engineering Degree

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

Note. $^{**}p < .01$.

TABLE 8
Correlation Between GPA and Leaving Engineering 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. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

We used a multiple regression analysis to examine how the three factors explained students' cumulative GPA. The three factors together accounted for approximately 20.7% of the variance in GPA ($R^2_{adj} = .207$), $F(3,88) = 8.93$, $p < .001$ (see Table 9). Curriculum difficulty was a significant predictor for GPA, $t(88) = -3.91$, $p < .001$, which accounted for 13.3% of the variance in GPA not accounted for by other variables ($pr = -.365$) and uniquely accounted for 13.6% of the GPA ($sr = -.365$). Holding other variables consistent, as curriculum difficulty increased by one, 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 predicators for GPA.

Three Factors and Choice of New Major

Using a Pearson correlation, we examined how the three factors were related to students' choice of a new major. To examine this relationship, we first classified these majors as being either technical (e.g., Computer/Information Science) (see Table 10) or non-technical (e.g., Art/Fine Arts). Fifty students (44.2%) reported they were pursuing a technical degree and 45 (39.8%) reported they were pursuing a non-technical degree.

We performed a logistic regression analysis between the three factors and the new major chosen as an outcome (see Table 11). Only lack of belonging was a significant predictor for the new major chosen, $X^2 = 5.483$, $df = 1$, $N = 113$, $p < .05$. For every one unit increase in lack of belonging, the odds for choosing a technical majors decreased by 37.9%.

TABLE 9
Result of Multiple Regression of Three Factors on GPA

Variable	$AdjR^2$	*B*	SE *B*	β	95% CI lower	95% CI upper	*t*	*df*	*Sig.*
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. ***$p < .00$.

TABLE 10
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

DISCUSSION

Exploring the Factors that Influence Decision to Leave

Our study showed that three factors influenced students' decisions to transfer out of engineering: Poor teaching and Advising (F1); difficulty level of the engineering curriculum (F2), and a lack of belonging in engineering (F3) (see Table 2). Our results are supported by prior work from Seymour and Hewitt (1997). Although they reported their results by gender, several of the top 10 reasons for leaving from both males and females (e.g., curriculum overload, poor teaching, and discouragement due to low grades) are in alignment with our factors one and two, and further items from the Seymour and Hewitt lists (e.g., turned off science, non S.M.E major more interest) correspond to the lack of belonging factor.

There were no differences by gender for any of the three factors in our study. These results are in contrast to the academic based gender differences found by Blickenstaff (2005) and Adelman (1998). The lack of gender differences for the academic factors in the current study may be largely explained by progress in closing the preparation gap over that time period; specifically the closing gender gap in math and science preparation (AAUW, 2008; Hyde & Linn, 2006). Additionally, our subsequent analysis of the cumulative GPAs students reported indicates that the female students who chose to leave were relatively strong academically. A paired *t*-test between male and female students' cumulative GPAs showed that, among leavers, female students (M = 3.20, SD = .52) had significantly higher cumulative GPAs than male (M = 2.95, SD = .59) students ($p < .05$). We note that the higher GPA result for the women in our sample combined with the lack of any gender

TABLE 11
Logistic Regression on Major Choice and Three Factors

	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. *$p < .05$.

differences for the three factors may be somewhat puzzling. In terms of GPA, these women were more qualified than their male counterparts, yet none of the three factors measured by our instrument were different for women. A potential explanation is that the current instrument is not capturing some factor that is important for women in their decision to leave. Alternatively, it may be that one or more of the instrument's factors are more important for women, but for some reason the women are "under-reporting" for that factor. In either case, this result may point to the need for instrument revisions perhaps combined with the addition of qualitative data to elucidate these results.

Further explanation of the factors comes from an open-ended question asking for the one biggest reason for students' transferring from engineering. Responses to this item verified that the curriculum difficulty factor was composed primarily of concerns about GPA. However open-ended responses also pointed to students' concerns with math and physics courses that are required for engineering curricula but offered by instructors outside of the engineering college. Of the 95 responses to this open ended item, 16 mentioned a difficulty with a math or physics course, or both. This female student describes physics as the roadblock: "Physics. The material was too difficult for me. I did well in high school physics but once I got to *Institution X* I found it very difficult." These data are a strong confirmation of the importance and potential impact on retention of these "barrier" courses that has also been found by previous studies (Felder et al., 1993; Suresh, 2006).

Also, approximately 35% of the open ended responses discussed some aspect of the poor teaching and advising factor. Among these was this quotation indicating how a female student felt a lack of academic support from faculty and evidenced a lack of a sense of belonging fostered by faculty in the department:

> …and the professors didn't seem to care at all whether or not people did well in their class. It was discouraging that the professors never remembered me or wanted to help me and the work load was way too hard to do alone.

Comments such as these verify prior work by Vogt (2008) and Walden and Foor (2008) and point to the effect that faculty actions (or inactions) can have on students' abilities to persist. Advising also surfaced in the open-ended comments. This African American male student's observation about the impersonal nature of advising is a powerful example of how this impacted his future in engineering.

> The advising system is very poor. I was a number not a name. The first 2 years are when students most need advising and ...we had advisors who basically told you to just follow the rubric in the engineering manual.

The survey items that comprise the lack of belonging factor (see Table 2) addressed a preference for a non-engineering career, feeling as if one did not belong in engineering and the "narrowness" of the engineering curriculum not aligning with the student's other interests. Responses to the open-ended item provided strong support for this "narrowness" component; nine students described that the engineering curriculum contributed to an unbalanced life both academically (e.g., taking elective courses) and socially. This majority male student's quote is exemplary of this view:

> The biggest factor was that I didn't feel that being an engineer allowed me to fit in my artistic and creative abilities. I also felt that I was very different from other engineers. I felt that I got negative reactions from them, because I went to parties and participated in other activities.

Conceptually the three factors (poor teaching and advising (F1), difficulty level of the engineering curriculum (F2), and a lack of belonging in engineering (F3) 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 or fit in engineering. The means for the factors cluster according to 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, providing evidence that this factor based in students' beliefs may be more of an influence towards students' decisions to leave engineering than the academic factors.

The Importance of Lack of Belonging

Our finding of lack of belonging as a factor contributing to students' decisions to leave engineering may be related to students' feelings of their self-efficacy (or the lack of efficacy) in engineering. Self-efficacy—a construct based in one's beliefs—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), and has been found to contribute to students' decisions to persist in difficult courses of study (Bettinger & Long, 2005; Downing, Crosby, & Blake-Beard, 2005).

Both self-efficacy and our study's lack of belonging factor are based in individual beliefs and the two may be inter-related for our student sample. Quotations from the open-ended item on students' reasons for leaving provide some support for the assertion of a relationship between self-efficacy and belonging. This majority male student describes his perception of courses that are not designed for supporting mastery experiences, but rather set up for failure.

> First year students that are taken by surprise by the new atmosphere and ways of college .... It is wrong to have weed-out courses that are designed for the single purpose of discouraging students from continuing a major.

In contrast this student describes how his new department reaches out to him every semester to build both efficacy and belonging:

> I felt like a number to the Engineering department. In Physics, the head of the department contacts me at the beginning and end of every semester to talk about progress and possibilities about the next semester. I feel like a person in physics.....

The significance of the potential relationship between the lack of belonging factor and student self-efficacy lies in research that indicates that beliefs such as self-efficacy can be influenced by external events or circumstances. For instance, one's self-efficacy can be influenced by interactions with significant others, such as faculty (Pajares, 2002). So although lack of belonging may be a belief held by students, factors external to the student that may be influenced by engineering educators (such as the curriculum, the way engineering careers are portrayed and student interactions with faculty and peers) could be made to have a positive influence on this belief-based factor.

Lack of belonging in the technical engineering discipline may have also influenced students' choice of their next major. Recall that lack of belonging was the only factor of the three that predicted whether students chose a technical or non-technical major after leaving engineering (see Table 11). The more lack of belonging contributed to a student's decision to leave engineering, the less likely he or she was to choose another technical major. Although the physics student just quoted is a non-example of this relationship, this result provides further evidence of the potential importance of this factor, as it may have even influenced these students as they moved forward in their college majors.

The relative strength of the lack of belonging factor as compared to the "academic" factors is of further interest when one compares the differences between the factors for non-Caucasian (which includes underrepresented minorities) and Caucasian students. Recall that non-Caucasians viewed curriculum difficulty as being significantly more of an influence on their decision to leave engineering than Caucasians (see Table 4) and there was a trend towards significance for lack of belonging, again with non-Caucasians reporting this as having more of an influence. These differing perceptions for non-Caucasians students, which may result from the underrepresented minorities included in this group perceiving their engineering experience in a different way, merit further studies, and are discussed further in the Implications for Educators section.

Relationship Between the Factors and Input Variables and GPA

As educators we are not only interested in what precipitated students' decisions to leave engineering but also what variables or conditions may contribute to those factors. We have classified the factors 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 that influenced students' decisions to leave engineering—when viewed in these two categories—are predicted by like types of inputs.

Specifically, we found that both the number of months spent in engineering before transferring out and students' perception of their high school preparation to study engineering were related to both of the academic factors (see Tables 5 and 6). The relationship was positive for number of months in engineering and negative for high school preparation. 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). Regarding time in engineering and the factors, engineering curricula are accepted by students and faculty as being challenging. Thus our result that the perception of 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 this negative result is consistent with prior studies (e.g., Seymour and Hewitt, 1997) and also supported by our study's qualitative data.

We also found relationships between the academic factors and an important academic "output" variable: cumulative GPA. Table 8 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.

We note that these same academic related input variables (e.g., high school preparation, GPA) were not significantly related to the non-academic factor lack of belonging; however, a non-academic input variable, initial confidence in completing an engineering degree, did (see Table 7) predict the lack of belonging factor. We posit that the conceptual consistency between the types of variables that are related to the three factors and the factors themselves (e.g., academic input variables related to the academic factors for leaving engineering) provides further support for the validity of the three factors our study found that most contributed to students' decision to leave engineering.

Implications for Educators

For engineering programs seeking to encourage program completion, the findings presented here suggest two separate but related areas for action: academic support and promoting a sense of belonging. The students in the present study highlighted the importance of overall preparation for engineering curricula, as well as the quality of teaching and advising in their decisions to leave. This serves as a call to K-12 and university educators to develop ways to adequately prepare students. High school engineering enrichment programs, such as Project Lead the Way (PLTW, 2010), would allow students interested in engineering to supplement their regular math and science courses with content that is specifically targeted towards engineering applications. Given that non-Caucasian students were more likely to cite curriculum difficulty as a reason for leaving, this may be even more important in schools who graduate a large percentage of students underrepresented in engineering programs.

At the university level, in assessing students' readiness, educators must go beyond standardized placement tests and subsequent placement in "remedial" courses and provide opportunities to develop other academic success skills (e.g., time management), and help students to be aware of and take advantage of the institutional resources in place designed to help them succeed. Students coming into engineering straight from high school were often high achievers there and seldom needed to seek out the tutoring, exam review sessions, and academic advising available in most higher education institutions. Peer mentoring can often be effective in providing academic behavior role models for new students, as students are often more open to accepting advice from peers. We recognize that these types of academic support systems exist in many engineering colleges; however, our data point to the importance of continuing to allocate resources and promoting such programs in order to improve retention.

Engineering curricula (including required coursework offered outside of the college of engineering such as math and science courses) and teaching styles should also be examined to consider the extent to which they are accessible to wider range of learners who may exhibit varied learning styles. Bernold et al.'s (2007) results indicated that individual learning styles and compatibility with faculty pedagogical styles were related to persistence and students' sense of belonging in engineering. Our study did not examine learning styles; however, our data do show that lack of belonging was more of a factor influencing leaving for

non-Caucasian students. Building on the Bernold study, it is possible these students' learning styles were less compatible with engineering teaching styles and curricular experiences leading to a sense of lack of belonging. The idea that curricular facets may impact students' sense of belonging is supported via this student's comments about the individually-oriented nature of the curriculum he experienced in engineering:

> …my personality does not concur with the typical engineer (as I am a more socially oriented person, as opposed to the individualistic curriculum [sp] that I experienced in Engineering.

This quote illustrates how students may perceive the discipline to be less interactive and socially grounded than others and further clarifies the need for curricula to model engineering's interactive aspects.

The importance of students' beliefs about belonging are further underscored as we found belonging was associated with confidence in completing an engineering degree (see Table 7), as did many other prior studies for students of varying ages and academic areas (e. g. Faircloth & Hamm, 2005; Freeman, Anderman, & Jensen, 2007; McMahon, Wernsman, & Rose, 2009). This link between confidence in completing an engineering degree and the belonging factor suggests that faculty and advisor interventions designed to increase student confidence (e.g., explicitly discussing that all students find the engineering curriculum difficult) might be a method of positively addressing the lack of belonging that these students perceived.

Students who feel as if they belong also view faculty interactions more positively (Freeman, Anderman & Jensen, 2007); further, positive faculty interactions are related to a higher GPA and greater likelihood of program completion (Kuh, Kinzie, Buckley, Bridges & Hayek, 2006). As such, engineering programs should educate faculty about the impact of learning styles and quality of classroom climate and seek to support and encourage faculty in developing more inclusive curricula and infusing a broader range of styles in their teaching. Students should also be afforded more opportunity to interact with faculty outside of the classroom, as this has been shown to also influence students' feelings of belonging (e. g. Hurtado & Ponjuan, 2005). Programs may also benefit from targeted efforts aimed specifically at underrepresented students to keep them involved and included as they progress through the program. It is important, however, to make sure that the entire college or school take on the responsibility of creating an inclusive and effective learning environment. Leaving this important task solely to diversity programs can end up contributing to students' lack of sense of belonging.

Limitations

We recognize that students who have already left the college of engineering maybe be overly negative. However, we counter this issue with data from the open-ended survey items on other comments they wished to make about their decision to leave. Many comments were very complimentary of the college and indicated an overall positive student experience. For instance this student remarks on the helpful programs the college offered. "There are a lot of helpful programs to assist you when you are in engineering..." Or this student who indicated the environment was welcoming but it just wasn't a good fit for her. "It was overall a very welcoming experience but just did not suit me." These data indicate students were not universally negative about engineering, but rather felt it was not a good fit for them.

Another criticism may be that these students were not academically prepared for engineering. However recall that our preliminary analysis of the subject pool found the respondents were similar academically (e.g., entering SAT scores and GPA) to those students who remained in engineering, thus lending credence to the data from our respondents. Further, the cumulative GPA data for the responding students show a wide range of academic performance and indicate these are not universally students that we would predict would fail to succeed in engineering.

The construction of the survey also deserves further examination. In its current form, the survey items that comprise the lack of belonging factor are less concrete in that they do not address specific areas of concern that may contribute to perceptions of lack of belonging, as compared to the more concrete items that compose poor teaching and advising, and curriculum difficulty. Future versions of the instrument will 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?

Lastly we recognize that a 19% response rate is lower than desired albeit a somewhat typical rate for online surveys (Palmer & Holt, 2009). We further speculate that the rate is due to the lack of motivation for students who are transferring *out of engineering* to complete a survey coming from *the college of engineering*. However, we have provided evidence that our responders are similar to the population they represent and also posit that our results still have considerable merit given that analysis showed the responding students were similar academically to those who persisted.

Conclusions

This study examined the factors that students from a large engineering school 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 non-Caucasian and Caucasian students for the curriculum difficulty factor and a trend towards significance for lack of belonging. In both cases the non-Caucasian 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 emerged 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 suggest that, despite accounting for the least amount of variance of the three factors, lack of belonging may be the strongest factor for all students. The lack of belonging factor mean was significantly higher than the means for the academic factors and the lower amount of variance accounted for may indicate that, when lack of belonging is a factor in students' persistence decisions, there are likely many other factors (e. g. ethnicity, gender, engineering department, institution, individual attitudes, and experiences) which share variance with beliefs about belonging. In contrast, when academic factors come into play, there may be fewer outside factors influencing persistence decisions, thus resulting in a higher percent of variance. Overall, the results suggest that academics are less of a reason for leaving engineering than the less tangible feelings and beliefs side of the equation. We argue that the importance of this study is that it provides results that can be translated into actions and setting priorities within engineering

colleges as well as contributing to the complex (and somewhat inconclusive) landscape of understanding engineering persistence.

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