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Exploring the motivations for migration among engineering students

Abstract

Students often graduate from a major other than that in which they first enrolled. A large proportion of this migration happens within engineering with students moving from one discipline of engineering to another. Some students migrate within engineering several times. While there has been extensive examination of why students leave engineering, very little research has looked into why students leave one engineering discipline for another. Longitudinal data collected from several engineering colleges has shown that there are definite trends within the movement of engineering students. This study examines the reasons for some of these trends using a unique approach which combines both environmental and personality factors. The study uses measures based on career theories such as Social Cognitive Career Theory, which has used extensively to explore vocational choice in engineering. These theories will be supplemented with measures of social influence and personality to explain disciplinary choices. In addition, this study considers the climate students are exposed to in the various engineering disciplines.

Introduction

Prior research with the MIDFIELD database (a National Science Foundation funded longitudinal database containing records of undergraduate students at ten US institutions) has concluded that at an average of 57%, the rate of retention to eight semesters in engineering is high compared to other disciplines [1]. Research has also found that over 20% of engineering students migrate among engineering disciplines and that there are larger trends in this migration[2]. This study examines the reasons for these migrations. There have been a large number of studies that have looked at what factors influence students' selection of a STEM major [3-7]. These studies have found that the factors influencing students' choice include climate, interest, goals, perceived supports and barriers, self-efficacy, and the influence of students' peers.

Climate has a strong influence on students', especially female students', learning and comfort in the classroom[8] and this can cause them to transition to other majors [9-11]. The chilly climate metaphor in which students do not feel welcome or feel out of place, students' peers and instructors devalue their efforts, intimidate, and in some cases even sexually harass them is a common framework to examine attrition. The leaky pipeline metaphor is also used to examine attrition. It was first introduced by Berryman [12] and later popularized by Alper [3]. It is commonly used to explain the declining numbers of women and other underrepresented groups as they progress along the trajectory from primary and secondary education, through college, graduate school, and various careers. These metaphors could also conceivably be used when discussing students' migration among engineering disciplines.

Emerging from these perspectives are factors which have been found to contribute to changes in the engineering pathway and conceivably, migration. These include the lack of female role models and support systems in engineering[13], the lack of rewarding career opportunities, limited access to information on career opportunities[14], the perception of engineering as lacking social relevance and responsibility[15] and lack of preparation. One of the largest contributors to attrition in the first year of engineering is a lack of preparation in science and mathematics[16]. If students do not prepare adequately for their engineering career starting in high school, they often find themselves unable to cope with the demands of college courses in math and science. This implies that the sooner students make their decision about pursuing engineering; the more likely they are to be successful in pursuit of those careers. Males generally decide to become engineers earlier than females[14] and therefore are often more prepared for courses in math and science and in a better position to decide on an engineering discipline.

Clues to the reasons for migration could also be found in the reasons why students decide to pursue engineering. Research has found that these reasons include: their belief that engineering makes the best use of their talents and abilities[13,17], job security, social status, prestige, high income, teachers influence, rewarding career opportunities, access to information on career opportunities[14], high scores on aptitude tests, influence of friends and mentors[18], opportunity to serve community, flexible career options[13], and familial expectations[19]. Factors such as intelligence[13] and traits such as communion and agency[20] have also been found to affect whether students choose to join, remain in, or leave engineering. Interest has also emerged as a significant factor in encouraging students to pursue careers in STEM fields[11,21,22]. A number of studies have demonstrated a strong relationship between students' interests and abilities and their persistence in engineering. It is therefore logical to assume that interest is also a factor in students' choice to migrate or remain in their discipline.

Other research into the choice of engineering as a major has taken a vocational theory perspective that can also be applied to the examination of migration. Social Cognitive Career Theory (SCCT) is a commonly used model of career choice in engineering. It was developed by Lent, Brown, and Hackett [23] and based on Bandura's Social Cognitive Theory [24]. This theory posits that career choice is based on an individual's self-efficacy (that individual's self-perception of their abilities), their outcome expectations (an individual's belief about what will result from their actions), their goals, and the barriers and supports that surround them [23]. This theory was tested in several studies of engineering students and was found to be strongly predictive[25], making it ideal for inclusion in this study.

Other factors previously considered include the lack of female role models and support systems in engineering [13] and the influence of friends and mentors [18,19]. Kelman's model of social influence (SI) provides a way to integrate these social factors. SI posits that social influence results through three processes: compliance, identification, and internalization [26]. When acting on a compliance motivation, the individual develops a rule orientation towards the social system wherein they comply with the expectations of the system/authority in return for rewards or in avoidance of punishment [26]. A removal of the authority compelling the conformity disengages the individual from the society. With the identification motivation, the individual develops a role orientation towards the social system where it becomes part of their self-identity. This process is more stable because identity is an internal construct, and while it can change, it usually does so on a longer time scale. The internalization motivation causes an individual to orient towards system values, finding that those values correspond to their own [26]. Under this motivation students are concerned with features such as engineering being socially relevant and responsible.

Based on the findings above regarding students' choices about their engineering career and major, this study examines students' performance, self-efficacy, interest, social orientation, the barriers and supports they encounter and the climate in their departments as factors affecting their satisfaction with their current major and their migration into and within engineering.

Methods

Data for this study were collected from a cross-section of engineering students across thirteen disciplines of engineering at a large Mid-Western university. The data were collected using an electronic survey administered to all students in their sophomore year and above (to capture those who have had an opportunity to experience and evaluate their major choice and possibly make changes). These data included demographic information, information about students' previous, current, and prospective majors, their graduation intentions, students' interest in engineering, students' social orientation and motivation, the barriers and supports they encounter, their self-efficacy, and their satisfaction with their major.

Students' satisfaction with their major was measured using Nauta's validated Major Satisfaction Scale[27] that contains items such as "I often wish I hadn't gotten into this major" and "I feel good about the major I have selected." Chen's General Self-efficacy Scale[28] tailored to engineering was used to measure students' self-efficacy. This scale contains items including "Compared to other people, I can do most tasks very well" and "I am confident in my ability to solve engineering problems". Social influence was measured using the Social Influence Scale[29]. The other scales used were developed by the researchers in this study. These included a technical interest scale containing seven items including "I enjoy solving technical problems" and "I like to understand how things work," a ten-item barriers-and-support scale with items such as "I feel pressure from my friends to change my major," and a twenty-item climate measure including items such as "I generally feel comfortable asking questions in engineering classes" and "I feel excluded from study groups." The study reported here is a work in progress, as data collection is still ongoing.

Participants

The participants in this study are engineering students at a large Midwestern university For the first phase of data collection, the participants are engineering students in their second year and beyond in an engineering major. This study is ongoing and currently contains 152 participants, 27% of whom were women. This was higher than the engineering population from which this sample was drawn which is 18.5% women. The racial distribution of this sample was 1.9% Native American, 2.6% Hispanic, 3.2% African American, 16.2% Asian American, 68.8% Caucasian American, and 7% International Students (which are all typical of population representation).

Of this sample, 12% had migrated within engineering and 7% had migrated from a major outside of engineering. 6% of the students in this sample were in their second year, 41% were in their third year, 37% were in their fourth year, 14% were in their fifth year and 2% were in their sixth year. The GPA distribution among students is shown in Table 1.

Table 1: Percentage distribution of students by GPA

GPA	% of Students in major	% of Students cumulative
4.0 - 3.6	25.3	25.7
3.5 - 3.1	25.3	34.2
3.0 - 2.6	40.3	33.6
2.5 - 2.1	8.4	5.9
2.0 - 0	.6	.7

Results and Discussion

When asked to rate their academic performance relative to their peers, the majority of students rated themselves as average or slightly above average (*figure 1*).

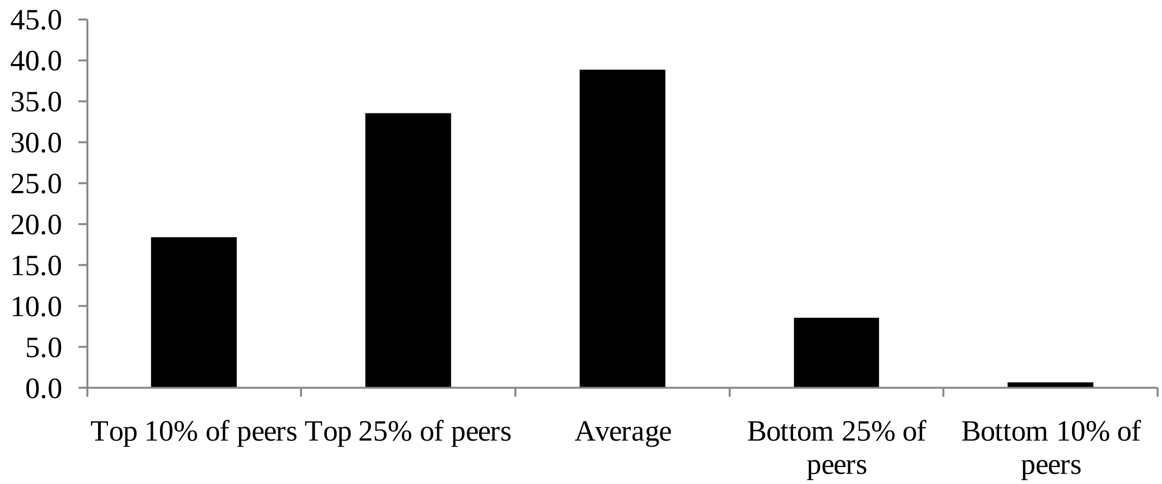

Figure 1: Students' self-rating of academic performance relative to their peers

The degree of correlation between students self-rated academic performance and their GPA was tested to determine the reliability of students' self-perception and the validity of their self-reports. As expected there was a high correlation between students' self-rating and their GPA (r = .8, n = 152, $p < .0001$) suggesting that their self-report scores are fairly reliable. The correlation between students' academic performance, their past migration within engineering, and their intention to graduate with an engineering degree was also tested and was found to be significant (*Table 2*).

Previous migration outside engineering was found to have a strong negative correlation with entering college as an engineering major suggesting that while some students enter engineering after starting in a major other than engineering, but it is rare for a student to start in engineering, try a non-engineering major, and then return to engineering. Previous migration within engineering was found to be negatively correlated with students' academic performance in this sample suggesting that students who have changed majors do not perform as well as students who have not. This could be due to students choosing to change majors because they were not performing well in their previous major, or it could be due to students struggling to acclimatize in a new major. Research to explore this question is ongoing. As expected, students' intention to graduate with an engineering degree was positively correlated with both their self-rated academic performance and their GPA suggesting that either good performance reinforces students' choice of major and encourages them to remain, or that students who are committed to their major put in the effort required and do well, or perhaps both.

Table 2: Correlations among path variables

N=152	**Self-rated academic performance**	**GPA**	**Entered college as an engr major**	**Previous migration within engr**	**Previous migration outside engr**	**Intention to graduate in engr**
Self-rated academic performance	1	**.8** .0001**	.023 .782	**-.167* .040**	-.139 .088	**.213** .009**
GPA		1	-.012 .881	-.135 .099	-.114 .164	**.227** .005**
Entered college as an engr major			1	.032 .697	**-.526** .0001**	.021 .797
Previous migration within engr				1	-.069 .399	-.010 .899
Previous migration outside of engr					1	-.127 .120
Intention to graduate in engr						1

When the relationships among motivational variables were considered self-efficacy was found to be significant and positively correlated with the students' technical interest in engineering, the climate in the department, the support students felt that they received, students' identification with their major, and students' internalization of the values espoused by their major. Most significantly, students' confidence in their ability to complete engineering tasks successfully was strongly positively correlated with their satisfaction with their major (*Table 3*). On the other hand, the barriers students felt they faced were negatively correlated with their self-efficacy. Self-efficacy was also negatively correlated with compliance motivation in students suggesting that students who feel forced to be in their major do not develop confidence in their engineering skills. As expected, students' satisfaction with their major is strongly correlated with identification with their major, technical interest, and a perceived positive climate in their department. The data above imply that for students to feel satisfied with their major and therefore be more likely to persist it is necessary for them to: identify with that major, to find things within that major that they value, to have an interest in that major, and to feel as though they are surrounded by both a positive climate and a supportive group. This satisfaction with their major could then help them develop confidence in their engineering ability which studies have shown leads to better performance. As more students participate in the study, regression will be used to determine the strength of the relationship of these variables to the choice to change majors. With a sufficiently large sample size, it will also be possible to explore whether certain variables are more predictive of certain trajectories.

Table 3: Correlations among motivational variables

	Self-efficacy	Technical interest	Barriers	Climate	Major Satisfaction	Support	Compliance motivation	Identification motivation	Internalization motivation
Self-efficacy	1	**.556****	**-.403****	**.324****	**.619****	**.176***	**-.345****	**.583****	**.570****
		.000	.000	.000	.000	.041	.000	.000	.000
Technical interest		1	**-.236****	**.380****	**.478****	**.164**	**-.342****	**.555****	**.568****
			.006	.000	.000	.056	.000	.000	.000
Barriers			1	**-.249****	**-.471****	.000	**.351****	**-.232****	-.155
				.005	.000	.999	.000	.007	.071
Climate				1	**.423****	**.296****	**-.343****	**.334****	**.394****
					.000	.001	.000	.000	.000
Major Satisfaction					1	.030	**-.502****	**.685****	**.521****
						.730	.000	.000	.000
Support						1	**.211***	**.205***	**.239****
							.014	.016	.005
Compliance motivation							1	**-.309****	-.155
								.000	.064
Identification motivation								1	**.748****
									.000
Internalization motivation									1

N=135

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