AC 2010-1835: DESCRIBING THE PATHWAYS OF STUDENTS CONTINUING IN AND LEAVING ENGINEERING

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Describing the Migration of Students within Engineering

Abstract

The number of students leaving their initial engineering discipline for other engineering disciplines and other fields of study is significant. This paper displays and describes the development of a model of the pathways taken by these students through their undergraduate academic careers. Specifically this paper looks at the migration of engineering students within various disciplines of engineering. This study uses the records of over 135,000 engineering student records from the Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD). This research shows that approximately 20% of engineering students graduate from an engineering discipline other than that into which they matriculated, and approximately 40% of students who matriculate into an engineering discipline leave the field of engineering. This research also found that there are specific pathways popular with engineering students.

Background

Research conducted over the past two decades has agreed that the rate of retention in engineering ranks amongst the lowest ranging from 30% to 50% nationally[1] with an average of less than 50% of initial enrollees[2,3]. Prior studies with the MIDFIELD database, a National Science Foundation (NSF) funded longitudinal database containing the records of all undergraduate, degree seeking students from fall 1987 to 2005 at ten US institutions has reported numbers at the high end of this range and, more importantly, that engineering retention rate is higher than the typical retention rate in other disciplines in higher education.

Analysis of data from the MIDFIELD database has revealed that the rate of persistence amongst engineering students is not significantly lower than that of students in other disciplines in the database. A study of 70,000 students who enrolled in engineering programs found that engineering actually had the most students (57%) persisting through eight semesters[4]. Other disciplines had lower rates of persistence (*see Table 1*).

Table 1: Persistence in various major groups to the eighth semester (*data from Ohland et. al.*[4])

Major	Engineering	Business	Social Science	Arts and Humanities	Other STM majors	Computer Science
% Persisting to 8th semester	57	55	51	50	41	38

While the average persistence amongst engineering students across the MIDFIELD institutions is 57%, actual persistence at individual institutions ranges from 37% - 67% [4]. This raises the questions of why persistence varies greatly across institutions and whether there are large differences between students who persist and those who do not. Seymour and Hewitt[3] performed a study with 460 students at ten institutions. They conducted a series of interviews, both group and individual, to determine why undergraduate students leave science, engineering, and math majors. This study found that students who persist (persisters) are actually very similar to students who move to other majors and both groups of students identified the same grievances[3]. Seymour and Hewitt[3] concluded that better teaches and pedagogical methods were the key to improving persistence. Another study conducted by Adelman[2] supported this finding, concluding that male and female engineering students are equally likely to persist provided they have the strong academic background, even though overall, men are 20% more likely to persist than women. A study conducted by Astin[5] also found that men leave engineering at the same rates as women. This equivalent persistence between male and female engineering students was also found in the MIDFIELD data with 57.5% of men and 55.9% persisting to eight semesters[6,7].

Though retention rates in engineering are comparable to or better than other disciplines, they are still low. Approximately 40% of students are leaving engineering[4] and a significant number of those who remain in engineering move from one engineering discipline to another. A closer examination reveals that the pathways chosen by engineering students differ greatly. Xie and Shauman[8] have published the most comprehensive research on Science, Technology, Engineering, and Math (STEM) student pathways to date. They studied STEM pathways (and particularly gender differences in those pathways) from early qualification and expression of interest in college study through pursuit of college study, persistence to graduation, pursuit of a career, and career persistence. An early MIDFIELD model (figure 1) hypothesized some critical transitions in the engineering pathway, but this model was too simplistic to represent some significant differences in curricula at different institutions. Further, this model did not account for a surprising amount of complexity in student behaviors. The aim of this research was to study the college pathway in greater detail, breaking down that pathway into smaller, discrete sections of the pipeline that described other critical transitions at which students (both female and male) were likely to choose to leave the pathway, and identifying their destinations. The MIDFIELD database was used to identify the various pathways pursued by engineering students, identify which were the most common and determine which were the most successful. A new model was developed using the preliminary findings from this work. Another special contribution of this work was the presentation of evolving attempts to develop methods to display this unique quantitative information.

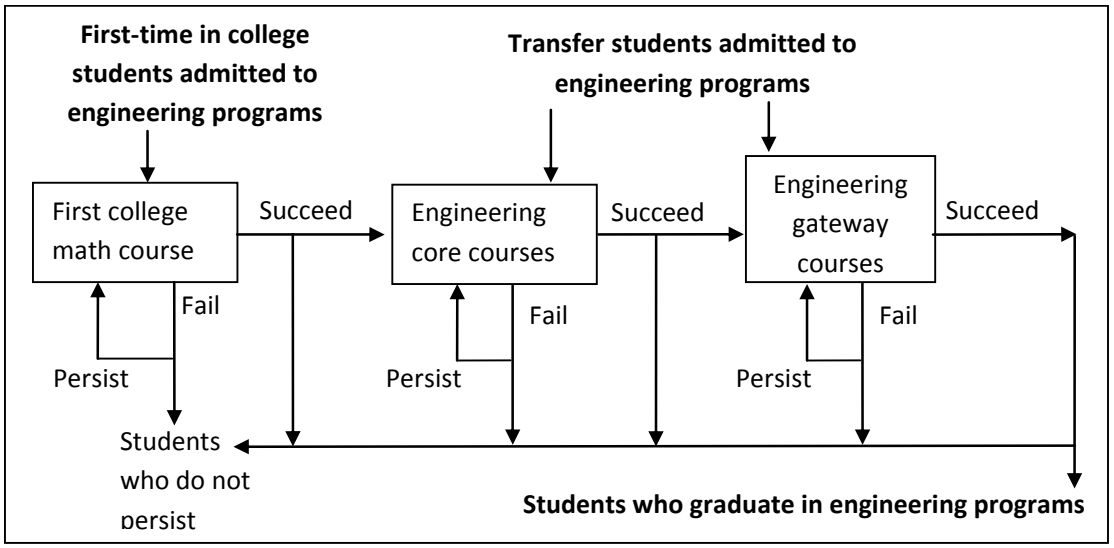

Figure 1: Model hypothesizing critical transitions in the engineering pathway

Method

This study used the MIDFIELD database to define the relevant distributions and identify trends within them. The MIDFIELD database is a National Science Foundation (NSF) funded longitudinal database containing the records of all undergraduate, degree seeking students from fall 1987 to 2005 at Clemson University, Florida A&M University and Florida State University (which have a joint College of Engineering), Georgia Institute of Technology, North Carolina A&T State University, North Carolina State University, University of Florida, University of North Carolina at Charlotte, and Virginia Polytechnic Institute and State University. The database contains the records of over 850,000 students, of whom over 135,000 were enrolled in an engineering program.

The database was used to identify students matriculating into engineering, students leaving engineering, and students migrating within engineering. Descriptive statistics were used to characterize these populations and define dominant trends within them, and graphical models were developed to represent the results. Because we have whole population data, we have omitted inferential statistics to simplify this discussion. Our findings are fully representative of the institutions studied, and can be generalized to other institutions to the extent that these institutions are representative.

Figure 2 is a MIDFIELD "Persistence in Major" chart. This is similar to the MIDFIELD Persistence Chart.[4] Whereas the Persistence Chart illustrates persistence in a group of majors (such as "Engineering" or "Arts & Humanities") to the eight semester (PG8) and persistence at the university to the eighth semester (PU8), the Persistence in Major chart has a narrower focus. The Persistence in Major chart shows the eighth-semester destination of students matriculating in

various specific engineering disciplines (PM8), but restricts the set of destinations studied to engineering majors.

The x-axis in Figure 2 is categorical, defining the population included in each column—the population that matriculated in the specific engineering discipline labeled below the column. Reading up the column identifies which engineering disciplines those students end up in by the eighth semester. The first destination is always the specific discipline in which the population matriculated, so that the bottom line shows the rate of persistence in each specific major to eight semesters (PM8). The discipline groups on the x-axis are in descending order of PM8. Note that students in first-year engineering programs cannot matriculate directly into specific engineering majors, but are included because they do migrate to these disciplines as intended as the first year courses are completed, and they represent a significant proportion of the sample. "Toledo" is used to label the "destination" of students for whom the real destination is unknown because no records are present in the database. In addition to drop-outs, this may include transfers and stop-outs who have not yet returned. "Toledo" is an acronym for "Trajectory of Leaving Education, Destination Obscure."

Above the PM8 line (again in each column) are the other specific engineering majors to which at least 3% of students in a matriculated discipline migrate, stacked in descending order of the number of students following each path. Rounding out that region of the graph is the remainder—the aggregate of all the students going to specific engineering majors that received fewer than 3%.

A helper line is provided to highlight PG8, the cumulative percentage of students matriculating in each specific engineering discipline that persist in any engineering major to the eighth semester. Above the PG8 line is, in all cases, the fraction of students matriculating in each specific engineering major who have not persisted for eight semesters in any engineering discipline. Some of each population persisted at the university in other majors and the remainder have no further academic record. The helper line for persistence at the university to the eighth semester (PU8) is not shown on a MIDFIELD Persistence in Major chart, because it would add additional complexity to the figure and be distracting.

At the bottom of the graph, proceeding from the categorical axis that shows each matriculation engineering major, there are small bars that show the relative size of each population. At the bottom left, a distribution of the population in the various specific majors takes the place of a traditional axis frame.

Results and Discussion

Reviewing Figure 2, we note that persistence in specific engineering majors at eight semesters (PM8) ranges between 22%-52% (not counting students who matriculate in first-year engineering programs), who are intended to select a particular engineering discipline well before the eighth semester. PG8 for individual disciplines ranges from 41%-60% and is notably more stable than PM8, but generally follows the same rank order as PM8. The two least populated engineering majors at matriculation shown on the graph, Industrial Engineering and Materials Engineering, have the highest PM8, but PM8 for the remaining engineering majors shows no particular relationship to population size.

Notably, Industrial Engineering captures 3% or more of students matriculating in each of the other specific engineering disciplines. Some expected migration patterns are visible—Electrical Engineering students migrate to Industrial Engineering (an engineering discipline that shares a mathematical modeling focus), Mechanical Engineering (possibly students interested in the more mechanical aspects of robotics), and Computer Engineering. Mechanical Engineering students migrate to Industrial Engineering (connected by manufacturing), Electrical Engineering (possibly students more interested in the control aspects of robotics), and Civil Engineering (maintaining the connection to mechanics).

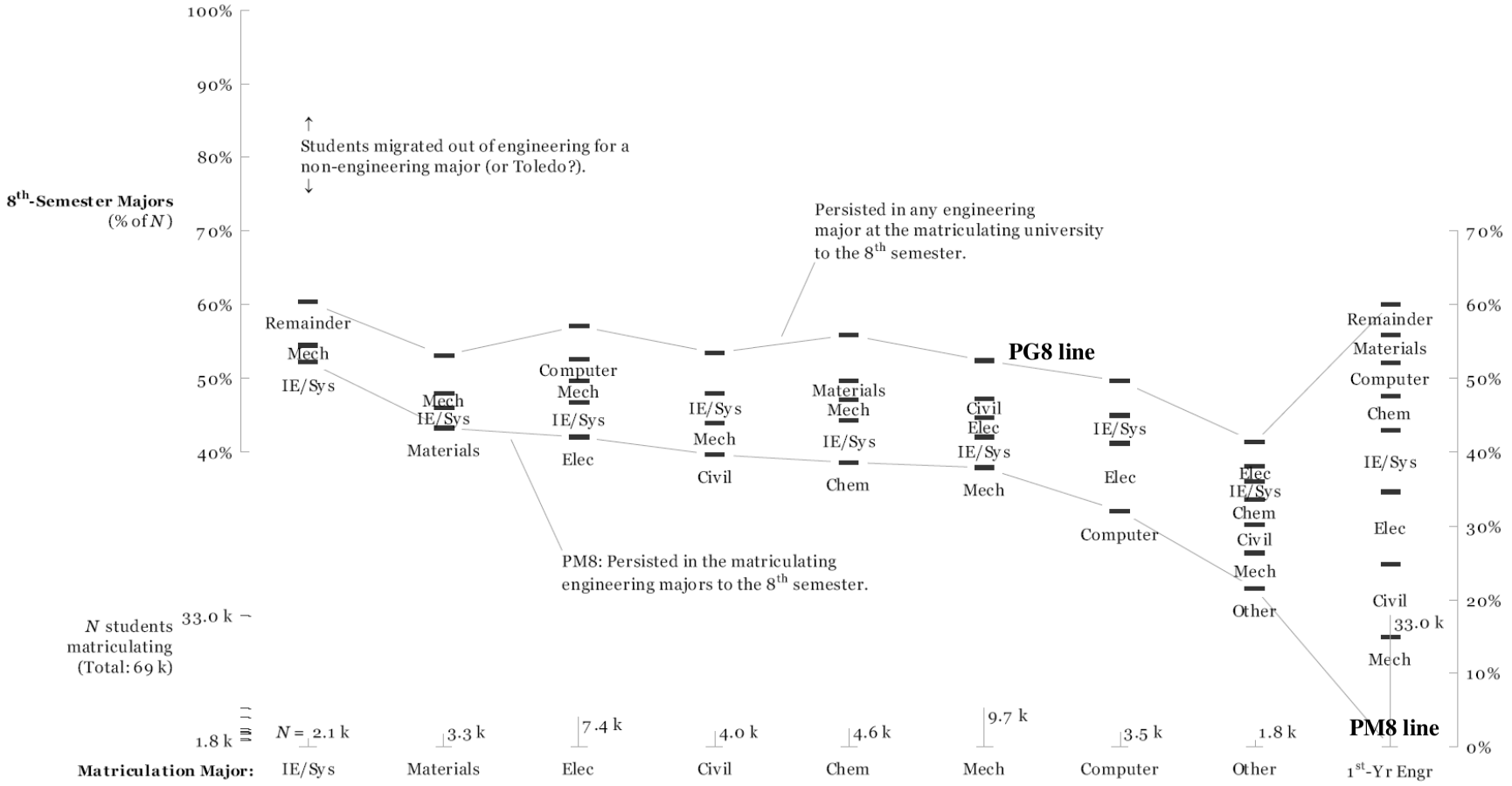

Figure 2: Persistence in specific engineering majors (lower helper line) and in any engineering major (upper helper line).

While a small fraction (about 3%) of students matriculating in Electrical Engineering migrates to Computer Engineering, approximately 10% of students matriculating in Computer Engineering migrate to Electrical Engineering. This seems odd, considering that Computer Engineering enrollments expanded significantly during the study period, drawing students primarily from those who would otherwise have matriculated in Electrical Engineering.

It is also clear that the eighth-semester persistence of students matriculating in first-year programs matches the best PG8 of the specific engineering disciplines (60% for Industrial Engineering). The current dataset does not include a sufficient number of institutions to draw conclusions related to the method of institutional matriculation to engineering (direct matriculation to the discipline vs. matriculation to a first-year engineering program). It is also observed students matriculating in first-year engineering programs migrate to the various specific engineering disciplines in different proportion to those students who matriculate directly to the disciplines.

Conclusions and Future Work

Understanding the migratory pathways within engineering can be helpful to understand the driving forces of major selection and persistence, and a better understanding of those processes can improve both recruitment and retention. Our continuing work in this area will include describing the frequency of specific migratory pathways and explaining why students choose those pathways. It will also include more detailed analyses of these migratory patterns by targeted groups for example, underrepresented students.

While the current dataset does not include a sufficient number of institutions to draw conclusions related to the method of institutional matriculation to engineering (direct matriculation to the discipline vs. matriculation to a first-year engineering program), additional institutions are being added to the database—Memoranda of Understanding have been executed by University of Utah, Purdue University, and the University of Colorado, and others are being processed. As the set of institutional partners in MIDFIELD is expanded, it will be possible to study the effect of institutional choices such as matriculation approach without risking a spurious conclusion and without compromising institutional confidentiality.

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