First Steps; Moving from the Freshman to the Sophomore Year in Engineering

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Abstract – With the nationwide emphasis on increasing STEM enrollments and persistence to graduation, researchers at the University of Memphis (U of M) are conducting a study designed to investigate factors that may influence retention, by identifying discernable trends in successful progress from the first year of the programs into the second and following years. In the fall of 2009, approximately 260 students were enrolled in classes that were identified as introductory/freshman level classes in the U of M Herff College of Engineering. Represented were entry-level classes in Civil, Mechanical/Biomedical, Electrical/Computer/Biomedical, and Engineering Technology. Each of the classes has an introductory nature but all have a significant computational component, an introduction to the engineering design process, and a communication component. Students were tracked academically through registration in the fall of 2010. Transcripts of all the students who were registered in the fall of 2009 were reviewed and the status of the students as well as possible reasons for lack of success were classified. Additional data based on characteristics of the students upon admission is being integrated into the study and a limited statistical analysis of the data is presented.

Keywords: Freshmen, Retention, Success

CHARACTERISTICS OF FRESHMAN CLASS OF 2009

The University of Memphis is an urban university with a student population that is drawn primarily from a region with a radius of 150 miles. 59% of the students come from within the county where the University is located with an additional 11% from counties which are adjacent and receive in-state tuition at the University. The majority of students come from public school backgrounds and reflect the ethnic and racial makeup of the region. 258 students were identified for this study as freshmen. The identification was based on their enrollment in a freshman level class in one of the programs. This includes 90 students with a previous enrollment in the University, 44 students who have transferred into the University for the Fall 09 semester, 105 true first time freshmen, and 19 students who have previously attended the University and who are being readmitted. In terms of hours earned, 141 of the students were classified as freshmen, 65 as sophomore, 31 as junior, 12 as senior, 7 as fifth-year, 1 as special, and 1 as a graduate student. The unique classification of the graduate student was a student with a biology degree who wished to complete a graduate program in Biomedical engineering and therefore was required to fulfill some fundamental engineering coursework.

The gender breakdown of this class was 14% female and 86% male. Gender distribution by major is shown in Table 1. At registration, students are allowed to self-select an ethnicity and based on this information, the class was 3.9% Asian, 32.6% Black not of Hispanic Origin, 1.2% Hispanic, 2.3% Non-Resident Alien, 53.5% White not of Hispanic Origin, and 6.6% did not specify an ethnicity. The ethnicity distribution by major is shown in Table 2. The average age of the students was 22.1 with a standard deviation of 5.8 years. This statistic is biased by the high percentage of students who are either transfer students or students who have previous college credits. 131 of the students were 21 or younger which is close to the number of students who are classified as "true" freshmen.

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Major	Female	Male	Total
BIOM	18.4%	81.6%	38
CIVL	16.0%	84.0%	50
EECE	12.2%	87.8%	49
MECH	7.9%	92.1%	38
TECH	13.9%	86.1%	79
UND	25.0%	75.0%	4

Table 1: Enrollment Distribution by Gender and Major

Table 2: Enrollment Distribution by Ethnicity and Major

				Ethnicity			
Major	Agian	Black, not of Hispanic	Uisponio	Non- Resident	Not	White, not of Hispanic	Total
Iviajoi	Asian	Ongin	Hispanic	Allen	Specified	Oligin	Total
BIOM	5.3%	13.2%			7.9%	73.7%	38
CIVL		26.0%			6.0%	68.0%	50
EECE		22.4%	6.1%	6.1%	8.2%	57.1%	49
MECH	7.9%	26.3%		7.9%	2.6%	55.3%	38
TECH	6.3%	55.7%			6.3%	31.6%	79
UND		25.0%			25.0%	50.0%	4

The average HS GPA of the students was 3.17 for all the students in the study. Students classified as new first time freshman entered with a HS GPA of 3.44. Composite ACT for the freshman class was 23.59 with new first time freshman having the highest overall average of 25.43. Transfer students had an average Composite ACT of 18.71. This may reflect a high percentage of transfer students who chose to attend local and regional two-year programs in order to become prepared for university studies. ACT Math scores follow a similar pattern with an average of 23.27 for all the students and a 25.03 average for first time freshmen.

While this demographic may not be typical of all engineering programs, it is consistent with urban public commuter programs that have a significant local student population. Students in this program may be atypical in the number of hours they work outside of the university. While exact data was not collected for this study, previous data collected in a number of classes points to the average student working 20 hours a week. The commitment of the student population entering engineering is shaped by their need to balance academic, work, and social concerns and the exact balance may not be the same at every institution.

TYPICAL COURSEWORK

Each of the programs in the U of M College of Engineering has a first year program. In the fall of 2009, the Biomedical engineering department shared first year classes with the Electrical and Mechanical departments with the course cross listed across the departments. This has changed for the 2010 academic year. Each of the courses introduces fundamental characteristics of the profession, computational exercises typical to the discipline, the engineering design process, group work and dynamics, and oral and written communication skills. Within the first year programs for each department, there are two classes, one typically taught in the fall and the other in the spring with the spring class being a deeper development of topics taught in the fall class. This study only considered students enrolled in the fall freshman classes.

Prerequisites vary across departments for entry into the classes. In Biomedical engineering, the student must have credit for or be qualified for a math class equivalent to College Algebra. There are no prerequisites for entry into the first Civil engineering class. Electrical and Computer engineering have the same requirements as Biomedical engineering. Mechanical engineering also requires the math prerequisite while Engineering Technology does not. Each of the courses is taught by full time faculty. As each of the courses also has a significant lab component, the faculty are supported by graduate student assistants during the labs but the teaching responsibility is on the faculty. Enrollments are limited to around 30 students per section.

Outside of the college, freshman students will be enrolled in courses in mathematics, science and general education. First time freshman entering the college are required to take a Calculus readiness test to determine where in the mathematics sequence they will enter. The university is currently using the ALEKS placement test to determine the Math Placement Level (MPL) of the entering students. An historical breakdown of placement recommendation based on performance on the ALEKS test is shown in Table 3.

Recommended Math Placement	Percentage of Students	
College Algebra	35%	
Trigonometry	20%	
College Algebra / Trigonometry	20%	
Calculus I or Higher	25%	

Table 3: Comparison of Student Performance for Groups Continuing and Not-Continuing in Engineering

Of the fall 2009 class, 28 were enrolled in College Algebra, 27 in Trigonometry, 54 in College Algebra/Trig, 41 in Calculus I, and 52 in math classes beyond Calculus I. Transfer students are not required to take the placement test but are evaluated based on math credits earned at their previous institution. Freshman engineering students may also take an introductory chemistry class based on their placement into a math class. The typical freshman sequence will also include an English class for a typical total of 14 semester hours. The freshman in the study took an average of 13.07 semester hours with a standard deviation of 2.91 semester hours. This may be somewhat misleading because if a student drops a class during the semester or withdraws from school any hours that they were originally enrolled for are reduced.

STUDENT RETENTION

The first retention measure that we considered was how many of the students who were part of the freshman class of 2009 were enrolled in fall 2010. There are two groups of students who were no longer in engineering: the first group no longer being part of the university and the second group being enrolled in the university but no longer enrolled as an engineering major. 32.6% of the original group of students were no longer enrolled as engineering students after one year. Of these students who were no longer in engineering, 76.2% were no longer in the university while the remaining 23.8% chose to major in something other than engineering. For female students, 72.2% of the freshman class remained after one year while for male students only 62.6% remained in engineering. 80% of the students self-identified as Asian returned, while only 52.4% of the Black, not of Hispanic Origin student did. All the Hispanic students continued, with 68.1% of the White, not of Hispanic Origin continuing.

The presentation of such an extensive amount of background material is to give an idea of the student population involved in the study and the scope of the data that is being considered. This information is the first in a series of studies that is being undertaken to understand factors influencing retention in our college.

Retention Characteristics

In a first attempt to develop some type of differential between students who continue in engineering as opposed to students who do not, we began to compare some of the characteristics between the groups. One obvious characteristic would be the performance of the students during the Fall 09 semester. When the grade points are compared for a difference in mean GPA between the two groups the students who remained in engineering had an average GPA of 2.88 with a standard deviation of 0.84 while the students who did not remain in engineering had an average GPA of 1.98 with a standard deviation of 1.16. Comparing the means of the two groups using a t-test with

unequal variances, there is a significant difference between the two groups. The second significant factor was the High School GPA difference between the two groups. For the continuing group, the mean HS GPA was 3.25 with a standard deviation of 0.64 while for the group that did not continue; the mean HS GPA was 2.99 with a standard deviation of 0.65. The means of these groups were also compared using a t-test comparison of means with a significant statistical outcome. Another significant difference between the two groups was their performance in the math class they were taking. Students who remained in engineering had an average math grade for the Fall of 2009 of 2.68 (B- approximately) with a standard deviation of 0.99 while the students who did not remain in engineering had an average grade of 1.33 (D+ approximately) with a standard deviation of 1.32. Additional comparisons of Composite ACT, ACT Math sub score, ACT Science sub score, and hours attempted also revealed significant differences between the groups, using an $\alpha = 0.05$ level of significance as a threshold. A comparison of both groups over the characteristics tested is given in Table 4.

	Mean		Standard Deviation		
	Continuing	Not- Continuing	Continuing	Not- Continuing	p-value
Semester GPA	2.88	1.98	0.84	1.16	1.96E-08
HS GPA	3.25	2.99	0.64	0.65	8.29E-03
Composite ACT	24.11	22.26	4.32	4.43	1.43E-02
ACT Math	23.80	21.96	4.69	4.69	2.22E-02
ACT Science	23.92	22.28	4.40	4.67	3.53E-02
Hours Attempted	13.35	12.52	2.83	2.99	4.63E-02
Math Grade	2.68	0.99	1.34	1.32	6.30E-11

Table 4: Comparison of Student Performance for Groups Continuing and Not-Continuing in Engineering

Based on the significance of the math grade, a breakdown of the differences between the two groups based on which math class they were enrolled in is presented in Table 5.

	Not Continuing	Continuing	Students Enrolled
College Algebra	66.7%	33.3%	18
Trigonometry	26.1%	73.9%	23
College Algebra / Trig	28.0%	72.0%	50
Calculus I	27.8%	72.2%	36
Calculus II	31.3%	68.8%	16
Calculus III	0.0%	100.0%	5

Table 5: Comparison of Student Performance by Math Class Taken

A breakdown of the two groups of students by gender and ethnicity is shown in Table 6.

	Continuing	Not Continuing	Number
Asian	80.0%	20.0%	10
Female	0.0%	100.0%	1
Male	88.9%	11.1%	9
Black, not of Hispanic Origin	53.0%	47.0%	83
Female	62.5%	37.5%	16
Male	50.7%	49.3%	67
Hispanic	100.0%	0.0%	3
Male	100.0%	0.0%	3
Non-Resident Alien	66.7%	33.3%	6
Female	100.0%	0.0%	1
Male	60.0%	40.0%	5
Not Specified	70.6%	29.4%	17
Male	70.6%	29.4%	17
White, not of Hispanic Origin	69.1%	30.9%	136
Female	83.3%	16.7%	18
Male	66.9%	33.1%	118

Table 6: Retention by Gender and Ethnicity

And finally, a comparison of HS GPA by persistence in engineering partitioned by Gender and Ethnicity is presented in Table 7.

Table 7: HS GPA by Gender and Ethnicity

	Not-Continuing	Continuing	Group Average
Asian	3.39	3.25	3.28
Female	3.25		3.25
Male	3.52	3.25	3.28
Black, not of Hispanic Origin	3.00	3.04	3.03
Female	3.69	3.20	3.26
Male	2.93	2.98	2.96
Hispanic		3.53	3.53
Male		3.53	3.53
Non-Resident Alien		2.81	2.81
Female		3.69	3.69
Male		2.38	2.38
Not Specified	2.21	2.75	2.66
Male	2.21	2.75	2.66
White, not of Hispanic Origin	2.90	3.41	3.31
Female	3.21	3.61	3.58
Male	2.89	3.37	3.27
Group Average	2.94	3.24	3.17

Initial Observations

Any observation made based on this data will be limited by the single point snapshot taken of one year's class. Without supporting information for multiple entering classes, observations made will only be valid for this particular group. Data is currently being collected on the Fall class of 2010 to extend the study. With this caveat, some points can be made of this class.

- 1. The better the high school preparation, as evidenced by the significance of High School GPA, the better the chance that a student will persist in engineering.
- 2. The first semester in engineering is critical. Students who have a low GPA their first semester in engineering are unlikely to continue in engineering.
- 3. ACT scores may also be a significant factor for predicting persistence in engineering.
- 4. Students who have the lowest level of math preparation, as evidenced by the math class they are placed into, tend to be the most susceptible to leaving engineering.
- 5. Students who identified themselves as Black, not of Hispanic Origin left engineering at a much higher rate than those of other groups who all had a persistence rate of around 70%. This is counter to the HS GPA distribution of the group which is in line with all the other ethnic groups.
- 6. Female students within each ethnic group, while small in number, tend to remain in engineering at a slightly higher rate than male students.
- 7. Students may be making a choice to leave engineering based on their early math classes. Poor performance in the initial math class is the most significant factor in differentiating between students who stay and students who leave engineering after one semester.

Plans for Further Study

It is very difficult to draw conclusions from this limited study. However, the data analyzed for this study suggests the value of a much deeper study of the retention patterns, given so many differences were identified between students continuing in engineering and those that were not retained. In particular, with the Fall class of 2010, additional data has been collected about attitudes toward engineering and specific disciplines and this will be incorporated in the next iteration of the analysis. The Fall 09 cohort will also be tracked for persistence into Fall 11 and how well they have performed in indicator classes in each major. In addition, once a significant dataset has been developed, regression techniques will be used to try to further ascertain predictor variables for persistence in engineering at our university. This will be compared to existing studies from other universities with different student populations to determine what differences in retention predictors exist, if any, for urban institutions with high commuter populations.

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