

AC 2009-1677: FRESHMAN RETENTION IN AN ENGINEERING AND TECHNOLOGY DEPARTMENT

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Freshman Retention in an Engineering and Technology Department

Abstract

This paper presents the results of an in-depth study of one-year retention rates for freshman engineering students in the Engineering & Technology (ET) department at Central Michigan University. The ET department is a distinct collaboration of engineering, engineering technology, and technology programs, offering eight majors including the newly added mechanical and electrical engineering. The freshman engineering course consistently draws high enrollment, but the retention of these students to the second-year engineering courses is an unusually low 26%. Furthermore, the data shows that these unretained students are not choosing the (less-math-intensive) engineering technology or technology programs, as anticipated. This paper discusses these findings, as well as retention rates versus math level, course grade, and cumulative GPA, and the majors declared by the unretained students. This analysis has shown avenues for improving the freshman engineering course.

Introduction

The Engineering & Technology (ET) department at Central Michigan University (CMU) is a unique collaboration of engineering, engineering technology, and technology programs. The department offers 8 academic programs, including Mechanical Engineering, Electrical Engineering, Mechanical Engineering Technology, Manufacturing Engineering Technology, and Industrial Technology Management. Thus, the department attracts a wide range of technology-interested students with various math and science backgrounds. While the technology programs are well established, the engineering program is just beginning: it graduated its first engineering students in 2008.

Within the engineering program, the introductory course (EGR120: Introduction to Engineering) has consistently drawn a relatively high enrollment of 120 students per year. This year it is seeing an increase to 150 students, and growth is expected as the program achieves ABET accreditation, gains popularity, and becomes well established.

However, the current retention rate of these students is unsatisfactory. The current retention rate of freshman students to their second year in engineering is a dismal 26%. The majority of the higher-level engineering classes have 10 to 20 students — a respectable number for a new program, except for the high freshman enrollment. The overall department is not much better: only 31% of the freshman engineering students stay within the ET department, in one program or another. That is, the majority of unretained students are not transferring to the (less-math-intensive) engineering technology or technology programs, as one would expect or hope.

These initial numbers have prompted a study of the demographics of the freshman engineering students (math level, science level, GPA, subsequent major, etc.), corresponding

Table 1: Grade point scale for CMU.

Grade	Point	Grade	Point
A	4.00	C	2.00
A-	3.67	C-	1.67
B+	3.33	D+	1.33
B	3.00	D	1.00
B-	2.67	D-	0.67
C+	2.33	E	0.00

retention rates, and where the unretained students are going. In the following sections, we present and discuss a program overview, general retention rates, major distribution, math level, and cumulative grade point average. The final section suggests some changes that we are implementing to improve our retention rates. Such ideas can be extended to programs and departments offering both engineering and technology majors.

Program Overview

The engineering program at CMU is similar to ones at other schools. Students typically take EGR120 the first semester of their freshman year. The rest of their first year is spent taking the necessary math, physics, and science backgrounds to continue into the sophomore-level Statics and Circuits (taken by both mechanical and electrical students). Specifically, these two gateway courses require calculus (I for Statics, II for Circuits), calculus-based physics, and EGR120. That is, students in EGR120 are not seen again in the engineering program until their second year.

The ET department lies within the College of Science and Technology, yet EGR120 draws students from around the university who are interested in engineering, technology, or just a fun design project. The course is offered both semesters and has no prerequisites, although it recommends Intermediate Algebra or higher. The syllabus covers introductory material such as the engineering profession, problem solving, measurement and units, ethics, economics, and basic mechanical and electrical concepts. Traditionally, the course includes one large group design project of either a cardboard boat race in the fall semester or a robot King-of-the-Hill competition in the spring semester.

Students at CMU are graded on a 4.00 scale, from A through E (fail); see Table 1. Students who withdraw from a course are noted with a “W”. If a student’s cumulative grade point average (GPA) falls below a 1.99 (below C average) for three consecutive semesters, the student is academically dismissed.[†] If dismissed, a student cannot attend CMU for at least one year, and must apply for and receive rematriculation to do so.

CMU admission is typical for a midsize state university. Students are required to submit

[†]Academic dismissal may also occur at any time, if a student’s GPA is below a threshold (between 1.00 and 1.95) defined by their number of completed credit hours.

ACT scores, with an average score of 22. The average high school GPA is 3.3. Of those who apply for admission, around 70% are admitted, 32% of which enroll.

General Retention Rates

To understand the demographics of the freshman engineering students, we collected data from current transcripts of all the students who have taken EGR120 between Fall 2005 and Fall 2007 (five cohorts; 319 students)[†]. Fall 2005 is the first semester that EGR120 was offered under the EGR designator; prior to that a similar course was offered under a technology designator. We recorded data including

- Highest math course (and grade) taken prior to, or concurrently with, EGR120
- Grades from other fundamental engineering courses (Statics, Dynamics, Circuits, Digital Circuits)
- Major and declaration date
- Current cumulative GPA

Data is current as of January 2009. That is, Spring 2009 enrollment (such as in Statics and Circuits) is included, and three semesters have passed since the most recent studied cohort took EGR120. We discuss the interesting results in this paper.

We consider a student “retained” from EGR120 if they have since taken the sophomore-level Statics or Circuits. This is a more accurate measure than declared major, because students are not required to declare until the middle of their sophomore year. Therefore, we consistently have students in the second-year engineering courses that are still Undecided, or declared a previous major. However, major *is* a decent measure of attrition, if the major was declared after taking EGR120.

Table 2 shows general retention rates for each semester and for overall. 319 students took EGR120 in the semesters studied, and 26% of them have since taken Statics or Circuits (*i.e.*, have been retained).

The remaining students *have not* taken Statics or Circuits (*i.e.*, have not been retained). 6% of the total have majored elsewhere in the ET Department and 20% have majored in another department. 48% are undecided: 12% have been academically dismissed, 20% have (voluntarily) not attended CMU in the last year, and 16% are still attending elsewhere at CMU. In the table, the categories are filled from left to right — *e.g.*, the few students who took Statics but then were academically dismissed are in the Took Statics/Circuits column.

Stated differently: of the students who take EGR120,

[†]We originally included the Spring 2008 semester, but found that many students had not yet taken sophomore engineering courses, nor had declared majors. It is not uncommon for students at CMU to take three semesters from EGR120 to Statics if they need to take Precalculus, Calculus I, then calculus-based physics.

Table 2: General retention rates for the cohorts used in this study. "S" signifies spring semester; "F" signifies fall semester.

	Took EGR120	Took Statics or Circuits ("Retained")	Did not take Statics/Circuits, and majored in...				
			ET Dept.	Other Dept.	Undecided, and ...		
					Acad. Dism.	Not Attending	Attending
05-06 F	79	20%	6%	32%	14%	22%	6%
05-06 S	33	21%	9%	18%	12%	30%	9%
06-07 F	94	27%	3%	22%	17%	19%	12%
06-07 S	26	23%	4%	23%	8%	31%	12%
07-08 F	87	34%	7%	8%	5%	13%	33%
TOTAL	319	26%	6%	20%	12%	20%	16%

Table 3: Retention of students who are still attending CMU.

	Retention of students still attending...	
	by Engr.	by ET Dept.
05-06 F	31%	41%
05-06 S	37%	53%
06-07 F	42%	47%
06-07 S	38%	44%
07-08 F	42%	50%
TOTAL	39%	47%

- 32% are lost from CMU entirely (they stop attending or are academically dismissed)
- 20% are lost to other departments
- 6% are lost to other programs in the ET department
- 16% are most likely lost (they have not taken Statics or Circuits), but are still Undecided
- 26% stay in Engineering

If we consider only students who are still attending CMU, then retention rates are slightly higher (see Table 3). Engineering retains 39% of the still-attending students; the ET department retains 47%. The remaining analyses, however, do not use this clarification.

These retention rates are quite low, and need to be improved. The national average for *graduation* retention of students admitted into engineering is around 56%¹. Typical *freshman-to-sophomore* retention is much higher, such as 74%² and 86%³. Therefore, the ET department has made retention improvement one of its top priorities.

However, the engineering program at CMU is still very new, and has not yet been advertised. Thus, most of the students in the program are students who came to CMU and decided to try engineering, rather than students who came to CMU specifically for engineering. Furthermore, the EGR120 course is well known as a fun project-based course, and may

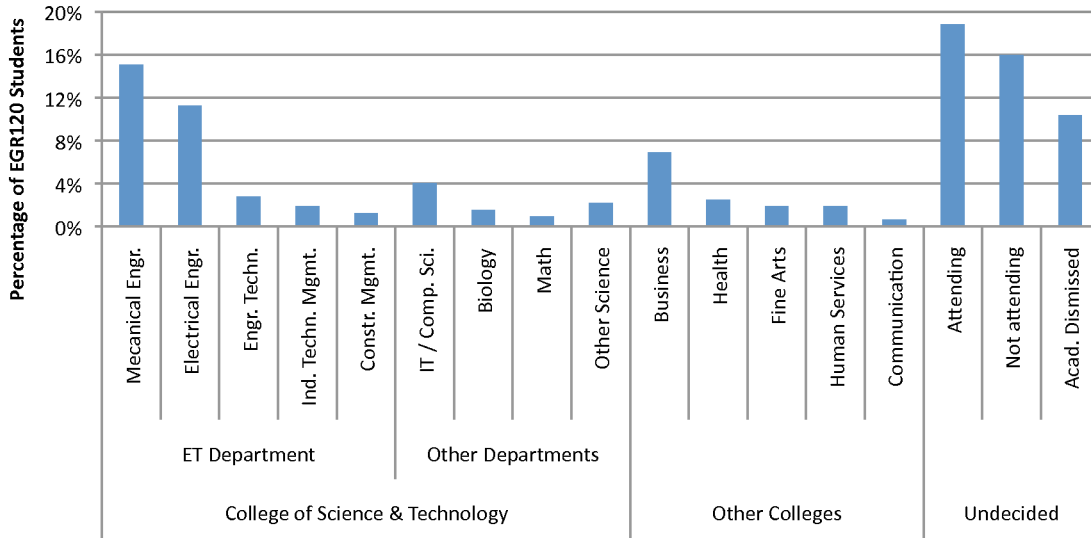


Figure 1: Distribution of declared majors. Majors are grouped by general topic (e.g., "Business" contains several business-related degrees).

attract students who are not really interested in an engineering degree (some students take it in the fall semester mainly to participate in the cardboard boat race).

The low transfer rate from engineering to engineering technology is not uncommon. Around 92% of the *unretained* students switch to a non-engineering related major. Dudeck *et al.* have seen similar numbers of around 90%.⁴

Majors

The second interesting set of data is that of declared majors. Figure 1 shows the current distribution of the majors declared by previous EGR120 students (grouped by general topic). This is not an accurate depiction of retention, however, as some Undecided students have taken Statics or Circuits, while some Engineering majors have not. This figure is meant to show where the students are declaring majors, if not in engineering.

The histogram shows where many of the students are going. Unfortunately, the vast majority of the students are still Undecided. However, those that have already declared majors outside of engineering are spread across the university. More students declare Business (7%) or Information Technology (IT) / Computer Science (4%), than Engineering Technology (3%). That is, for every EGR120 student that chooses Engineering Technology, two choose Business. These and other trends will become clearer as students declare majors in the coming years.

This data is discouraging because it shows that the unretained EGR120 students are not pursuing the less-math-intensive Engineering Technology or technology degrees, as hoped. This also implies that our poor retention rate is not due to technology students trying

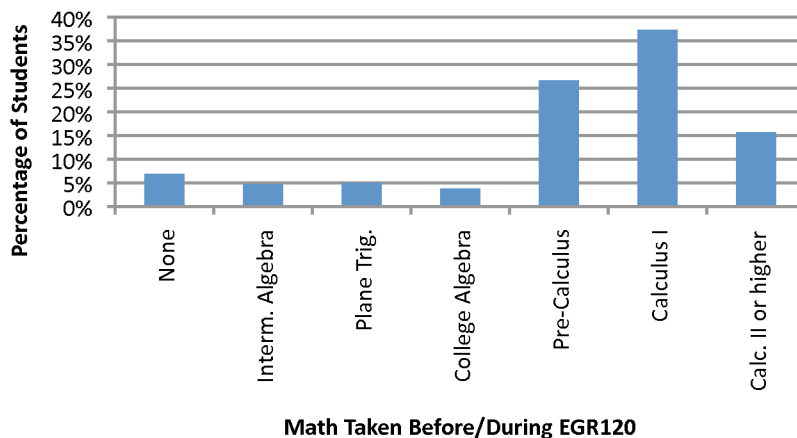


Figure 2: Distribution of math level.

EGR120 and deciding against engineering; if it was, then we should see these students go into other technology programs. Nor are we appearing to lose many students to the challenging background topics such as math, physics, or chemistry.

Math Level

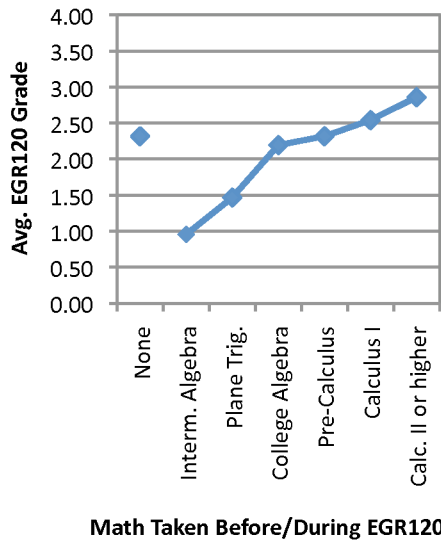
The data on math background is also interesting.

Because EGR120 does not have prerequisites, the students have very diverse math backgrounds. Figure 2 shows the distribution of math taken at CMU, before or during the EGR120 semester (defined as “math level”). Most of the students are at a precalculus or higher level, with Calculus I being the most common[†]. Much fewer students take EGR120 without already taking precalculus. Note that “None” does not convey math level; rather it signifies that students have not yet taken any math course *at CMU*.

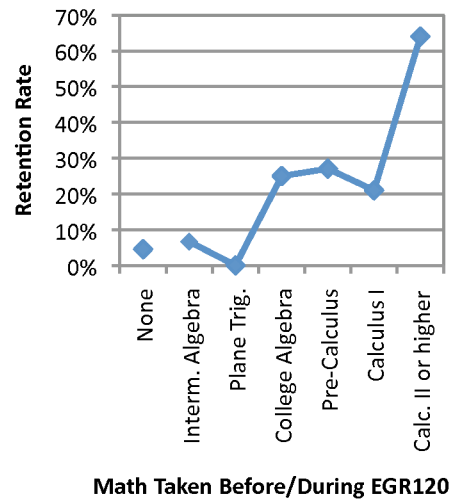
Surprisingly, there is a near linear relationship between Math Level and grade received in EGR120 (see Figure 3a). Students with only Intermediate Algebra average a D in EGR120, while students with a math level past Calculus I average a B. EGR120 does not incorporate significant math and relies heavily on teamwork, so it would seem that low-math-level students could easily get high grades in the class. Therefore, this trend might reflect the motivation or work ethic of the students: students who have a poor work ethic may be more likely to be behind in math as well as more likely to get a poor grade in EGR120.

The relationship between retention and math level is similar, although not as strong and not as surprising (see Figure 3b). Students who are at low math levels (and perhaps do not enjoy math) are less likely to stay in engineering, while those who are at high math levels (and perhaps enjoy math) are.

[†]Taking Calculus I during one’s EGR120 semester is considered on-track.



(a)



(b)

Figure 3: (a) EGR120 grade versus math level. (b) Retention versus math level.

Grades

Figure 4 shows a histogram of grades given in EGR120. The average grade on a 4.00 scale is a 2.33 (C+), and the majority of the students receive B's and C's. Retained students average a 2.97 (B), while unretained average 2.21 (C/C+). Within the ET department, future Engineering Technology majors average a 2.70 (B-), future technology majors average a 2.53 (B-/C+).

The histogram for (current) cumulative GPAs is very similar (Figure 5a). The average GPA of retained students is 2.76 (B/B-), while for unretained it is 2.39 (C+).

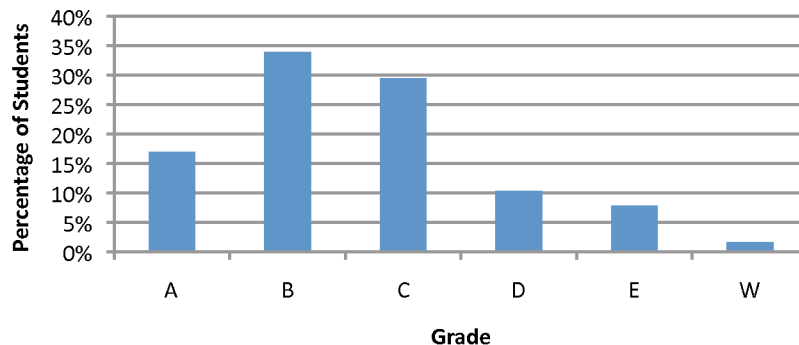
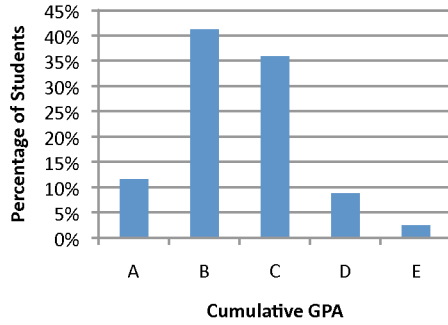
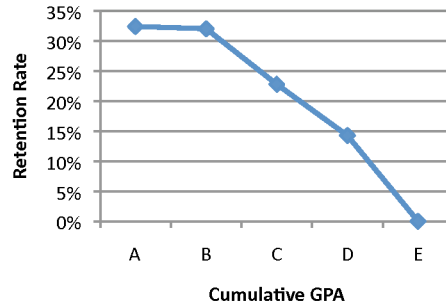


Figure 4: Distribution of grades given in EGR120. “W” signifies that the student withdrew from the course.



(a)



(b)

Figure 5: (a) Distribution of (current) cumulative GPAs for previous EGR120 students. (b) Retention versus cumulative GPAs.

Furthermore, there is a correlation between retention and cumulative GPA, as shown in Figure 5b. Students with high cumulative GPAs are more likely to be retained in engineering. Retention percentages are 32% for A students, 32% for B students, and 23% for C students. Of course, low-C and D students are susceptible to academic dismissal, so these rates may not be informative.

It is not surprising that engineering is retaining high-GPA students. Engineering takes hard work, and so draws hard-working students. However, the retention rates are still low.

Conclusions

Clearly, the retention in the engineering program at CMU needs to be improved. The data shows that unretained students are going to programs throughout the university, rather than to the other, less-math-intensive programs in the ET department, as one would hope. Therefore, EGR120 needs to be redesigned to (1) retain engineering students, and (2) retain the remaining students in the other programs in the department.

We are implementing several improvements to the EGR120 course to accomplish these goals.

- We have split the one large EGR120 section into several smaller sections, to promote interactions between students and instructor, and camaraderie among students.
- We have various ET department professors come and talk about themselves, their research, and their fields, to expose the students to the department and its faculty.
- We have the engineering and technology student groups come and present, to encourage involvement.
- We have included lab tour days, so students see the department's robotics lab, wind tunnel, electronics labs, machine shop, etc.

- We have incorporated more hands-on weekly projects in the course (made easier by the smaller class sizes), with emphasis on learning, design, and improving society.

Finally, in the future we plan to have upperclassmen as advisors the EGR120 project groups, so the freshman students better understand what it takes to be an engineering student.

The retention rates may also improve as the program gains recognition. As mentioned earlier, we have not yet marketed our (not-yet-accredited) program, and so the majority of the students in it chose engineering after coming to CMU, rather than the other way around. Advertising the program should target students more likely to stay in engineering.

In the coming years, we will see if these changes have improved retention. We will continue to address what we can do to retain students in engineering, *and* what we can do to retain the remaining students in technology. We plan on continuing our data collection, and have begun giving semester-beginning and semester-ending surveys to the EGR120 students. If successful, such a model can be extended to programs and departments offering both engineering and technology majors.

Acknowledgments

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