First Year Mathematics Course Credits and Graduation Status in Engineering

So Yoon Yoon, P. K. Imbrie, and Teri Reed
Texas A&M University, soyoon@tamu.edu, imbrie@tamu.edu, terireed@tamu.edu

***Abstract* – This study explored how first year engineering (FYE) students' types of mathematics course credits and performance relate to their graduation status. The data of 1,975 new first time freshman, in the fall of 2006 in an engineering program at a southwest public university, showed that 19.5 % of students got transfer course credits for Calculus I. Among them, 10.9 % of students achieved credits from AP and CLEP exams. On average, students who achieved transfer course credits graduated more from engineering than students who took the course at the university. However, when transfer course credits were disaggregated, students who achieved credits from AP and CLEP exams graduated more from engineering than students who took the course at the university, followed by students who achieved transfer course credits from other institutions. In addition, students' graduation rates in engineering significantly varied by their letter grades and types of course credits. Students who earned an A or B at the University graduated more from engineering than students with transfer course credits on Calculus I.**

Index Terms – First year engineering students, mathematics course performance, graduation rates

INTRODUCTION

I. Importance of First Year Common Courses

Courses for the beginning engineering students commonly consist of mathematics, chemistry, physics, and introductory engineering courses. As most engineering programs require a similar curriculum for freshman students, the roles of the first year common courses are important in various ways. First, students can gain fundamental base of knowledge and skills through common courses [1]. Second, accordingly, students' performance on the first year courses has a direct impact on the next level course performance. Particularly, a sophomore curriculum usually requires more advanced courses than the first year common courses. In other words, students, who performed well on the first year common courses, tend to be successful at the upper grade levels. Finally, the literature has shown a strong positive relationship between engineering students' first year common course performance and their persistency in engineering or graduation rates from engineering. Students, who performed well on their first year common courses, have high tendency to ultimately achieve an engineering degree [2].

Several studies explored the association between engineering students' first year common course performance and their upper level course performance or retention/graduation rates. For example, Felder, et al. [3] revealed strong and significant correlations between engineering students' sophomore chemistry course performance and first year mathematics (Calculus I and II), chemistry (Chemistry I and II), and Physics grades. The correlation between sophomore chemistry course grades and first year engineering course grades was moderate. Collura, Ciston, & Savage [4] showed a strong correlation between two chemistry course grades, each required in freshman and sophomore year curriculums from data of 50 engineering students at the University of New Haven, CT. In an early study by Hoyt, Ellsworth, and Katz [5], about 70% of students who achieved A, B, or C on a freshman physics course graduated from engineering. However, only 21% of engineering students, who initially failed on a physics course, could graduate from engineering.

Similarly, Budny et al. [1] explored the impact of the first year mathematics performances on engineering students' 6th semester persistence at Purdue University from 1966 to 1993. When students successfully completed the first year core courses with a grade of C or better, they were allowed to apply for a specific engineering major starting from their sophomore. On average, 64% of them could enter into an engineering major program in that period. Exit interview results revealed that students, who failed in becoming sophomore, faced difficulty in mathematics, chemistry, and physics. Budny et al. [1] also found that the first semester GPA was a better predictor of students' 6th semester retention status in engineering than their SAT-Math scores. In sum, the relationships between students' first year course performance and their upper level course performance as well as their graduation status in engineering were apparent in the literature.

While students usually take the common courses offered by the institution, there are several different ways that students can get credits for the courses. For example, students can get transfer course credits through Advance Placement (AP) exams, College Level Exam Program (CLEP) exams, or dual credits taken from other institutions while they are in high school or in college. For international students, international baccalaureate (IB) course credits are transferrable for common courses. However, most studies in

the literature investigated the effects of common course credits directly taken from institutions of the interest and there has been a lack of research about the efficiency of the transfer course credits on students' upper level performance or graduation status in engineering.

II. Purpose of the Study

This study investigated the association between engineering students' first year mathematics course credits and their graduation status. As students achieve the mathematics course credits through different ways, the following research questions guided this study.

- How do students in engineering achieve credits for a first year mathematics course?
- How do graduation rates in engineering differ by the types of credits achieved for a first year mathematics course?

To do this, we also attempted to track students' graduation status in engineering across years.

METHODS

I. Setting

At a southwest public university, engineering is the largest program that provides 14 departments with 17 degree programs. While there exist a total of 19 different curriculum tracks, 13 tracks from 11 departments have an almost identical first year engineering curriculum that includes mathematics (engineering mathematics [Calculus] I and II), chemistry (fundamentals of chemistry I and II), physics (mechanics and electricity and optics), and engineering (foundations of engineering I and II) as shown in Table 1. Particularly, Calculus I is required for all curriculum tracks.

TABLE 1
FIRST YEAR ENGINEERING COMMON CURRICULUM

Discipline	First Semester		Second Semester	
	Subject	Cr	Subject	Cr
English	Composition and Rhetoric	3	–	
Chemistry	–		Chemistry for Engineers	4
Engineering	Foundations in Engineering I	2	Foundations in Engineering II	2
Mathematics	Engineering Mathematics I (Calculus I)	4	Engineering Mathematics II (Calculus II)	4
Physics	Mechanics	4	Electricity and Optics	4
Elective	University Core Curriculum elective	3	University Core Curriculum elective	3
Health	Health and Fitness Activity	1	Required Physical Activity	1
Total Credit		17		18

II. Participants

The participants of this study were 1,975 new first time freshman, who started their first semester in the fall of 2006 in an engineering program at the southwest public university. We defined them as 2006 cohort for the purpose of this study. More male students (n = 1,556; 78.8%) enrolled in the engineering program than female students (n = 419; 21.2%) and about 71.7% of students were White (n = 1416), followed by Hispanic (n = 309; 15.6 %) and Asian (n = 103; 5.3%). The majority of the students (n = 1,931; 97.8%) were domestic. Students' age ranged from 16 to 24 with M = 18.04 and SD = 0.43. While mechanical engineering has the most number of FYE students (n = 308, 15.6%), radiological health engineering had the least number of FYE students (n = 8; 0.4%).

III. Procedure

The 2006 cohort students' course performance and graduation status in engineering were tracked for 7.5 years through the data retrieved from the university archive. Therefore, the fall of 2013 was the semester that showed 2006 cohort students' last academic activities if there were any. Here, students' Calculus I course credits were categorized into two groups: transfer course credits and credits from the university. The transfer course credits were disaggregated into credits from AP or CLEP exams and credits from other institutions. Credits from the university was the first attempted course credits of the students who took Calculus I at the institution and transfer course credits were the last credits that students achieved prior to the enrollment at the university. Students' graduation status was categorized into one of three groups: graduation in engineering, graduation in non-engineering, and no graduation.

IV. Data Analyses

First, descriptive statistics were applied to identify trends in the data. Second, coefficients of the point-biserial correlation, which is the special case of the Pearson product moment correlations, were calculated to explore the relationship between common course grades (a continuous variable) and graduation status (a dichotomous variable) [6].

RESULTS

I. Graduation Status

Table 2 shows graduation rates by year at the institution. After 7.5 years, only 53.5 % of the 2006 cohort achieved a degree in engineering, and 24.5% received a degree out of engineering. Therefore, 22.0% did not earn a degree in any majors at the university.

TABLE 2
2006 COHORT STUDENTS' GRADUATION STATUS ACROSS YEARS AT THE INSTITUTION

Graduation Status	Term	F08	S09	F09	S10	F10	S11	F11	S12	F12	S13	F13
	Yrs	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5
Graduation in Engineering	n_A	0	2	8	334	624	905	983	1,023	1,038	1,052	1,054
	$\%_A$	0.0	0.1	0.4	16.9	31.6	45.8	49.8	51.8	52.6	53.3	53.5
Graduation in Non-Engineering	n_A	1	4	23	177	300	398	449	459	469	476	480
	$\%_A$	0.1	0.2	1.2	9	15.2	20.2	22.7	23.2	23.7	24.1	24.5
Graduation at the Institution	n_A	1	6	31	511	924	1,303	1,432	1,482	1,507	1,528	1,534
	$\%_A$	0.1	0.3	1.6	25.9	46.8	66	72.5	75.0	76.3	77.4	78.0

Note. Yrs = years taken for graduation; F = fall; S = spring; n_A = accumulative number of students; $\%_A$ = accumulative percentage

Table 3 shows the graduation status of 2006 cohort students broken down by their demographic information. According to proportional comparisons by subgroup, more female students (51.8%) left engineering than male students (45.2%), but more female students (83.3%) achieved a college degree than male students (76.2%). Among racial/ethnic groups, Black students had the lowest graduation rates (29.4%) in engineering followed by Hispanic students (44.3%). More percentage of international students (72.7%) achieved an engineering degree than domestic students (52.9%), but a similar portion of students (22.7% and 22.3%) did not graduate from the university.

TABLE 3
2006 COHORT STUDENTS' GRADUATION STATUS BY DEMOGRAPHIC PROFILE

Category	2006 Cohort	Graduation in Engineering		Graduation in Non-Engineering		No Graduation	
	N	*n*	*%*	*n*	*%*	*n*	*%*
Gender							
Female	419	202	48.2	147	35.1	70	16.7
Male	1,556	852	54.8	333	21.4	371	23.8
Residence							
Domestic	1,931	1,022	52.9	478	24.8	431	22.3
International	44	32	72.7	2	4.5	10	22.7
Race/Ethnicity[a]							
Hispanic	309	137	44.3	72	23.3	100	32.4
American Indian or Alaska Native	5	2	40.0	1	20.0	2	40.0
Asian	103	59	57.3	21	20.4	23	22.3
Black	68	20	29.4	19	27.9	29	42.6
Native Hawaiian or Other Pacific Islander	1	0	0.0	1	100.0	0	0.0
White	1,416	787	55.6	356	25.1	273	19.3
Multi-racial	25	16	64.0	7	28.0	2	8.0
Unspecified	4	1	25.0	1	25.0	2	50.0
Total	1,975	1,054	53.4	480	24.3	441	22.3

Note. [a]Race/Ethnicity was categorized for domestic students only.

II. Graduation Status by Types of Calculus I Course Credits

While a majority of students (77.9%) took Calculus I at the institution, as we expected, students also achieved the course credits in various ways. About 19.5% of students earned transfer course credits for Calculus I. Among them, 10.9% of students achieved the transfer course credits through AP and CELP exams and 8.6% took the course at other institutions, such as community colleges or four-year institutions to achieve the transfer course credits. About 2.4% of students (n = 48) did not earn any Calculus I course credits. Table 4 shows students' graduation status by types of Calculus I course credits.

On average, students who achieved transfer course credits (61.2%) graduated more from engineering than students who took the course at the university (53.1%). However, when transfer course credits were disaggregated, students who achieved credits from AP and CLEP exams (69.0%) graduated more from engineering than students who took the course at the university (53.1%), followed by students who achieved transfer course credits from other institutions (51.4%). Figure 1 shows the apparent trend in graduation status by the types of course credits.

TABLE 4
GRADUATION STATUS BY TYPES OF CALCULUS I COURSE CREDITS

Source of Credits	Total	Graduation in Engineering		Graduation in Non-engineering		No Graduation	
	N	*n*	%	*n*	%	*n*	%
Institution	1,538	814	53.1	383	24.9	339	22.0
Transfer	389	238	61.2	92	23.7	59	15.2
Exams[a]	216	149	69.0	37	17.1	30	13.9
Other Instructions	173	89	51.4	55	31.8	29	16.8

Note. [a]Credits are from AP and CELP exams.

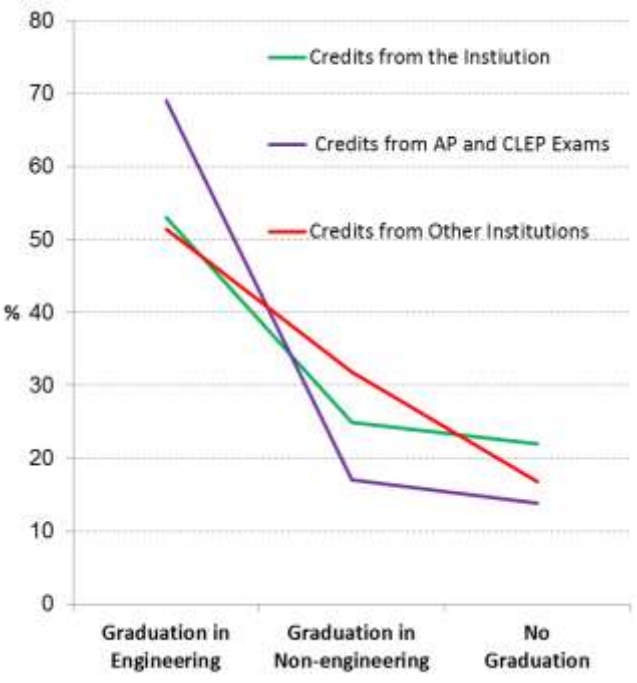

FIGURE 1
GRADUATION STATUS BY TYPES OF CALCULUS I COURSE CREDITS

III. Graduation Status by Calculus I Course Grades

When students' graduation status was explored by their Calculus I course grades, students' graduation rates in engineering significantly varied by their letter grades and types of course credits. Figure 2 shows 2006 cohort students' graduation status by Calculus I course grades broken by types of course credits. Here, grades of A, B, C, and DFWQ (draw, fail, withdraw, and Q-drop) indicate students' performance on Calculus I at the university. T grades indicate that students achieved transfer course credits from AP and CLEP exams. TA, TB, TC, and TDFWQ grades refer to transfer course grades of A, B, C, and DFWQ, respectively.

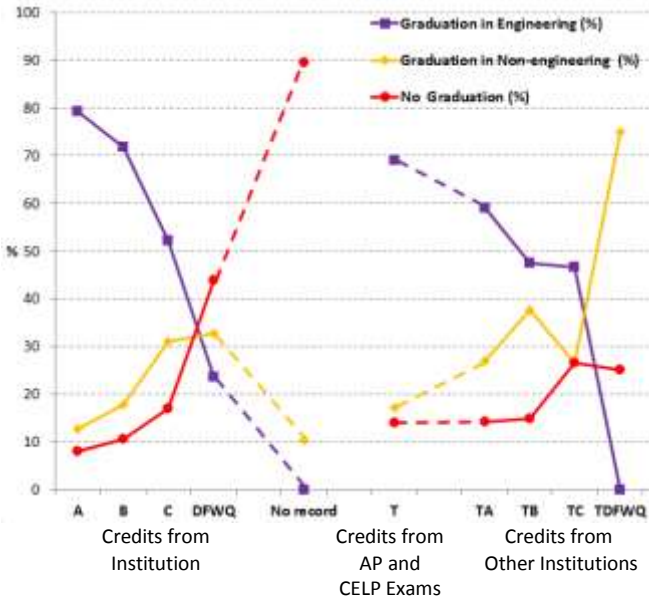

FIGURE 2
GRADUATION STATUS BY CALCULUS I COURSE GRADES

On average, students who earned a grade of C or above at the university (66.4%) graduated more from engineering than students with transfer course credits (51.4%) on Calculus I at other institutions. In detail, students, who earned a grade of A or B at the university, had high graduation rates, which are 79.3% and 71.9%, respectively. Students, who received a grade C at the university, had a relatively low graduation rate (52.1%). However, students with transfer course credits from other institutions showed overall low graduation rates, which are 59.0%, 47.5%, and 46.7% corresponding to grades of TA, TB, and TC, respectively. Interestingly, students who obtained transfer course credits from AP and CELP exam had a high graduation rate (69.0%). None of the students with no credits on Calculus I achieved a degree in engineering.

A point-biserial correlation coefficient between letter grades and graduation in engineering of students, who earned course credits at the university, was 0.429 (n = 1,538, p < 0.001) except students with no mathematics course credits (n = 48). However, a point-biserial correlation coefficient between letter grades and graduation in engineering of students, who earned transfer course credits at other institutions, was 0.081 (n = 173, p = 0.287) except students with transfer course credits from AP and CELP exams (n = 216).

DISCUSSION

The 2006 cohort students enrolled in engineering at a southwest public university showed 51.8% of graduation in engineering after six years, which is similar to the literature. However, students continued to graduate in engineering after six years, so as of fall 2013, 53.5% of students achieved a degree in engineering. The trends of graduation status in engineering by gender and race/ethnicity were also similar to the literature as male students graduated more from engineering and Asian students followed by White students showed higher graduation rates in engineering than other race/ethnic groups. Interestingly, international students, who might have cultural and language barriers, showed higher graduation rates in engineering than domestic students. Further investigation would warrant understanding of the factors that make international students persist in engineering.

First year engineering common courses are critical for students to persist and be successful in engineering. This is particularly true as the literature showed strong relationship between students' first year common course performance and their upper level course performance, persistency or graduation in engineering. First year common courses are sometimes called different names, such as barrier courses, gateway courses, and gatekeeper courses when students show highest DFWQ rates on the courses (Suresh, 2006-2007). Seymour and Hewitt [7] warned about the *weed-out philosophy* by faculty (perceptions of keeping best students and weeding out poor students through gatekeeper courses) because such perceptions of faculty can be a factor that contribute students' attrition in engineering. In this study, the DFWQ rate of students who took Calculus I first time at the university was 24.3%. Even though almost a quarter of students did not pass Calculus I at their first attempt, 23.5% of them could finally achieve a degree in engineering. This implies low achieving students' potential to be successful in engineering. Therefore, with appropriate support (e.g., tutoring) for those students, their persistency can be improved.

While students have various pathways to achieve transfer course credits on first year engineering common courses, in this study, about 19.5% of students achieved transfer course credits on Calculus I. However, students' graduation rates differed by types of transfer course credits. Overall, students who achieved credits from AP and CLEP exams had the highest graduation rates in engineering, indicating efficiency of the credits in terms of time and financial saving. As students with AP credits have a high possibility of being on an honors track, their higher graduation could be predicted.

Even though there was no distinguishable difference in overall graduation rates in engineering between students who took the course at the institution and at other institutions, students showed varied graduation rates in engineering depending on the course performance. On one hand, the significant and positive correlation between course grades achieved from the institution and graduation status in engineering indicates that if students perform better on Calculus I, then they tend to graduate more from engineering. On the other hand, while grades of TB and TC are passing transfer course credits, students with a grade of TB or TC on Calculus I showed lower graduation rates in engineering than students with a grade of C on Calculus I. This trend was apparent in the nonsignificant correlation between transfer course grades and graduation status in engineering. This implies that grades of TB and TC do not show any differences in graduation rates in engineering between them and some students with a grade of TB or TC may not have enough mastery of knowledge of Calculus I when other conditions are equal. Therefore, further investigation is necessary to reveal effects of transfer course grades on next level mathematics course performance. In addition, extending this line of research to other first year common courses, such as chemistry and physics, will show dynamics of the effects of transfer course credits and grades on students' graduation status in engineering and identification of students at risk.

While there have been various approaches to explore the effects of first year engineering common courses on students' upper level course performance and persistency in engineering, most studies limited their focus on the course grades earned at an institution of their interests. As students can achieve first year common course credits in various ways, this study attempted to extend the scope of investigation to the transfer course credits and explored the association between students' graduation status in engineering and types of transfer course credits on Calculus I.

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AUTHOR INFORMATION

So Yoon Yoon Post-doctoral research associate, Dwight Look College of Engineering, Texas A&M University, soyoon@tamu.edu

P. K. Imbrie Director of Undergraduate Academic Programs, Dwight Look College of Engineering, Texas A&M University, imbrie@tamu.edu

Teri Reed Assistant Vice Chancellor of Academic Affairs, Dwight Look College of Engineering, Texas A&M University, terireed@tamu.edu