BOISE STATE UNIVERSITY

OFFICE OF INSTITUTIONAL RESEARCH

What is related to student retention in STEM for STEM majors?

Abstract:

The purpose of this study was look at the impact of English and math courses and grades on retention in the STEM major after one year compared to (a) retention at the university but not in STEM and (b) attrition from the university. This study was based on first-time full-time students who began in the fall of 2007 through fall 2011 with a declared STEM major. The study was limited to students who took both math and English courses during their first year.

Results confirmed the importance of success in students' first math course as well as the level of math that students began in, especially when comparing those who remained STEM majors one year later and those who switched to a non-STEM major. For engineering majors, Receiving an "A" in their first math course was the best way to determine who would remain a STEM major with the "A" students being seven (7) times more likely to remain STEM majors compared to those who received a "D", "F", or "W". Enrollment in MATH 108 was another way to differentiate those who remained STEM majors and those who switched to a non-STEM major. Compared to students who began in Calculus I, students who enrolled in MATH 108 were only about half as likely to still be STEM majors one year later.

For math and science majors, receiving an "A" in their first math course was the best single way to differentiate who would remain a STEM major and who would switch out. Enrollment in MATH 108 was also an important predictor, though the effect of enrolling in this course was not nearly as strong for math and science majors as it was for engineering majors.

When the comparison was between STEM retainers and those who left the university entirely, performance in students' first English course was most important factor. An "A" or "B" in the first English course improved the odds of remaining a STEM major more than seven times and was the best way to differentiate the two groups. Math grades and level of first math course also helped differentiate between those who remained STEM majors and those who left the university.

In general, engineering majors and math/science majors had both different retention rates and different factors that best predicted retention in STEM.

Introduction

A national push is on to increase the number of STEM (Science, Technology, Engineering, and Math) graduates. To get to graduation, however, STEM majors must first be retained in the STEM disciplines. This study is a first look at the relationships between retention as a STEM major and the English and math grades and courses that students took during their initial year of enrollment.

This study was based on first-time-in-college students who began in the fall of 2007 through fall 2011 with a declared STEM major. The study was limited to students who took both math and English courses during their first year and included two comparisons: (1) students who remained STEM majors with students who were retained but switched out of a STEM major and (2) students who remained STEM majors with students who were not retained at the university. For shorthand purposes, the groups will be known as STEM retainers, STEM switchers, and leavers.

The study addresses the following questions:

- What were the first English and math courses that new STEM students took and what were their grades?
- How did the courses students took and the grades they received relate to retention in STEM and at the university after one year?
- Were findings similar for all STEM majors or was the relationship between courses, grades, and retention different for engineering majors compared to math and science majors?

Methodology

The initial base of the study included 1,810 first-time full-time students who started at Boise State as STEM majors beginning with fall 2007 and ending with fall 2011. The number in the study was reduced to 1,472 students (81% of the total) who enrolled in both English and Math courses during their first year. For purposes of this analysis the following STEM majors were included: Applied math, Biology, Biology Secondary Ed, Chemistry, Chemistry Secondary Ed, Civil Engineering, Computer Science, Earth Science Education, Electrical Engineering, General Engineering, Geology, Geophysics, Mathematics, Math education, Materials science, Mechanical engineering, Physics, and Physics education.

A majority were engineering majors (937 or 64%). Most were male (74%) and less than 20 years old (84%). White non-Hispanic or Asian students predominated (78%), but 13% were under-represented minority students, 4% were non-resident aliens, and the race/ethnicity categorization was unknown for 5%.

Students' earliest enrollment in English and math during their first year in college was selected for the analysis. The breakdown of English and math courses can be found in Table 1. In math, most students began below the level of calculus I, although 30% were calculus-ready. In English, a majority began in ENGL 101. Table 2 displays the first math and English grades that students received. In math, the most common grade was a D, F, or W. In English, however, the most common grade was an A.

Figure 1 below shows differences between engineering majors and math/science majors in terms of level of first math and English course and grades in those courses. Note that more engineering majors were ready for or had already taken calculus compared to the math/science majors. Grades, however, were fairly similar for the two groups.

Table 1. First Math and English course by STEM group

Course	Number of science or math majors enrolled	Number of engineering majors enrolled	Total enrolled (% of total)
MATH 15[1]	3 (1%)	6 (1%)	9 (<1%)
MATH 25	62 (12%)	94 (10%)	156 (11%)
MATH 108	128 (24%)	161 (17%)	289 (20%)
MATH 124 or 130	21 (4%)	13 (1%)	34 (2%)
MATH 143 or 144 or 147	209 (39%)	325 (35%)	534 (36%)
MATH 160	8 (1%)	6 (1%)	14 (1%)
Calculus I (MATH 170) or higher*	104 (19%)	332 (35%)	436 (30%)
ENGL 90 or ESL (ENGL 121, 122, 123)	46 (9%)	104 (11%)	150 (10%)
ENGL 101	294 (55%)	539 58%)	833 (57%)
ENGL 102 or higher*	195 (36%)	294 (31%)	489 (33%)
Total	535 (100%)	937 (100%)	1472 (100%)

*Denotes the course to be used as the comparison in the analysis

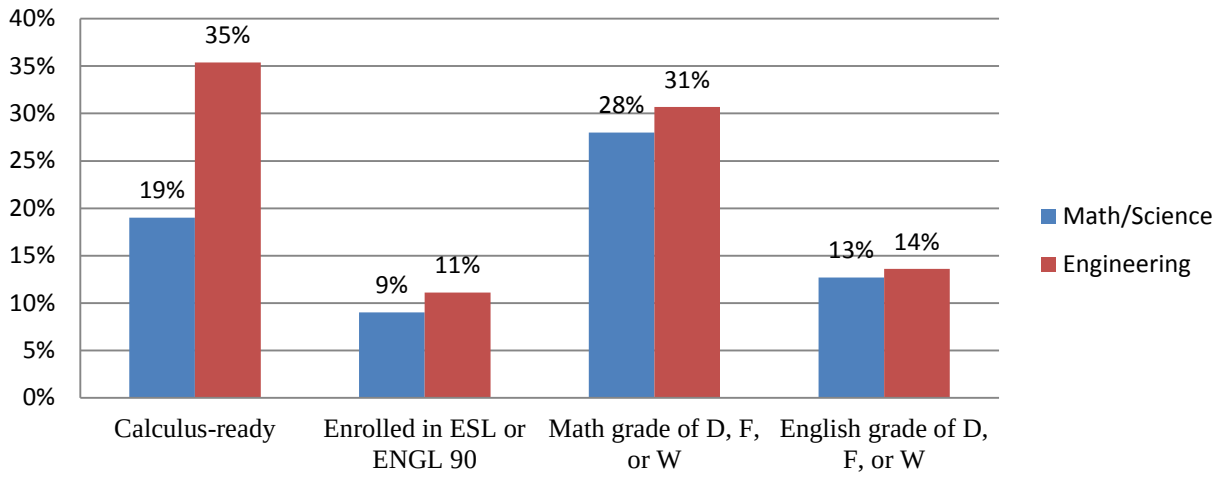
Table 2. Math and English grades by STEM group

Grade	Number of science or math majors with grade	Number of engineering majors with grade	Total with grade (% of total)
Math grade of D, F, or W*	150 (28%)	288 (31%)	438 (30%)
Math grade of C	114(21%)	229 (24%)	343 (23%)
Math grade of B	131 (24%)	234 (25%)	365 (25%)
Math grade of A	140 (26%)	186 (20%)	326 (22%)
English grade of D, F, or W*	68 (13%)	127 (14%)	195(13%)
English grade of C	84 16%)	176 (19%)	260 (18%)
English grade of B	121 (23%)	237(25%)	358 (24%)
English grade of A	262 (49%)	397 (42%)	659 (45%)
Total in groups	535 (100%)	937 (100%)	1472 (100%)

*Denotes comparison grade to be used in the analysis

[1] Removed from further analysis due to small numbers

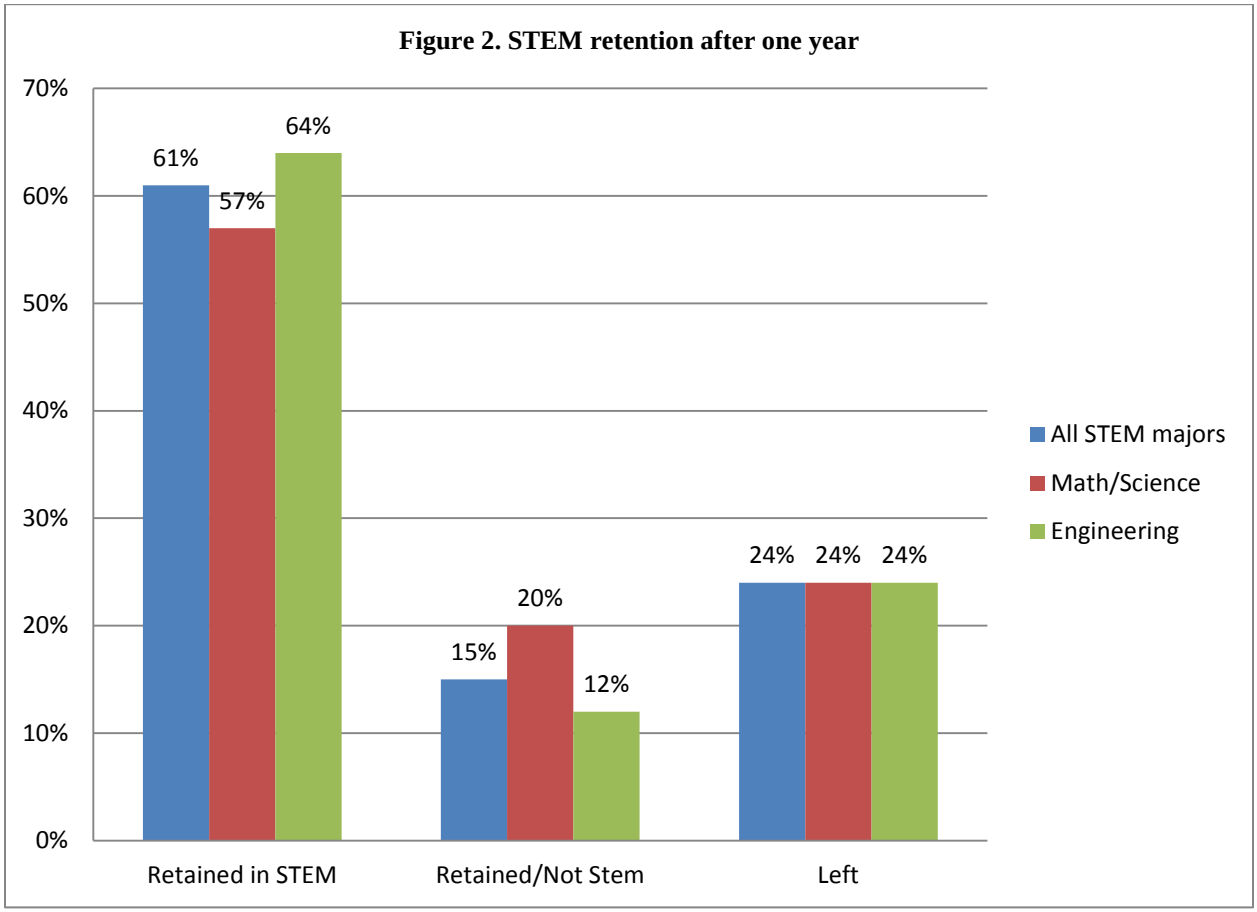
Figure 1. Enrollment and failure rates in key math and English courses by STEM major



The variables used to predict retention included level of first math course, where the comparison was based on students who began in Calculus I or higher; level of first English course, where the comparison group included students who began in ENGL 102 or beyond; grade in first math course; and grade in first English course. The comparison groups for grades were those who received a "D", "F", or "W" the first time they took the English or math course. To check to see whether the relationship between course level, grades, and retention was similar for engineering and for math/science majors, type of major (engineering=1, math/science=0) also was included.

The outcome of interest was retention in STEM one year later. There were three possible retention outcomes: (1) retained and remained a STEM major, (2) retained but changed to a non-STEM major, and (3) not retained at the university. The groups were referred to as STEM retainers, STEM switchers, and leavers respectively. Because logistic regression was used in the analysis, which allows for only two outcomes, the first comparison included only STEM retainers and STEM switchers. The second comparison included STEM retainers and leavers. Checks were performed to see if any of the course or grade variables behaved differently based on STEM type. If any significant interactions were found using $p<=.05$, separate analyses were conducted for engineering and math/science majors.

After one year, 61% of the group was retained as STEM majors, 15% were retained at the university but switched to a non-STEM major, and 24% left the university. Engineering majors were somewhat more likely to be retained in STEM compared to math/science majors, though both groups had similar percentages that left the university (see Figure 2 for details).



Results

Differentiating between those who were retained in STEM after one year and those who were retained but not in STEM (STEM retainers vs. STEM switchers)

Separate analyses were performed grouping engineering majors together and math/science majors together because the initial analysis revealed that enrollment in ENGL 90 had a different effect on retention for engineering majors compared to math/science majors.

Variables which positively influenced engineering majors to stay in STEM instead of switching to a different major included receiving a "B" in English, an "A" in math, and enrolling in ENGL 90 or ESL. The influence of ENGL 90 or ESL was probably due more to the number of international engineering majors who start in ESL and less to do with enrollees in ENGL 90. Variables which negatively influenced engineering majors to stay in STEM included enrollment in Math 25, 108, or 124/130. Recall that the comparison groups were a D, F or W for grades, and enrollment in calculus or higher for math courses, and enrollment in ENGL 101 for English courses. See table 3 for details.

The only variable which was positively related to remaining in STEM for math and science majors was receiving an "A" in math compared to receiving a D, F, or W. Negative influencers included enrollment in Math 108, 143 or 160 compared to being calculus ready. Details are again provided in Table 3.

Table 3. Logistic regression model for predicting retention in STEM one year later vs. retention but not in STEM for engineering and math/science majors

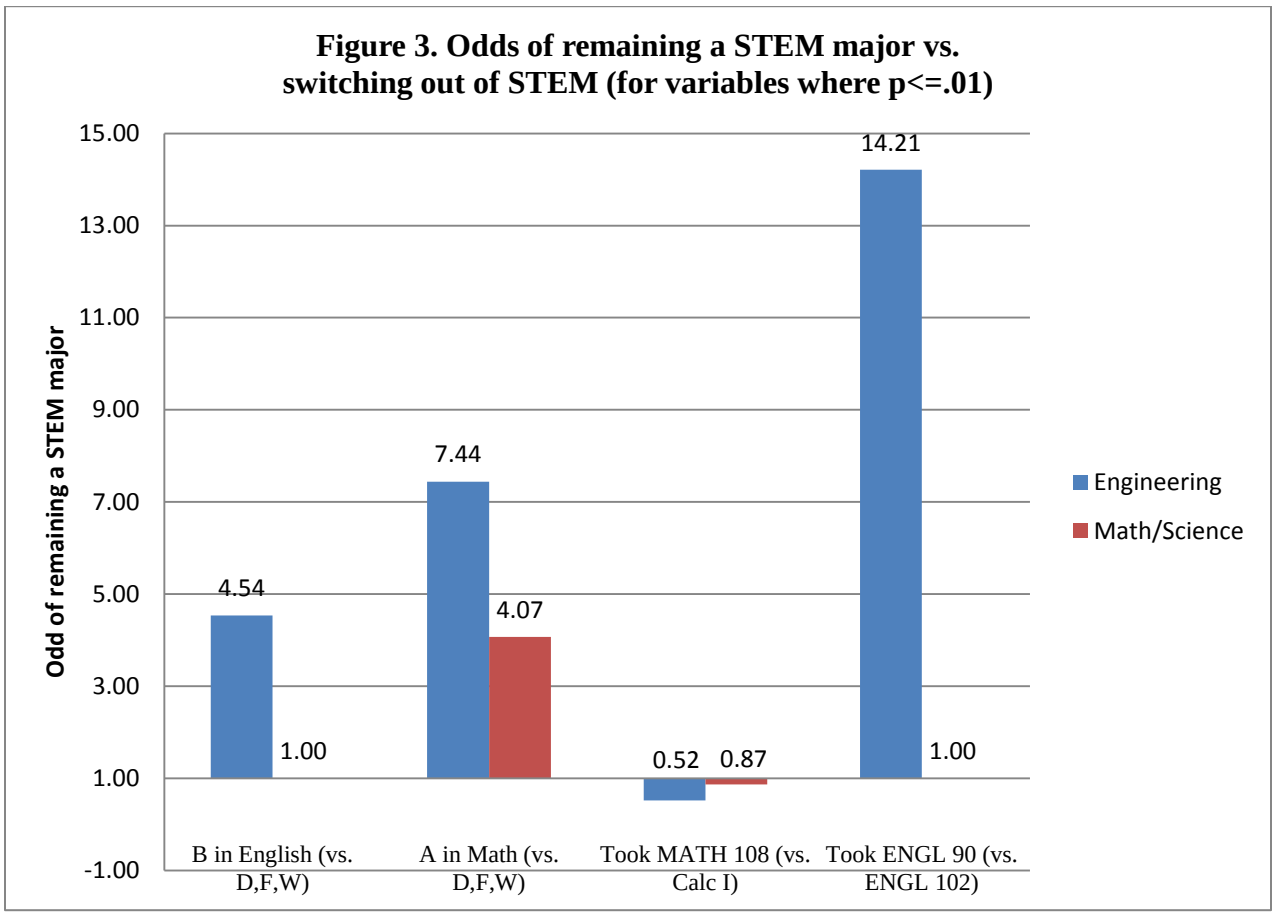
Parameter	Engineering (n=703)				Math/Science			
	Estimate	Wald χ^2	Prob	Odds	Estimate	Wald χ^2	Prob	Odds
intercept	1.66	23.33	<.0001	--	1.94	18.65	<.0001	--
A - ENGL	0.37	1.63	.2023	NS	-0.27	0.71	.4001	NS
B - ENGL	0.81	5.09	.0240	4.54	0.14	0.11	.7368	NS
C - ENGL	-0.30	0.46	.4965	NS	0.57	0.71	.4010	NS
A - MATH	1.29	12.31	.0004	7.44	0.77	5,74	.0166	4.07
B - MATH	0.53	3.30	.0692	NS	0.45	1.79	.1809	NS
C - MATH	0.08	0.08	.7831	NS	0.31	0.83	.3612	NS
M025	-1.09	5.61	.0179	0.83	-0.71	2.08	.1492	NS
M108	-1.29	16.12	<.0001	0.52 (1.92)[a]	-0.95	5.32	.0211	0.87 (1.15) [a]
M124/130	-2.13	5.35	.0207	0.72 (1.39)[a]	-0.70	1.13	.2877	NS
M143	-0.47	2.91	.0879	NS	-0.78	4.26	.0390	0.96 (1.04) [a]
M160	-1.57	1.56	.2115	NS	-1.79	2.09	.0484	0.99 (1.01) [a]
ENGL 90 or ESL	1.48	6.13	.0133	14.21	-1.13	2.09	.1487	NS
ENGL101	-0.31	1.51	.2188	NS	-0.64	5.22	.0224	0.91 (1.10) [a]

NS= not significant

[a]Reverse odds

In addition, Figure 3 displays the odds ratios for the most significant variables (p<=.01) for differentiating STEM-retainers compared to STEM-switchers. Note that when the odds are the same for the two groups, the odds ratio is one (1). Ratios of less than one indicate that it is less likely that students will remain in STEM than the comparison group, while whose greater than one indicate that they are more likely to remain in STEM. Because it can be difficult to interpret odds ratios of less than one, the reverse odds is shown in parentheses (e.g., student did NOT enroll in MATH 108 instead of student did enroll in MATH 108.)

To summarize, receiving an "A" in the first math course significantly improved the probability of remaining a STEM major for both the engineering and math/science majors. Enrolling in MATH 108 significantly decreased the odds of remaining a STEM major for both groups. All other results differed for the two types of STEM majors. For engineering majors, enrollment in other lower level math courses (i.e., Math 25 and Math 124/130) was associated with reduced odds of remaining in STEM, but enrollment in these courses was non-significant for math/science majors. Instead, the lower level math courses for math/science majors that were associated with reduced odds of remaining in STEM were MATH 143 and 160. Enrollment in ENGL 90 or ESL boosted the odds of remaining a STEM major for engineering but had no effect for math/science majors. Instead, enrollment in ENGL 101 decreased the odds of remaining in STEM for math/science majors compared to starting by enrolling in ENGL 102 or higher.



Differentiating those who were retained in STEM after one year and those who left the university (STEM retainers vs. leavers)

Again, the first step was to test whether the relationships between retention and grades and courses was similar for engineering and math/science majors when the comparison of interest was retention in a STEM major vs. leaving the university. Significant interactions for a "B" in math and for ENGL 101 meant that separate analyses for engineering and math/science majors were again needed. Results are shown in Table 4 and displayed graphically in Figure 4.

For engineering majors, variables that were positively related to remaining a STEM major included receiving an A or B in English and an A or B or C in math compared to receiving a D, F, or W. Variables which were negatively related to remaining a STEM major included enrolling in Math 108, 124/130, or 143/144/147 or enrolling in ENGL 101. Recall that the comparisons were students who were calculus ready for the math courses and enrolling in ENGL 102 or beyond for English. See Table 4 for details.

Table 4. Logistic regression model for predicting retention in STEM one year later vs. leaving the university for engineering and math/science majors

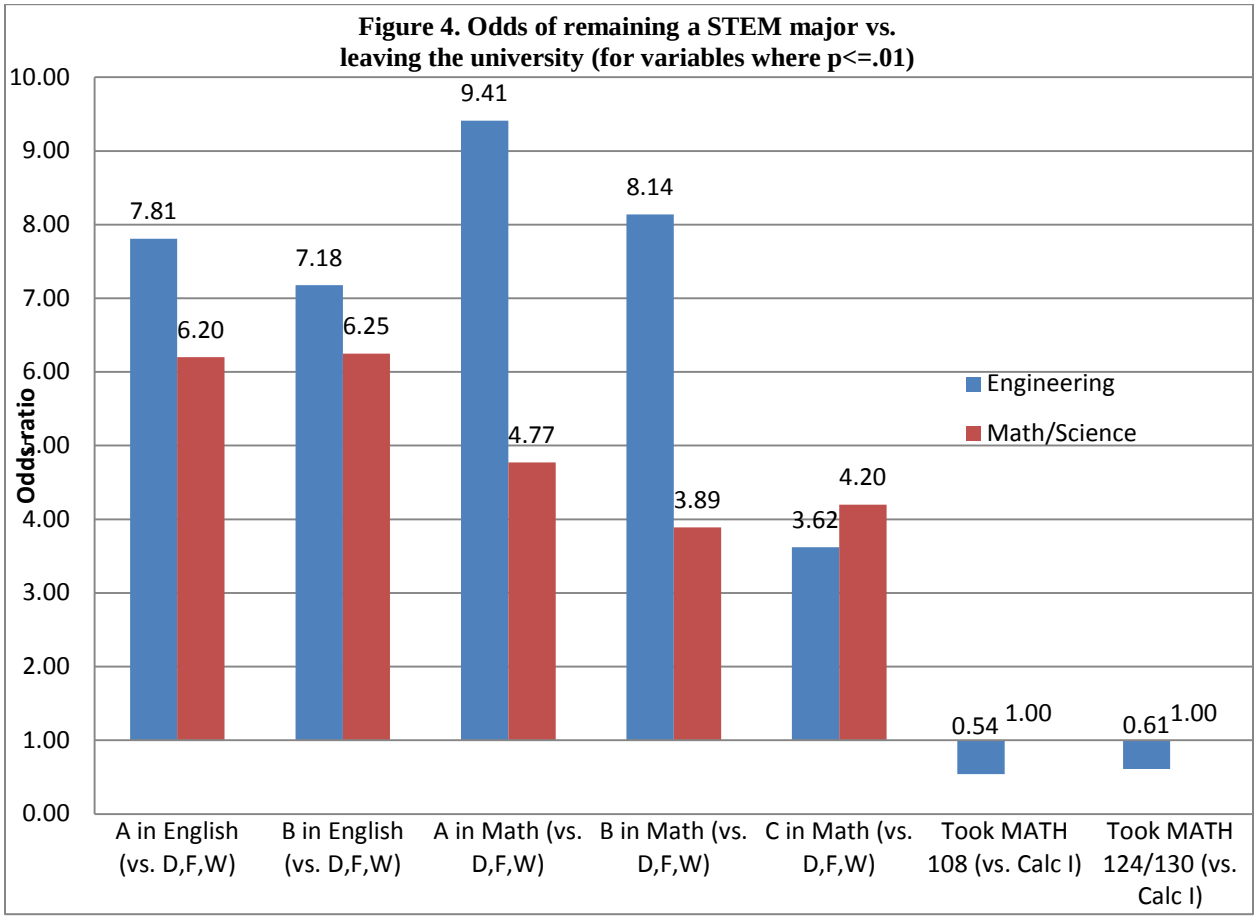
Parameter	Engineering (n=821)				Math/science (n=427)			
	Estimate	Wald χ^2	Prob	Odds	Estimate	Wald χ^2	Prob	Odds
intercept	0.05	0.04	.8367	--	0.00	0.00	.9892	--
A - ENGL	1.60	47.75	<.0001	7.81	1.25	18.06	<.0001	6.20
B - ENGL	1.45	29.41	<.0001	7.18	1.08	7.96	.0048	6.25
C - ENGL	0.61	3.50	.0614	NS	-0.05	.0141	.9056	NS
A - MATH	1.66	31.53	<.0001	9.41	0.93	8.18	.0042	4.77
B - MATH	1.55	31.53	<.0001	8.14	0.70	4.25	.0393	3.89
C - MATH	0.83	30.34	<.0001	3.62	0.76	4.82	.0281	4.20
M025	-0.62	2.74	.0978	NS	-0.69	2.18	.1397	NS
M108	-1.15	17.35	<.0001	0.54 (1.85)[a]	-0.60	2.54	.1109	NS
M124/130	-2.05	6.71	.0096	0.61 (1.64) [a]	-0.45	0.46	.4978	NS
M143	-0.46	4.05	.0442	0.99 (1.01) [a]	-0.38	1.27	.2604	NS
M160	-1.74	2.96	.0853	NS	-0.56	0.29	.5920	NS
ENGL 90 or ESL	0.53	1.54	.2153	NS	0.70	1.55	.2124	NS
ENGL101	-0.48	4.87	.0273	0.95 (1.05) [a]	0.18	0.46	.4958	NS

NS= not significant

[a] Reverse odds

For math and science majors, receiving an A or B in their first English course and an A or B or C in their first math course was also associated with remaining a STEM major compared to leaving. However, none of the math or English course enrollments that were significant for engineering majors were also significant for math/science majors. See table 4 for details.

To summarize, students who remained in STEM compared to those who left the university received good grades in their first math and English courses. Engineering majors who remained in STEM instead of leaving the university did better if they were calculus ready, although not all pre-calculus math courses reached the level of statistical significance.



Summary and Discussion

In the STEM disciplines, and especially in engineering, it is often assumed that students need to arrive at the university ready to take calculus. This study was designed to look at the role that first math and English courses play in student retention and whether the level of the course is more important than student success in the course as measured by grades. Two retention comparisons were undertaken: (1) students retained in STEM after one year vs. students who switched to a non-STEM major, and (2) students retained in STEM after one year vs. students who left the university.

By looking at the level of the STEM majors' first math course, it is apparent that our students did not arrive ready for calculus. Only about 35% of new engineering majors and 20% of science and math majors took calculus as their first math course. In addition, many stumbled in their performance in their first math course. About 30% received a grade of D, F, or W. When students who received a C in their first math course were included, over 50% had poor or lackluster performance. It should be noted, however, that these findings are based on first-time-in-college students who arrived between the fall of 2007 and fall of 2011. As noted in a recent report[2], much effort has been placed on improving students' math performance, and results are paying off in terms of grades and retention.

Engineering students were quite different from math and science majors. Fewer math and science majors were likely to remain STEM majors one year later compared to engineering majors (57% vs. 64%). And the variables that predict retention behaved differently for the two groups in many cases.

[2] Belcheir, M. (2013) Addressing the pattern of changes in retention and graduation. Boise, ID: Office of Institutional Research. See the article at http://ir.boisestate.edu/wp-content/uploads/2013/11/RR-2013-03-Addressing-the-pattern-of-changes-in-retention-and-grad.pdf

Two variables, however, were important to both groups when predicting who will remain a STEM major vs. switch to a non-STEM major. The most important variable for both engineering majors and math/science majors was receiving an "A" in their first math course. An "A" in the first math course was associated with improving the odds of remaining a STEM major more than seven times for engineering majors and more than four times for math/science majors when compared to students who received a "D," "F," or "W." Enrollment in MATH 108 was the other variable that was important for both groups. Enrollment in MATH 108 halved the probability of remaining a STEM major for engineering students. Although the effect was not as strong for math and science majors, the chances of remaining in STEM was reduced by 15% for MATH 108 enrollees compared to students who first enroll in Calculus I or higher.

When comparing those retained in STEM and those who switched out of STEM, the role of ENGL 90 or ESL was very different for engineering majors and math/science majors. Engineering majors who enrolled in ENGL 90 or in one of the English courses for non-native English speakers were 14 times *more* likely to remain STEM majors compared to students who first enrolled in ENGL 102. It is unlikely that the course itself is having such a powerful and positive impact on STEM retention. It is more likely that the number of international students in engineering was the reason for the impact on STEM retention[3]. A total of 6% of engineering majors in the study were non-resident aliens compared to only 1% of the math and science majors. And enrollment in ENGL 90 or ESL had a non-significant effect for math and science majors.

The differences between engineering majors and math/science majors continued to be evident in the analysis comparing those who remained in STEM and those who left the university after one year. For engineering majors, grade in first math course was the best way to determine who would be retained and who would not. Receiving an "A" or "B" in English, however, was also highly important for engineering majors. Enrollment in MATH 108 continued to have a negative impact on retention.

For math and science majors, the best way to determine who would be retained and who would not was to look at whether the student received an "A" or "B" in English. Grades in the first math course were also significant but less so when compared to performance in English. Level of first math or English course made no difference.

These results indicate that one of the most powerful ways to improve STEM retention is to ensure success in the first math course at whatever level it is taken. In addition, however, enrollment in MATH 108 has been a serious barrier to remaining a STEM major. As mentioned earlier, a great deal of work has been focused on this course and efforts seem to be paying off.

Although English courses are typically not perceived as important as the math courses, the analysis also shows that success in the first English course also improved the probability of remaining a STEM major. It could be helpful to explore further the role that English grades and courses play for STEM majors. Are English grades a general indicator of academic success or is there something critical about the content that is important for STEM majors?

Readers are encouraged to keep in mind some of the limitations of the study. As previously mentioned, the math curriculum has been changing so an analysis based on more recent students might show some different effects. In addition, all of these measures are pale stand-ins for the more complex processes involved in negotiating success in a STEM major. Recall the strong impact found for ENGL 90 or ESL courses for engineering majors. It is likely that the number of international students in engineering was driving this finding. These students have received support for four years of study so are more likely to be retained due to their support than to their enrollment in an English course.

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Office of Institutional Research

[3] Another version of this study is being completed with Janet Callahan, Associate Dean for the College of Engineering for submission to a journal. Students who were non-resident aliens were removed from the analysis, and the results became clearer and more similar for engineering and science/math majors.