UNDERSTANDING THE LEAKY STEM PIPELINE BY TAKING A CLOSE LOOK AT FACTORS INFLUENCING RETENTION AND GRADUATION RATES

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Introduction

Student retention has been increasingly recognized as a critical issue by American colleges and universities since the early 1970s [1]. Retention is directly related to student educational attainment and time to degree completion. Therefore, graduation rates are often used by the public and government to measure the success and effectiveness of higher education institutions [2, 3]. A number of previous studies have focused on the persistence and graduation rates of underrepresented minority students, students with lower socioeconomic status, and first-generation students [4-8]. However, there are not many studies quantifying the retention and graduation performance for freshmen with aspirations to obtain their degree in a STEM (Science, Technology, Engineering and Mathematics) discipline, despite the fact that STEM has become one of the progressively hot topics inside higher education and for funding initiatives in recent years. According to a 2010 University of California-Los Angeles study [9], there is a substantial number of undergraduates across the country choosing to leave STEM programs before they graduate with a STEM degree, and many students who start in those STEM programs struggle to finish their degree within four years, or drop out. This loss after college admission is critical given the efforts to enhance STEM enrollment due to the growing demands of a highly skilled workforce and the shortage of STEM graduates production from our colleges and universities [10, 11].

Previous studies on retention have found that a student's decision to remain at an institution is due to personal characteristics, academic background, and integration into the academic and social life of the campus [12]. A number of researchers have linked academic ability and achievements with students' persistence in college [13]. In addition to the background of students, the characteristics of the institution are also relevant to students' persistence and success. Adequate financial aid, individual academic support systems, better social and cultural support systems, and a welcoming campus environment were also found to promote retention. Whether these risk factors from traditional attrition models also play a role in students' decision to change their majors from STEM to Non-STEM have not been fully understood.

Methodology

The Consortium for Student Retention Data Exchange (CSRDE) at the University of Oklahoma has expanded the main CSRDE survey to include an optional survey which summarizes and benchmarks the retention and graduation rates of first-time full-time freshman cohorts majoring in STEM. In our study, data from the CSRDE main and STEM surveys for the 2007-2011 cohorts are used to compare first to second year retention rates of the entire entering cohorts of first-time full-time freshmen: institution-wide and discipline-specific for STEM students of the same entering cohort.

The analysis uses data from five historical fall entering first-time full-time freshman cohorts, 2007 to 2011. Depending on which detailed retention and graduation measurements are being compared, different entering cohorts are used for rate calculations. For example, for the second year retention rates, all five cohorts can be used. However, the four-year graduation rate can only be generated for the 2007 and 2008 cohorts.

The CSRDE STEM survey defines which disciplines are to be considered STEM and uses the 2010 CIP codes for further definition. The 2010 CIP codes representing STEM disciplines include 03.XXXX, 11.XXXX, 14.XXXX, 15.XXXX, 26.XXXX, 27.XXXX, 40.XXXX. Additionally, it also includes 01.0000, 01.0801, 01.09 through 01.9999 and 30.1901. According to the CSRDE STEM survey definitions, a total of 87 academic plans at the University of Delaware are flagged as STEM disciplines, among which more than 50% are from the College of Engineering or the College of Arts and Sciences.

In general, retention outcome is whether a first-time full-time freshman is retained from the first fall to the second fall semester. STEM institution-wide retention outcome is reflecting whether entering students majoring in a STEM discipline are retained in any major (STEM or Non-STEM) in the following fall semester. In contrast, STEM discipline specific retention outcome is measuring whether entering students majoring in a STEM discipline are persisting in *any* one of the STEM majors. For this latter outcome, either students who didn't enroll or students enrolled in non-STEM majors are regarded as non-retained under the discipline specific retention definition.

The four-year graduation outcome is the primary graduation outcome of interest. Similar to the retention rates, the three types of graduation rates are representing (1) the percentage of first-time full-time freshmen who completed their degree in four years; (2) the percentage of STEM entering students who completed their degrees in any field in four years; and (3) the percentage of STEM entering students who completed their degree in one of the STEM disciplines in four years. In the third outcome, if a STEM entering student fails to graduate before the 5^{th} fall with a

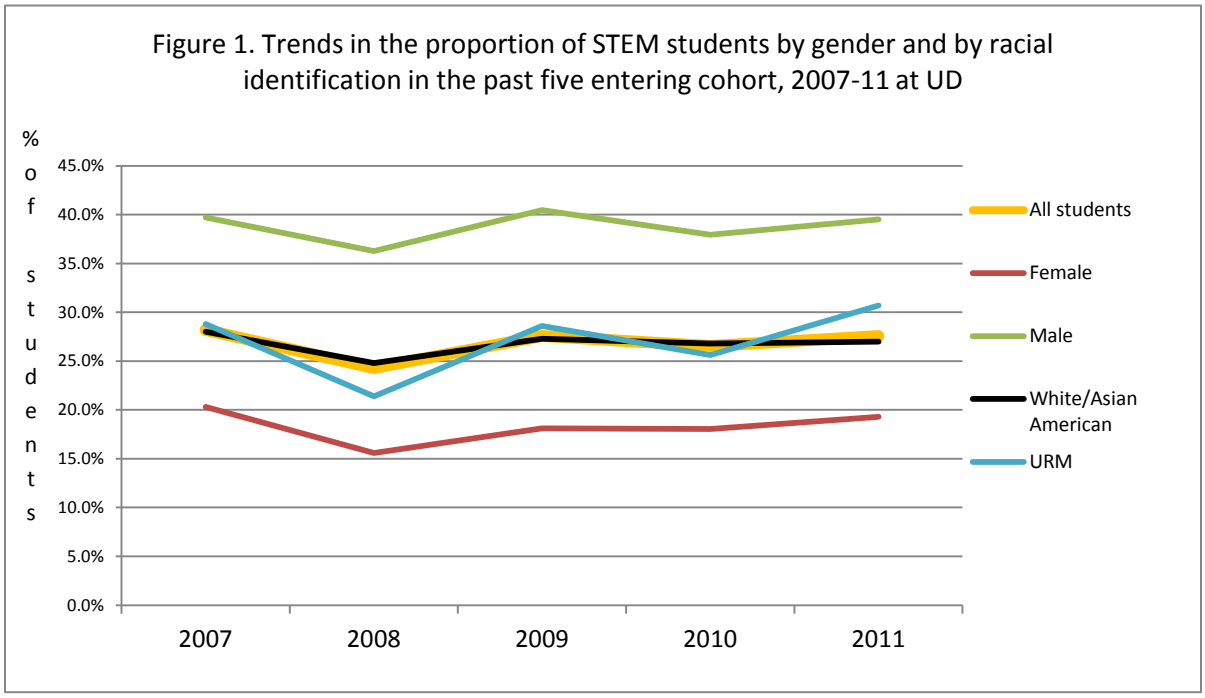
STEM degree they are regarded as non-graduated under the discipline specific graduation definition.

The percentage descriptive statistics are calculated to compare the three types of retention rates and graduation rates overall, by gender, and by race/ethnicity. Multinomial logistic regression analyses were performed among the STEM entering students to evaluate the potential risk factors relating to increased partial odds of changing to Non-STEM major as opposed to persisting in STEM programs from the first fall to the second fall. The STEM entering students in all five entering cohorts are used for the analyses. Factors being evaluated include demographic factors (gender, race, age, residency), socioeconomic factors (low income, Pell Grant, first generation), academic background (honor student, SAT scores), and which college initially enrolled in. Odds ratios (OR) after adjusting for cohort effect and 95% confidence intervals (CI) are used as indicators of the strength of association. A p-value less than 0.05 is considered as statistically significant throughout the study.

Results

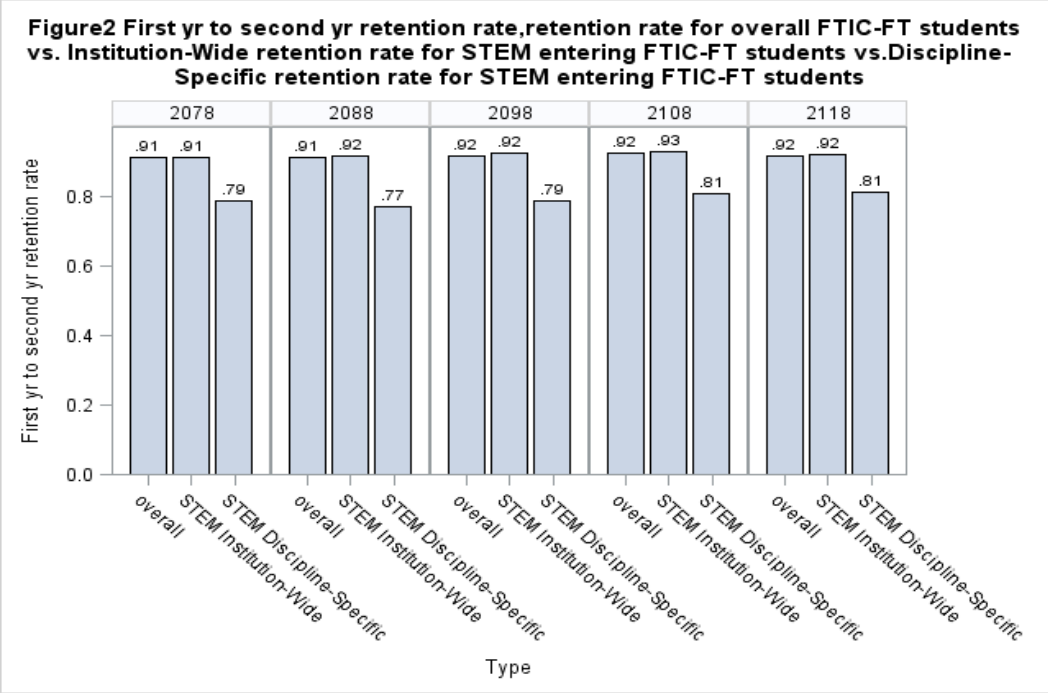
The sample population from the past five entering cohorts is 18,143, among which 4,873 (26.9%) students are initially majoring in a STEM discipline. The sample size of the five cohorts is consistent, ranging from 3,365 (2010 cohort) to 3,905 (2011 cohort). Over the past five years, the overall proportion of STEM students in the entering cohorts has been relatively stable, fluctuating between 24.3% and 27.6%. Male students far outpace their female peers majoring in a STEM discipline throughout the entire five entering cohorts. There is a slightly upward trend for the Underrepresented Minority group (URM) starting with a STEM major from 2007 to 2012

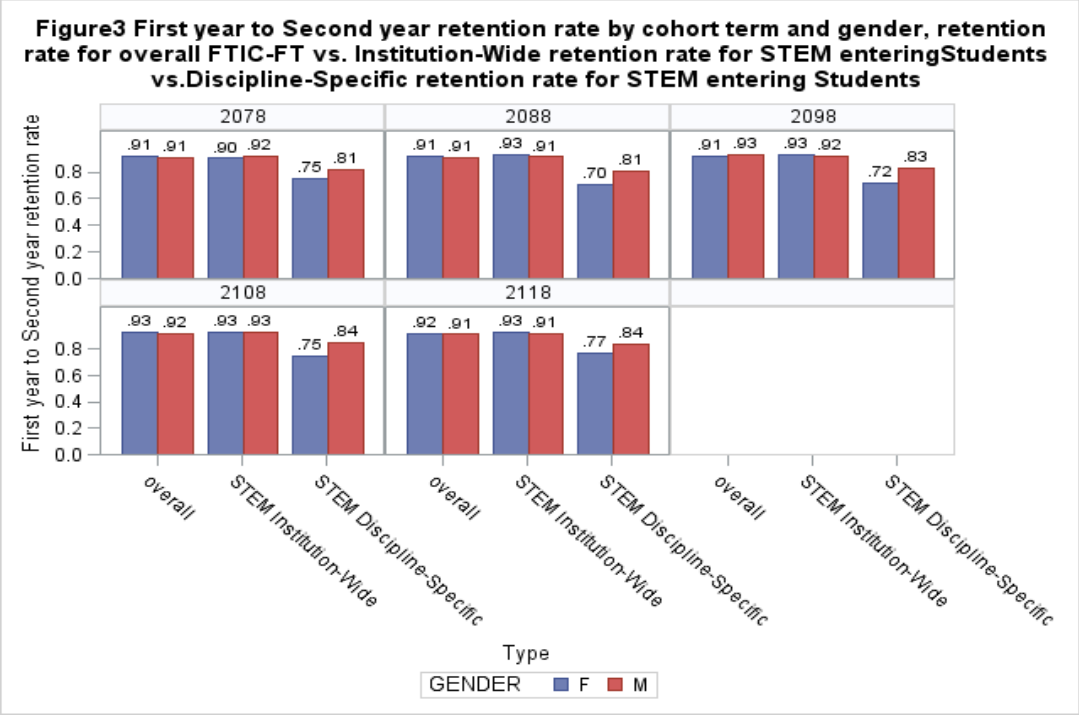
(Figure 1), which is likely the result of recent STEM recruitment initiatives or the increasing number of Non-Resident Aliens at the University of Delaware.

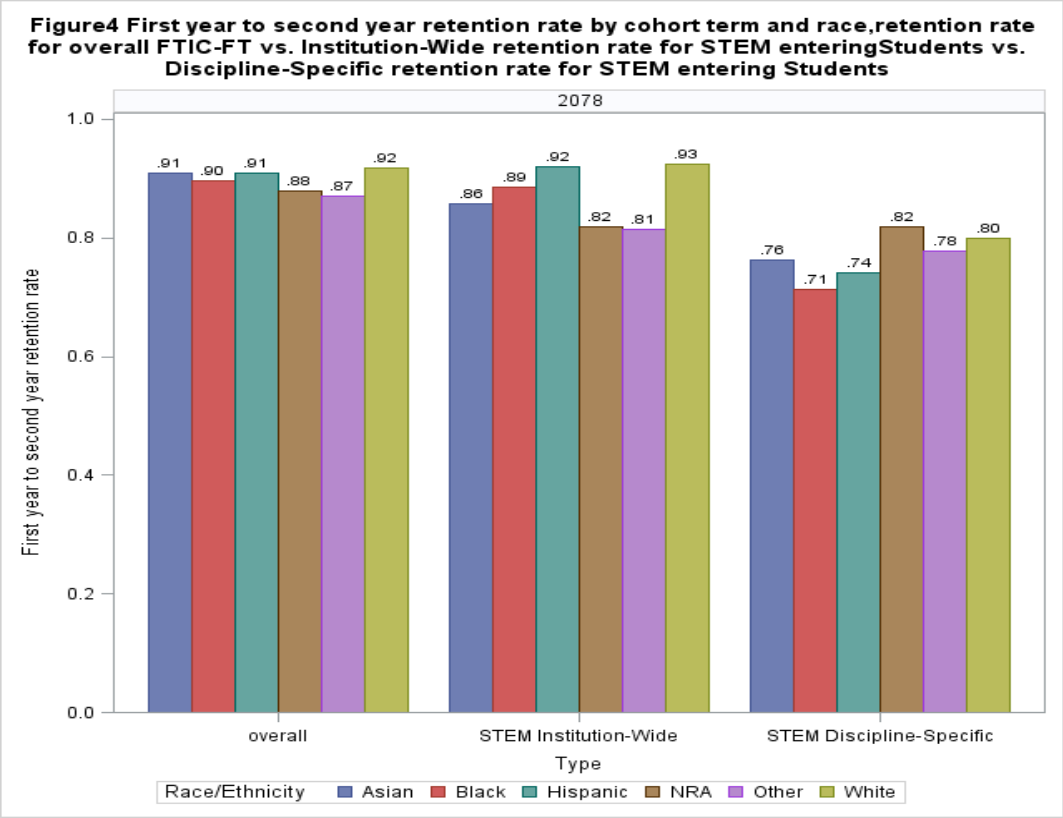


Figures 2 to 4 show the comparison of three types of Year1 – to-Year2 retention rates by cohort only, by cohort and gender, and by cohort and race (only 2007 data are presented). The retention rates for the entire five entering cohorts of first-time full-time freshmen are consistently above 90% at UD. There is no doubt that the STEM entering students, if not outperform, performed as well as well as overall first-Time full-time freshmen with regard to the Institution-wide retention rates. However, when comparing that with the discipline specific retention rates, the retention rates for STEM entering students drops by an average of 13% across the five cohorts, indicating essentially 13% additional STEM-specific attrition among those STEM entering students (Figure 2). Although females tend to have slightly higher retention rates for overall first-time full-time freshmen and higher institution-wide retention rates for STEM entering students, they invariably lag behind males with respect to STEM discipline-specific retention performance across all five

cohorts (Figure 3). Both African-Americans and Hispanics are subject to the highest proportion (18%) of STEM-specific attrition from the first fall to the second fall semester.

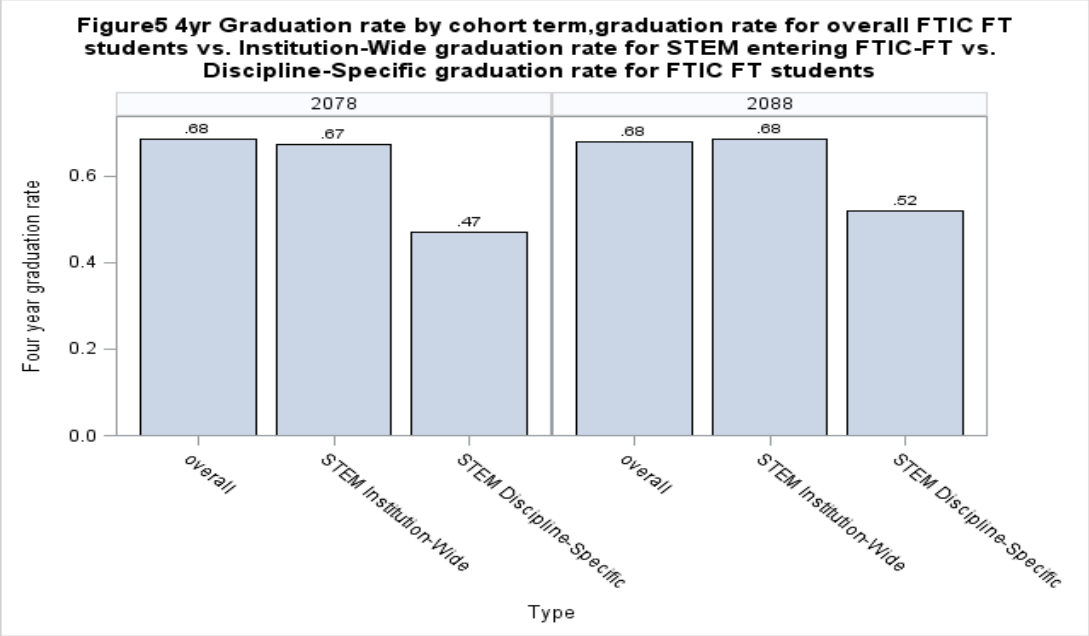


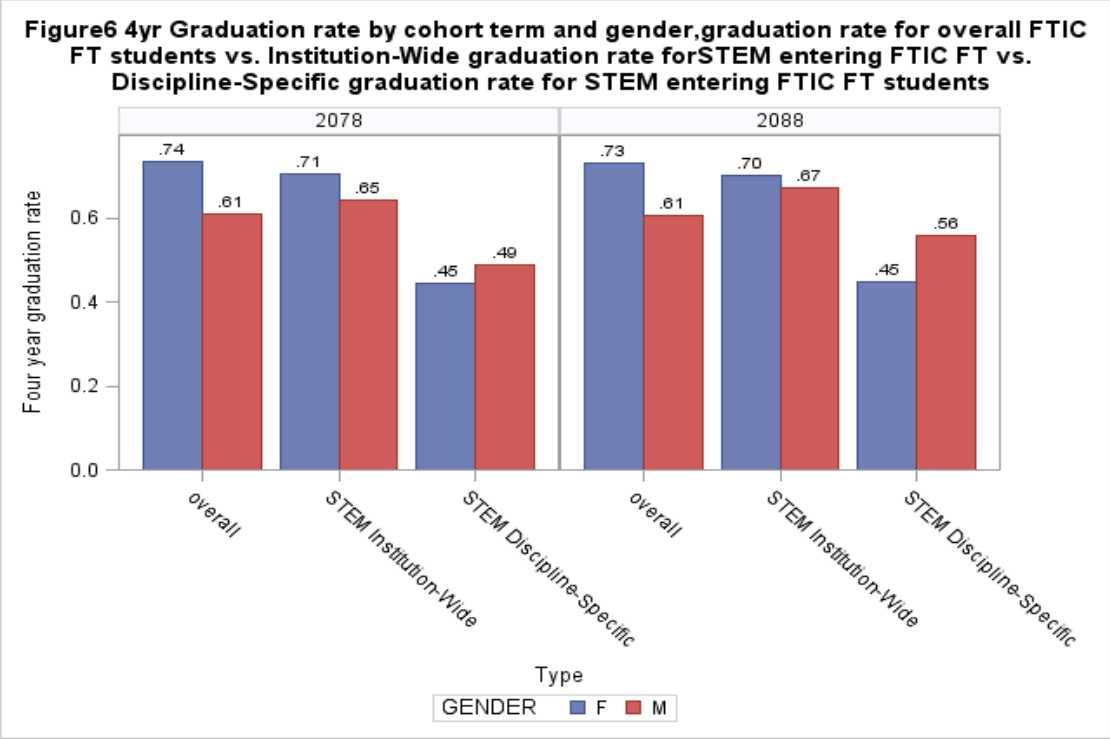


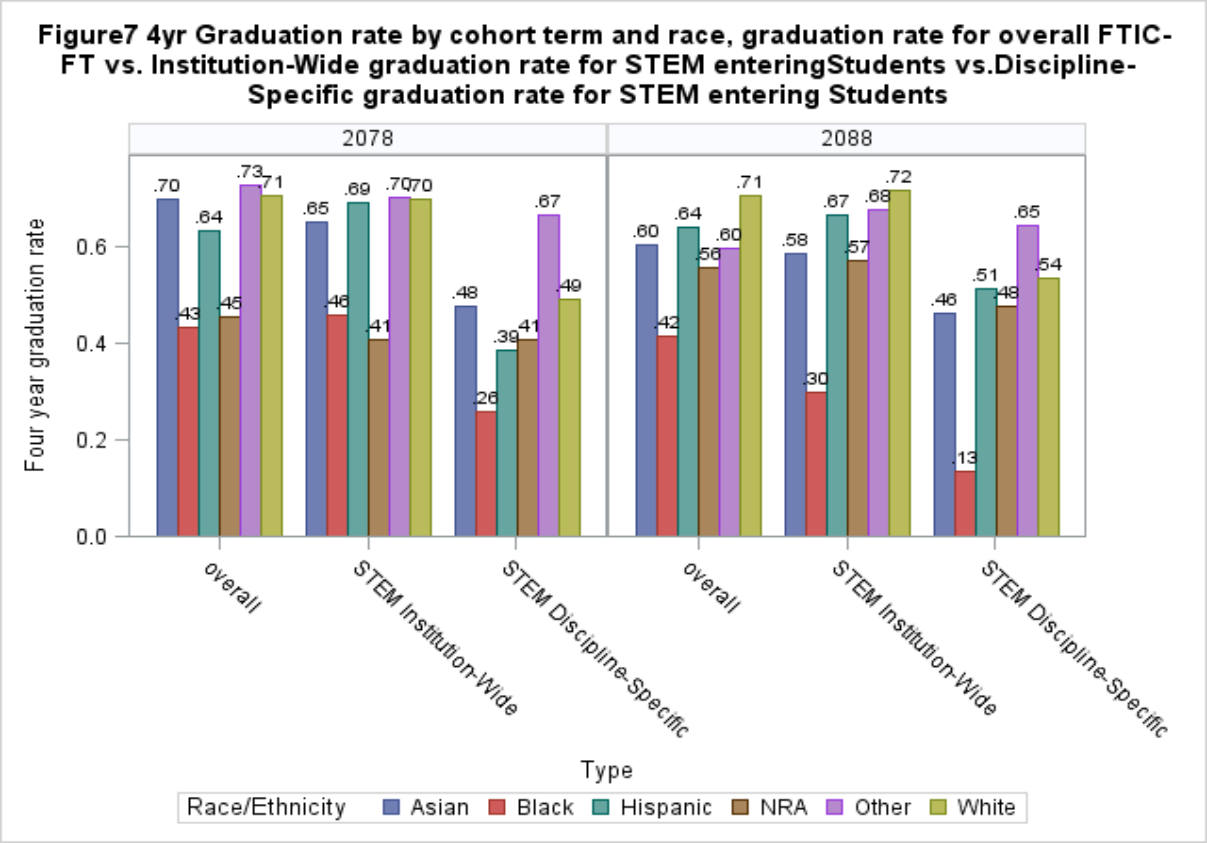


Approximately 68% of the entire five cohorts of first-time full-time freshmen graduated within four years. A similar proportion of STEM entering students graduated from any major within four years, while only close to 50% of them graduated with a STEM degree within four years (Figure 5). Similar to retention rates, in comparison to males, females have higher four year graduation rates for one of the two cohorts of first-time full-time freshmen and the subset of STEM entering students, if not taking into consideration what degree they completed. In contrast, STEM entering males outpace their female peers in the percentage of obtaining a STEM degree within four years (Figure 6). There is great variation in the four year graduation rates for different race/ethnicity groups. African-Americans are far behind others in all three types of measurements for four-year graduation rates. STEM entering Hispanics are likely to have higher four-year graduation rates graduating from any major than the overall Hispanic subpopulation.

STEM entering Non-Resident Aliens seem to have the highest proportion of graduates with a STEM degree, but their overall graduate rates are less than 50% (Figure 7).







A total of 4,488 (92.1%) out of 4,873 STEM entering first-time full-time freshmen persist in the second year, among which 3,866 (86.1%) continue to major in one of the STEM programs at UD. Individual factors significantly associated with higher risk for changing to Non-STEM majors as opposed to persisting in a STEM program include being a female, being a Delaware resident, being the first person in their family to attend college, having a SAT math score less than 650; while Non-Resident Aliens/International students, Honors students, or students who started their STEM program in the College of Engineering seem less likely to switch their major to non-STEM (Table 1).

Although STEM-specific attrition is not a favorable outcome, it may indicate whether students were able to receive sufficient academic advising when they realized a STEM major was not a good fit. In that sense, female students, Delaware residents, and Honors students are more likely

to change to non-STEM programs relative to dropping out. However, International students and students with an initial STEM program in the College of Engineering are more likely to drop out as opposed to change to a non-STEM major (Table1).

Table1 Relationship between individual factors and the likelihood of changing to Non-STEM majors

Factors		Partial Odds Ratio* (95% Confidence Interval)	
		out of STEM vs. persist in STEM	out of STEM vs. discontinue
Gender	Female vs. Male	2.2(1.9,2.6)	2.1(1.6,2.7)
Race/Ethnicity	Asian vs. White	1.0(0.7,1.4)	1.1(0.6,1.8)
	Black vs. White	1.2(0.8,1.8)	0.6(0.4,1.1)
	Hispanic vs. White	1.0(0.7,1.4)	0.7(0.4,1.3)
	NRA vs. White	0.4(0.2,0.7)	0.3(0.1,0.6)
	Other[1] vs. White	0.7(0.4,1.2)	0.7(0.4,1.4)
Underrepresented	Yes vs. No	1.1(0.8,1.4)	0.7(0.5,1.0)
International Student	Yes vs. No	0.4(0.2,0.7)	0.3(0.1,0.6)
Residency	in-state vs. out of state	1.3(1.1,1.5)	1.7(1.3,2.3)
Pell grant receiver	Yes vs. No	1.3(1.0,1.7)	0.7(0.5,1.0)
First generation	Yes vs. No	1.4(1.1,1.8)	0.9(0.6,1.2)
Low income	Yes vs. No	1.1(0.7,1.7)	0.6(0.4,1.1)
Honor student	Yes vs. No	0.7(0.5,0.8)	1.7(1.2,2.4)
SAT Math score	<650 vs. >=650	2.1(1.8,2.5)	1.2(0.9,1.5)
SAT Reading score	<600 vs. >600	1.1(0.9,1.4)	0.8(0.6,1.0)
College originally enrolled in	Agriculture vs. Engineering	1.9(1.3,2.7)	1.9(1.1,3.2)
	Arts&Sciences vs. Engineering	3.4(2.8,4.2)	3.0(2.3,4.0)
	Health Science vs. Engineering	13.1(6.2,27.6)	3.4(1.2,9.6)
	Earth Ocean vs. Engineering	2.5(1.7,3.8)	3.3(1.6,6.8)

[1] Other includes race/ethnicity unknown, multi-ethnic, American Indians, Native Hawaiians and Pacific Islanders

* All odds ratios were controlled for the cohort effect.

Conclusion/Discussion

Without question, science and engineering capability will be the foundation of economic success for the U.S. in the 21st century. According to the U.S. Bureau of Statistics, in the next five years, STEM jobs are projected to grow twice as fast as jobs in other fields. Based on this projection, the U.S. will have over 1 million job openings in STEM-related fields by 2018. Yet only 16% of graduates in U.S. will specialize in STEM (data from U.S. Bureau of Statistics). Apparently, our education system is not preparing enough STEM majors to meet the demand. The results of this study visually underscore the leak in the STEM education pipeline for higher education. The gender and racial differences in STEM retention rates and graduation outcomes are highlighted as well. This study calls for the need to regularly track STEM discipline-specific retention and graduation rates to raise concerns and attention among senior administrators, especially for institutions with impressive overall retention and graduation rates.

Students' personal characteristics and academic background have significant impact on their decisions to persist in STEM programs. It is interesting to know that students who begin a STEM program in the College of Engineering are less likely to change to a non-STEM program, compared to other STEM entering students. This may be due to the fact that males are largely overrepresented in the College of Engineering or the College is providing better academic support services. Females still lag behind in representation of both the STEM entering and STEM graduating populations. Compared to their male peers, STEM entering females are subject to more STEM specific attrition after college admission, although they are less likely to drop out from the University. There are multiple theories to explain the gender gap including the test based theories, biological determination theories, cognitive learning difference theories, and

social-psychological theories [14].Future studies focusing on assessing students' attitudes and beliefs about women in STEM-related disciplines will be helpful to better understand the loss of female STEM graduates.

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