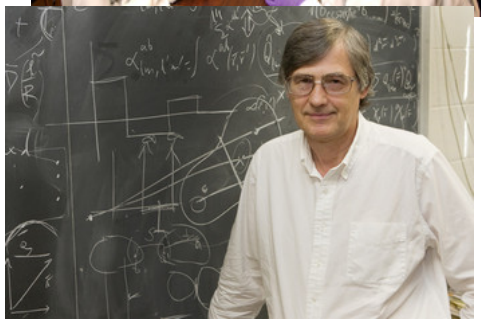
Understanding the leaky STEM Pipeline by taking a close look at factors influencing STEM Retention and Graduation Rates



Di Chen

Institutional Research Analyst

Heather Kelly

Director of Institutional Research

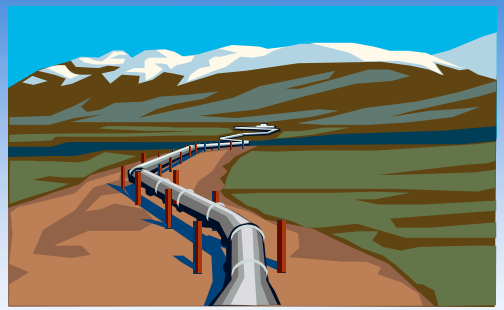
The National STEM Crisis: Mismatch of STEM Supply and Demand

- 23% of college freshmen declare a STEM major.[1]
- STEM Bachelor's degrees in the in the U.S. declined by 18% during the past 2 decades.[2]
- The U.S. ranks 17th amongst developed countries in the proportion of college students receiving BS degrees in Science and Engineering. [2]
- The U.S. will have over 1 million job openings in STEM-related fields by 2018, yet only 16% of graduates in the U.S. will specialize in STEM (U.S. Bureau of Statistics).
- Problems with STEM diversity - gender gap in higher education and the work force.

[1]Secretary Arne Duncan's Remarks to the President's Council of Advisors on Science and Technology, October 23, 2009 http://www.ed.gov/news/speeches/secretary-arne-duncans-remarks-presidents-council-advisors-science-and-technology

[2]Augustine, N. R. (2007). *Is America Falling Off the Flat Earth?* Washington DC: National Academy of Sciences.

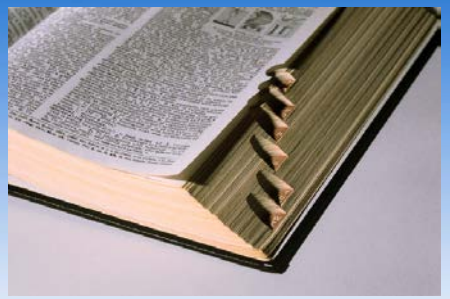
The STEM Pipeline



Interest in knowing UD's performance in:

1) admitting students into a STEM major: proportion of freshman who declare a STEM major.
2) successful progress in a STEM major: STEM-wide retention rates.
3) completion - obtaining a STEM degree on time: STEM-wide graduation rates.

Defining STEM



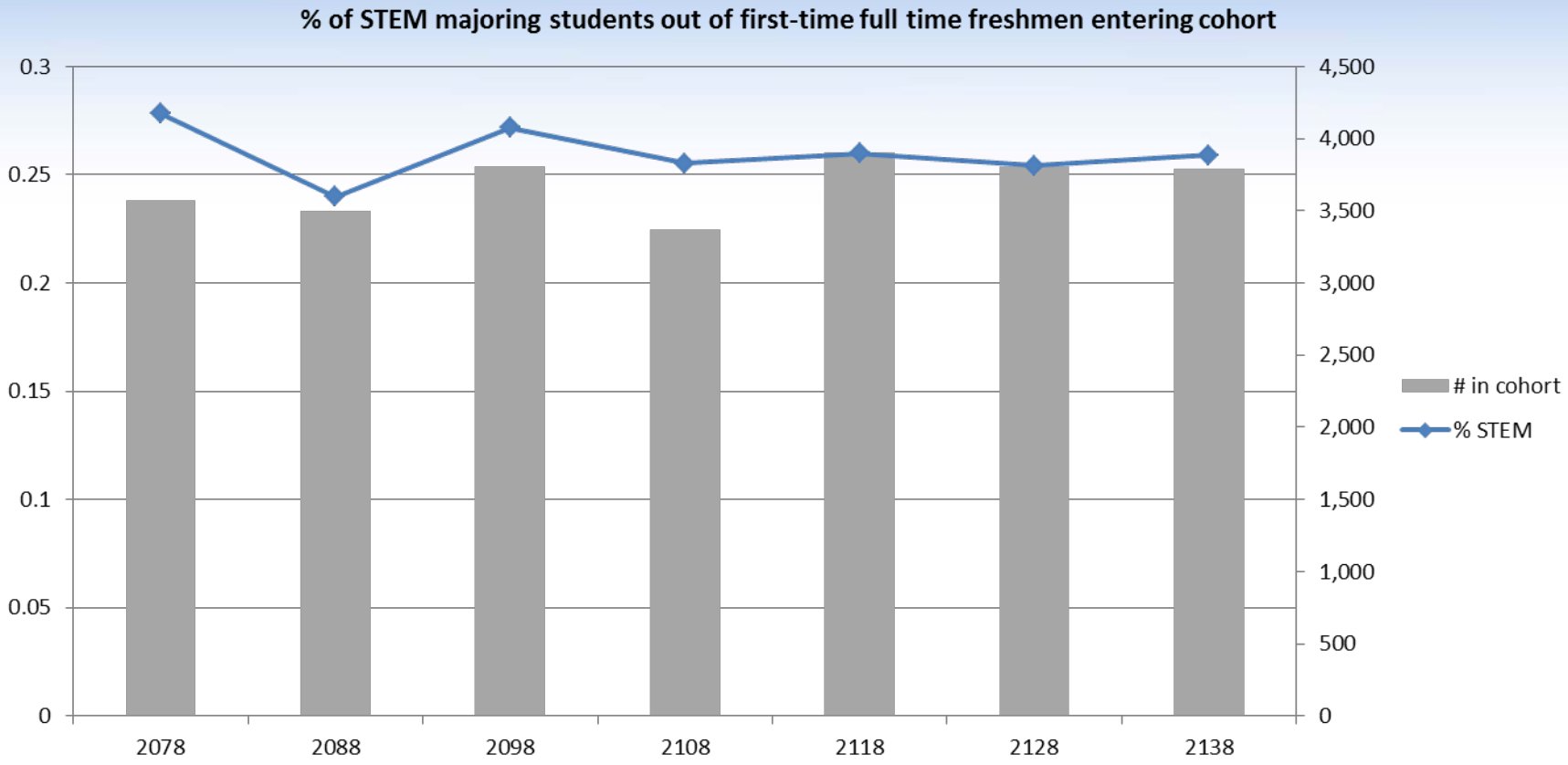
- STEM definition varies across and inside institutions.
- UD does not have its own STEM definition; what majors should be defined as STEM depend on the purpose of the request.
- STEM lists include: Homeland Security (used by NCES), NSF (w/wo SBS), Louis Stokes Philadelphia AMP, CSRDE.

<u>CSRDE definition was used because of benchmarking.</u>

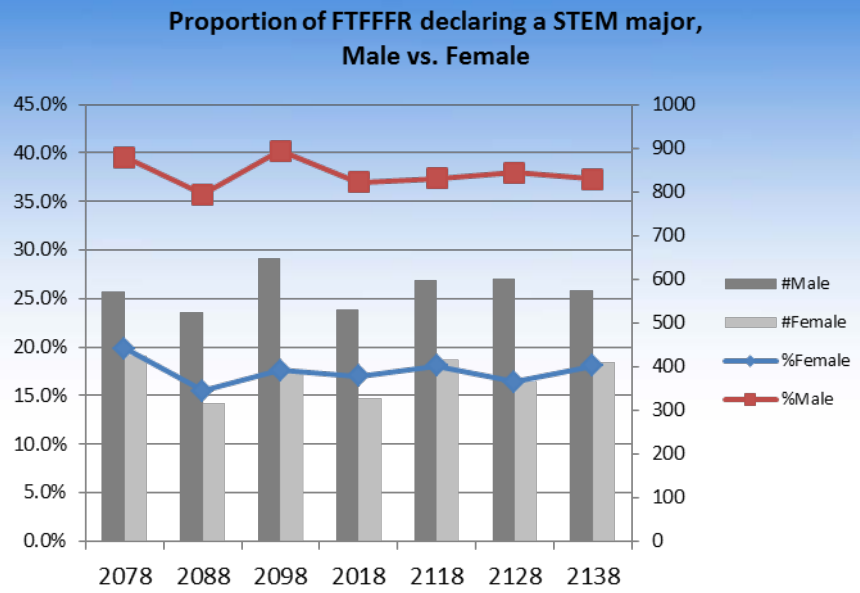
Example of UD STEM Disciplines Based on CSRDE STEM Definition

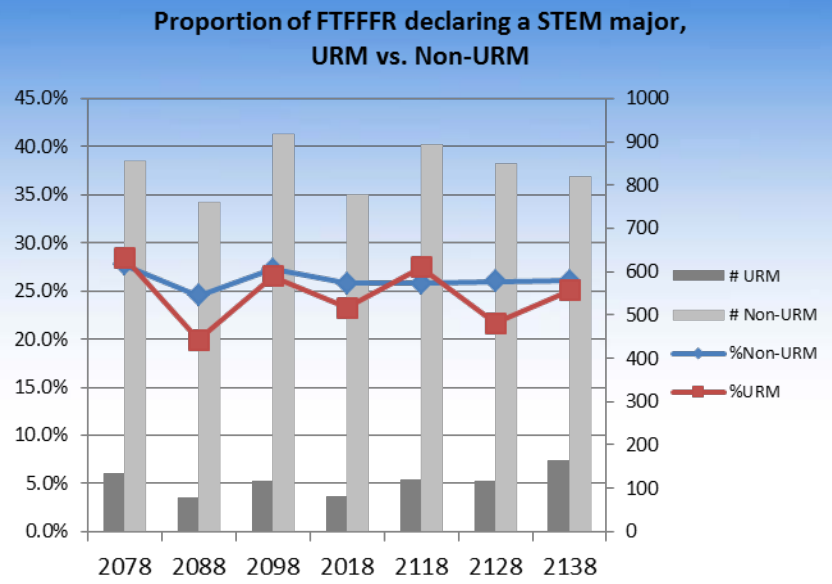
UDSIS Current CIP_CODE	UDSIS Current CIP Description	STEM category
01.0000	Agriculture, General	Biological Sciences
01.0901	Animal Sciences, General	Biological Sciences
03.0103	Environmental Studies	Biological Sciences
03.0104	Environmental Science	Biological Sciences
03.0201	Natural Resources Management and Policy	Biological Sciences
03.0601	Wildlife and Wildlands Science and Management	Biological Sciences
15.0000	Engineering Technology, General	Engineering
26.0702	Entomology	Biological Sciences
26.0101	Biology/Biological Sciences, General	Biological Sciences
26.0202	Biochemistry	Biological Sciences
26.1100	Biomathematics and Bioinformatics	Biological Sciences
26.1501	Neuroscience	Biological Sciences
27.0101	Mathematics, General	Math and Physical Science
40.0501	Chemistry, General	Math and Physical Science
40.0801	Physics, General	Math and Physical Science
03.0103	Environmental Studies	Biological Sciences
03.0104	Environmental Science	Biological Sciences
40.0601	Geology/Earth Science, General	Math and Physical Science
49.0309	Marine Science/Merchant Marine Officer	Math and Physical Science
30.1901	Nutrition Sciences	Biological Sciences
11.0101	Computer and Information Sciences, General	Engineering
14.0100	Engineering, General	Engineering
14.0701	Chemical Engineering	Engineering
14.0801	Civil Engineering, General	Engineering
14.0901	Computer Engineering, General	Engineering
14.1001	Electrical, Electronics and Communications Engineering	Engineering
14.1401	Environmental/Environmental Health Engineering	Engineering
14.1901	Mechanical Engineering	Engineering
22.0207	Energy, Environment, and Natural Resources Law	Biological Sciences

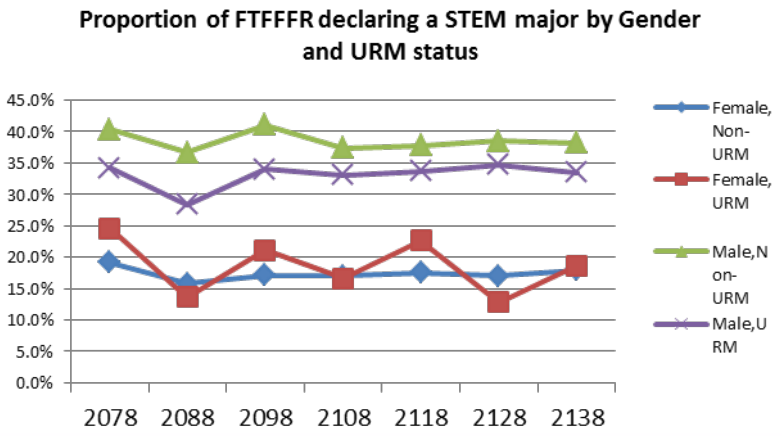
Initial Enrollment: Proportion of FTFFFR declare a STEM major



Gender and Racial Differences in the initial STEM enrollment



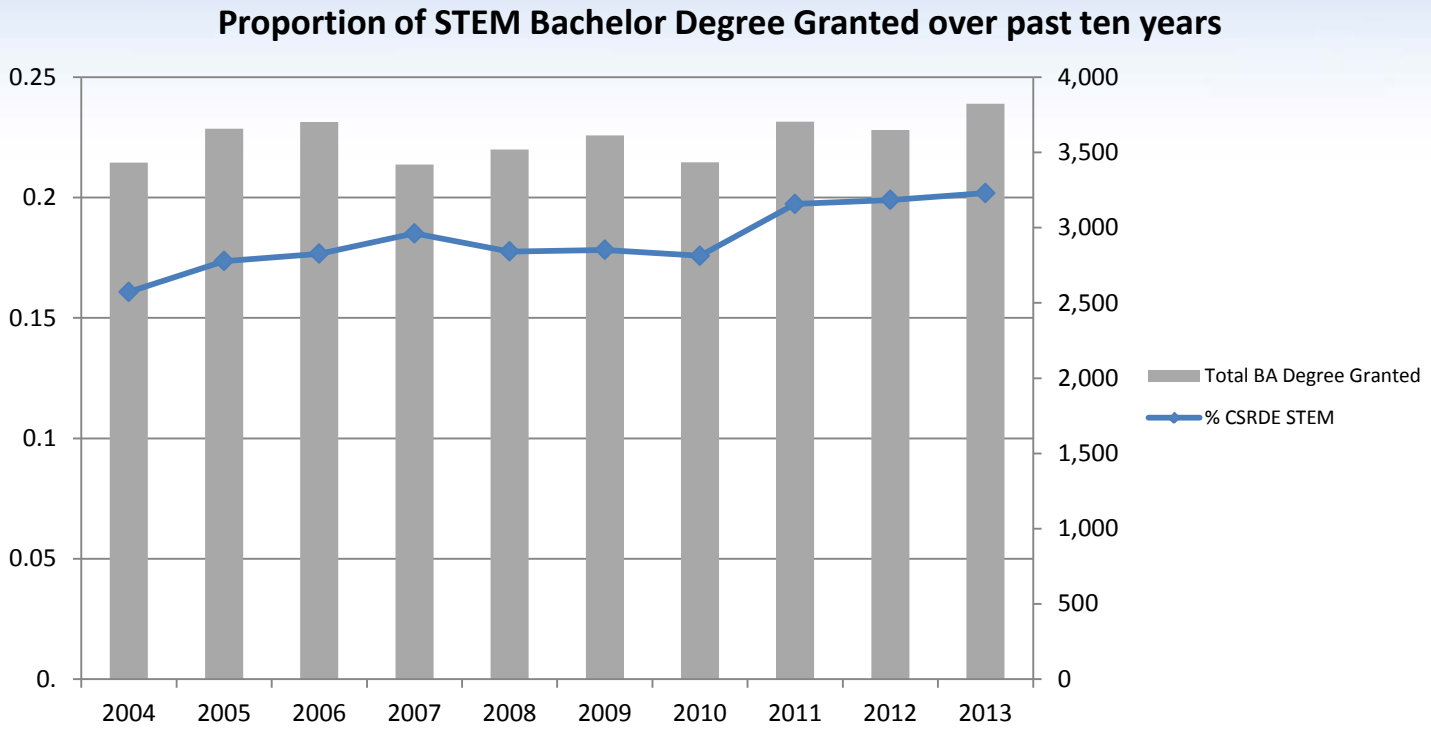




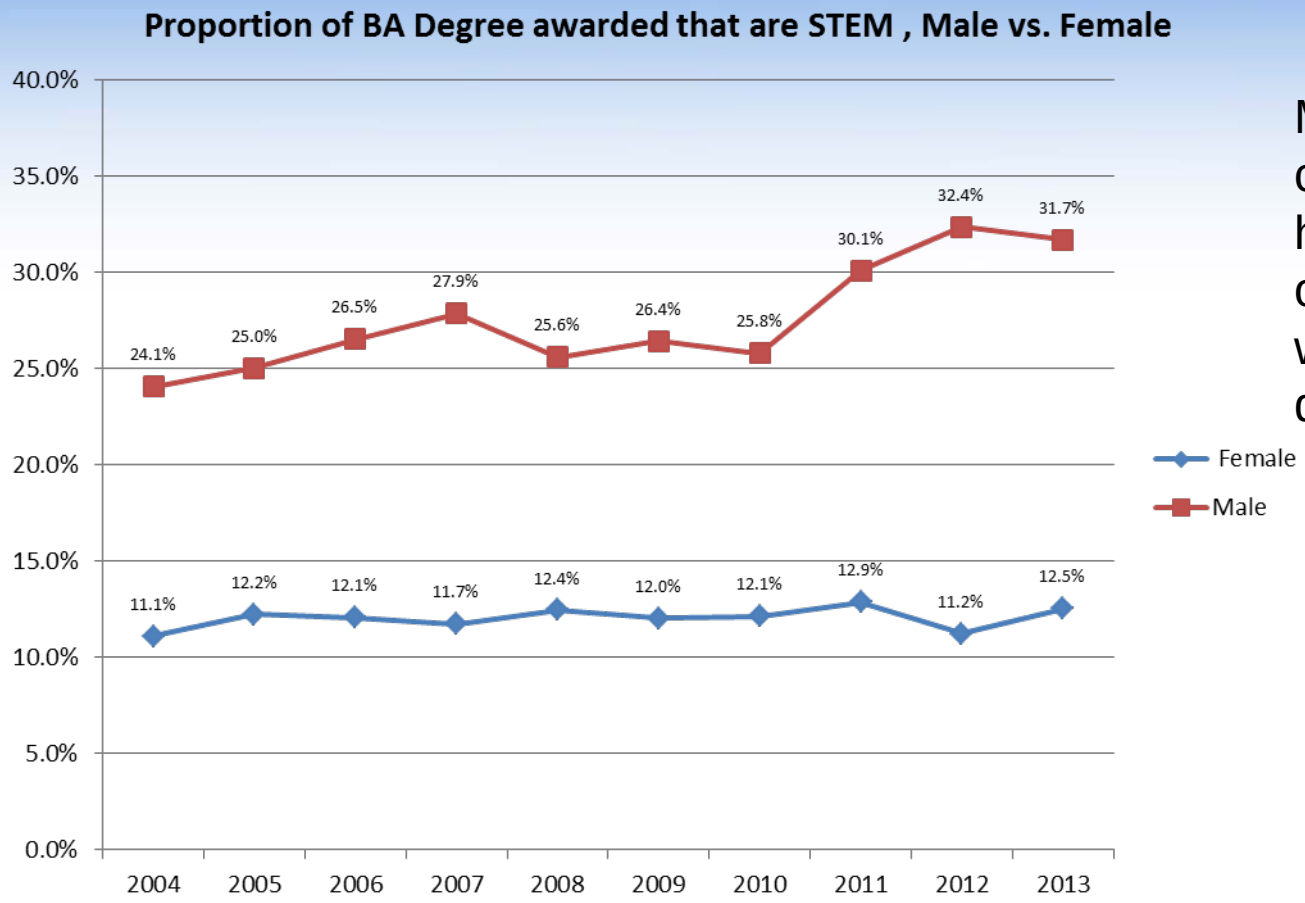
- Gender gap exists between males and females in both % and number of STEM majors.
- Although the proportion is similar, initial STEM majors are primarily non-URM students.
- Among males, non-URM has higher proportion of STEM majors than URM.

UD's STEM Bachelor's Degree Completion Fact

Over the past decade, the proportion of Bachelor's degrees awarded by UD that are STEM is only between 16% to 20%. (the proportion down from 25% at initial enrollment, although not the same cohort)



UD's STEM Bachelor's Degree Completion Fact: Gender Gap Exists in College Grads



Males are consistently a higher proportion of the graduates with a STEM degree.

UD CSRDE Retention and Graduation Rates

1st Year to 2nd Year Retention Rates

Cohort	2007	2008	2009	2010	2011
UD Overall	91.4%	91.2%	92.0%	92.5%	91.8%
STEM → Any Major	91.2%	91.8%	92.5%	93.0%	92.1%
STEM → STEM	78.8%	76.9%	78.7%	80.7%	81.2%

4-Year Graduation Rates

Cohort	2007	2008
UD Overall	68.4%	68.0%
STEM → Any Major	67.2%	68.4%
STEM → STEM	47.0%	51.8%

What the data tell us….

- While we align with the national proportion of entering STEM majors (25% compared to 23%), we need to do a better job attracting undergraduates to STEM majors, especially females and URMs.

- We continue to lose STEM majors after they enter UD.

STEM MAJOR ≠ STEM DEGREE

GOAL: STEM MAJOR = STEM DEGREE

Research Questions

- Understand who and why leaving STEM?
- Is the leaky STEM pipeline caused by STEM majors changing to non-STEM majors (STEM-wide dropout) or by leaving UD altogether?
- What are the risk factors for STEM attrition? Does the gender gap still exist after controlling for those factors?

Methodology

- Focus on first-year retention because literature shows most STEM attrition occurs during the first year.
- Analyses use data from the six most recent historical fall entering first-time full-time freshman cohorts (CSRDE cohort), 2007 to 2012.

  [Total N=21,954; Initial STEM majors=5,697 (26%)]
- CSRDE STEM disciplines are grouped into three STEM categories:

Biological Science: all biological-related disciplines and agriculture science

Engineering: all engineering and technology based disciplines

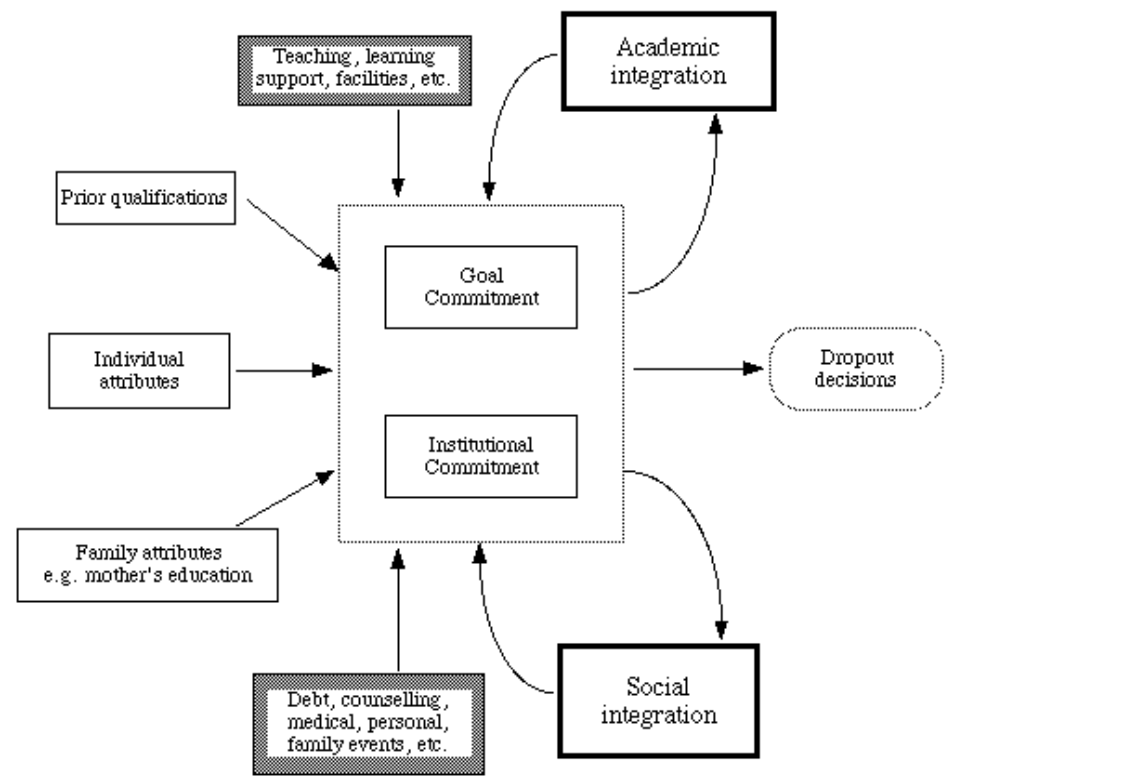
Math & Physical Science: mathematics, statistics, physics
earth science, marine science, geology

Outcome Measurements

- *University-wide retention outcome is whether a FTFFFR continued to enroll in the following fall semester ~ dichotomous*
- *STEM-wide retention outcome is reflecting whether a FTFFFR declared a STEM major initially continued to enroll and declare in any STEM major as their field of study in the following fall semester ~ dichotomous*
- Status at the 2nd fall can be (1) continue to enroll and declare a STEM major (2) continue to enroll but change to a non-STEM major (STEM-wide dropout) (3) dropout of UD ~ *multicategorical*

Explanatory variables

According to Tinto's student attrition behavior model, whether students persist or dropout is strongly predicted by their degree of academic integration, and social integration.



Applying the same idea, we took a look at variables related to academic and social integration, as well as the demographic variables that are documented in UDSIS as explanatory variables.

Explanatory Variables

- Demographic: gender (Female vs. Male), race (URM status, IPEDS race/ethnicity), residency (In-State vs. Out-of-State)
- SES: first-gen (Y vs. N), low income (Y vs. N), Pell Grant receiving status at the time of initial enrollment (Y vs. N)
- Pre-college academic preparedness: SAT score (Math score and SAT total score)

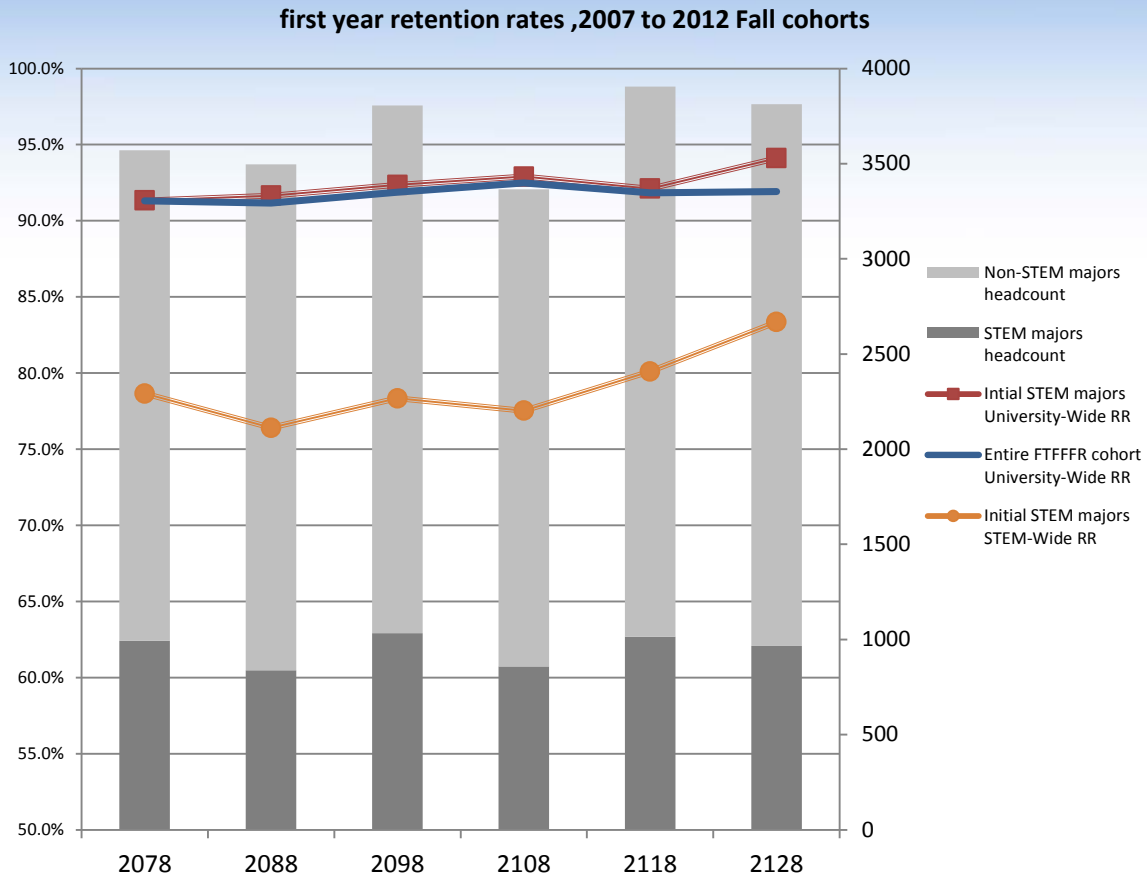
Pre-college academic preparedness		Initial STEM majors	
		Y	N
SAT Math	Median	650	600
	Mean	626	580
SAT Total	Median	1850	1780
	Mean	1800	1728

- College academic experience: first term GPA, initial STEM category

	Initial STEM	
1st Term GPA	Y	N
Median	3.02	3.05
Mean	2.91	2.93

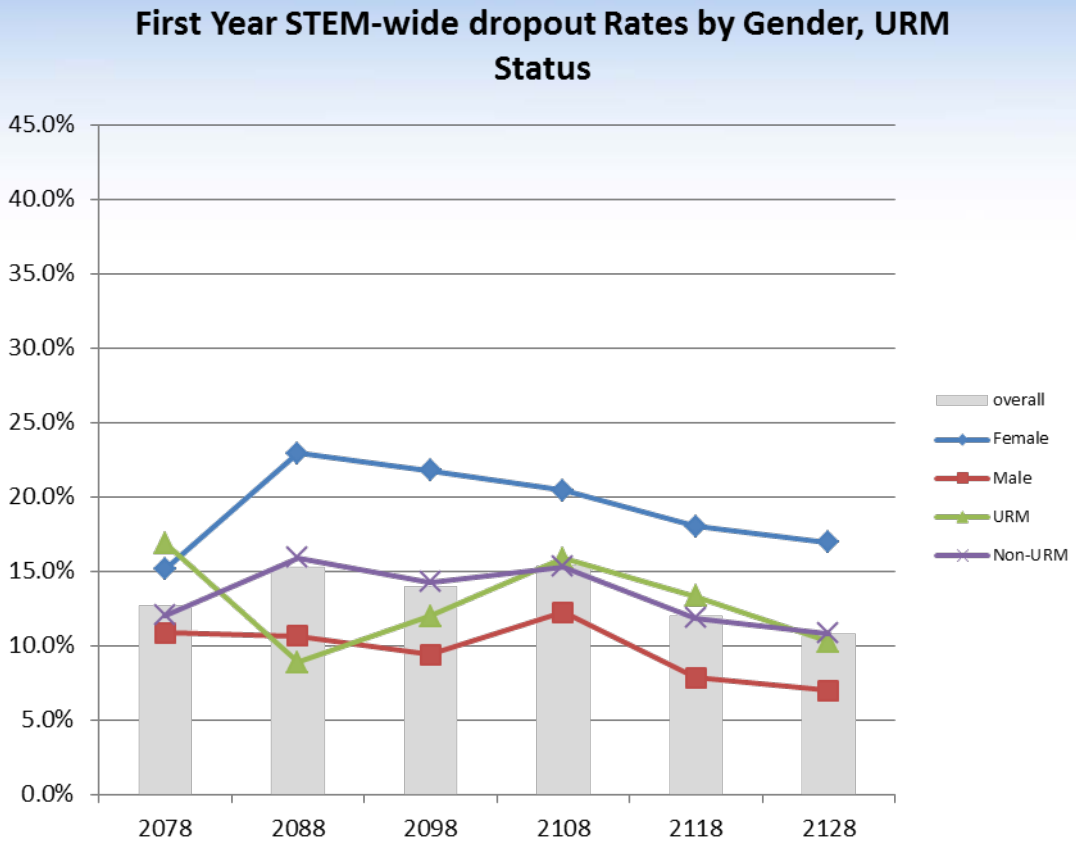
Descriptive Analyses Result: 1st year retention outcome

Different first-year Retention Rate Measurements Comparison: Initial STEM majors University-Wide Retention Rate vs. Entire Cohort University-Wide Retention Rate vs. Initial STEM majors STEM-Wide Retention Rate



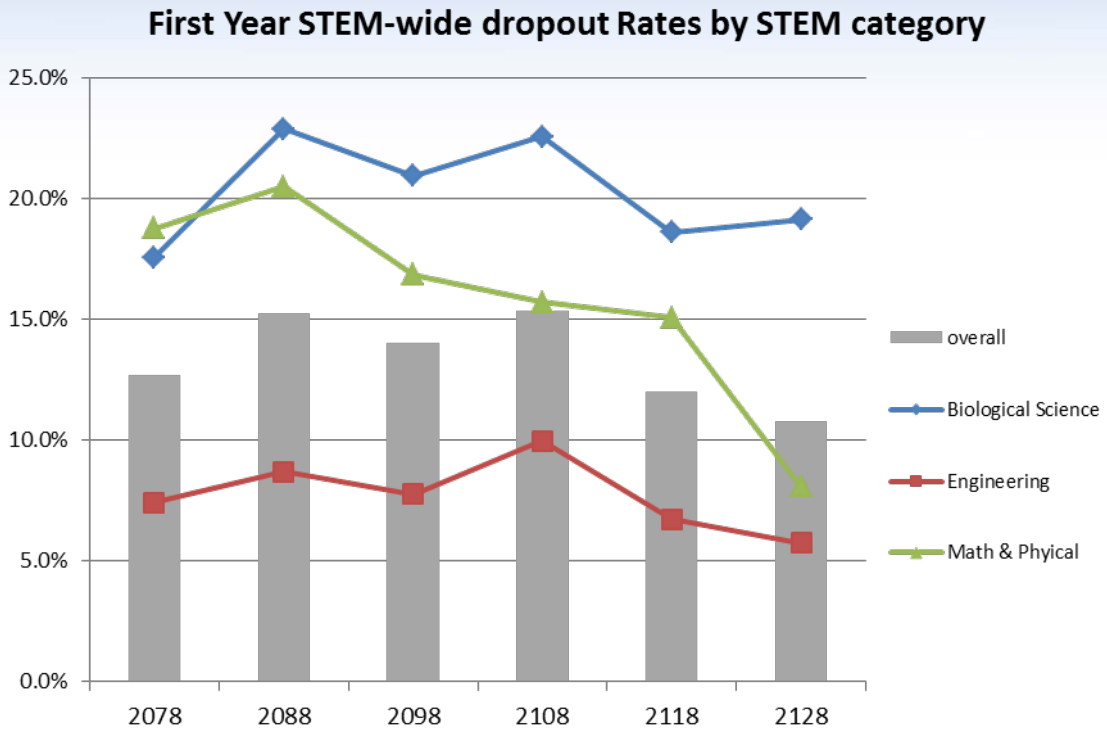
- Initial STEM majors outpaces entire cohort in terms of first-year university-wide retention rate ~ over 90%.
- There is approximately 15% STEM-wide dropout during the first year.
- **STEM attrition is mostly attributable to the change to a non-STEM major (STEM-wide dropout).**

Descriptive Analyses Result: gender, racial differences in STEM-wide dropout



- On average, approximately 13% of initial STEM majors leave STEM because of changing to Non-STEM major.
- Descriptively, female and URM has higher STEM-Wide dropout Rate.
- Similar findings can be found in the literature.

Descriptive Analyses Result: does different STEM discipline categories account for different STEM-wide dropout rates?



Descriptively, students declaring an Engineering STEM major initially outperformed the other two categories by having the lowest STEM-wide dropout rate. In contrast, those majoring in Biological Sciences have the highest STEM-wide dropout rate.

Descriptive Analyses Table

	STEM status at 2ndfall(N=5,697)						
	change to Non-STEM major N=757(13.3%)		Persist in STEM major N=4,517 (79.3%)		Dropout of UD N=423(7.4%)		All
	N	%	N	%	N	%	
GENDER							
F	424	19.0%	1641	73.6%	166	7.4%	2231
M	333	9.6%	2876	83.0%	257	7.4%	3466
URM							
N	672	13.3%	4020	79.6%	356	7.1%	5048
Y	85	13.1%	497	76.6%	67	10.3%	649
IPEDS RACE Condensed							
Asian	53	14.1%	299	79.5%	24	6.4%	376
Black	39	15.2%	187	72.8%	31	12.1%	257
Hispanic	37	12.0%	243	78.9%	28	9.1%	308
NRA	11	5.2%	183	87.1%	16	7.6%	210
Other	23	10.6%	173	80.1%	20	9.3%	216
White	594	13.7%	3432	79.3%	304	7.0%	4330
CURRENT_RESIDENCY							
Out of State	458	12.2%	2976	79.6%	307	8.2%	3741
In State	299	15.3%	1541	78.8%	116	5.9%	1956
FIRST_GEN_COLLEGE_FLAG							
N	641	12.7%	4050	80.3%	353	7.0%	5044
Y	116	17.8%	467	71.5%	70	10.7%	653
LOW_INCOME_FLAG							
N	709	13.2%	4268	79.6%	383	7.1%	5360
Y	48	14.2%	249	73.9%	40	11.9%	337
PELL_GRANT_FLAG							
N	663	13.0%	4079	80.0%	356	7.0%	5098
Y	94	15.7%	438	73.1%	67	11.2%	599
SAT Math Score							
<700	640	15.1%	3246	76.5%	355	8.4%	4241
>=700	117	8.0%	1271	87.3%	68	4.7%	1456
SAT Total Score							
<2000	602	14.0%	3352	77.9%	350	8.1%	4304
>=2000	155	11.1%	1165	83.6%	73	5.2%	1393
First-TermGPA							
<3.0	435	16.1%	1959	72.4%	311	11.5%	2705
>=3.0	322	10.8%	2558	85.5%	112	3.7%	2992
STEM category							
Biological Science	455	20.1%	1647	72.9%	157	6.9%	2259
Engineering	225	7.7%	2490	84.7%	225	7.7%	2940
Math & physical Science	77	15.5%	380	76.3%	41	8.2%	498

Statistical Analysis Results:

Individual Factors associated with the likelihood of changing to Non-STEM major

- Multinomial Logistic Regression was applied. The association was measured by partial odds ratio and its 95% confidence interval.

		Partial OR (95% CI)	
		dropout of STEM vs. persist in STEM	dropout of UD vs. perist in STEM
Gender	Female vs. Male	2.3(1.9,2.6)***	1.1(0.9,1.4)
URM staus	URM vs. Non-URM	1.0(0.8,1.3)	1.5(1.2,2.0)**
Race	Asian vs. White	1.0(0.7,1.4)	1.0(0.6,1.5)
	Black vs. White	1.2(0.8,1.7)	1.9(1.3,2.8)***
	Hispanic vs. White	0.9(0.6,1.3)	1.3(0.9,1.9)
	NRA vs. White	0.3(0.2,0.6)***	1.2(0.7,1.9)
	Other vs. White	0.8(0.5,1.2)	1.3(0.8,2.1)
Residency	In-State vs. Out-state	1.3(1.1,1.5)**	0.7(0.6,0.9)**
First Generation	Y vs. N	1.6(1.3,2.0)***	1.7(1.3,2.2)***
Low Income	Y vs. N	1.2(0.9,1.7)	1.9(1.3,2.7)**
Pell Grant	Y vs. N	1.4(1.1,1.7)*	1.8(1.4,2.4)***
SAT Math	>=700 vs. <700	0.5(0.4,0.6)***	0.5(0.4,0.6)***
SAT total Score	>=2000 vs. <2000	0.7(0.6,0.9)**	0.6(0.5,0.8)***
1st Term GPA	>=3.0 vs. <3.0	0.6(0.5,0.7)***	0.3(0.2,0.3)***
Initial STEM cateogry	Engineering vs. Biology	0.3(0.3,0.4)***	1.0(0.8,1.2)
	Math&Physical vs. Biology	0.7(0.6,0.9)*	1.1(0.8,1.6)

- Female, Delawareans, first-generation, Pell Grant recipients are more likely to switch to Non-STEM major as opposed to persisting in STEM.
- NRA, students having higher SAT scores, students obtaining higher first term GPA, and students whose initial STEM major is related to Engineering, Math & Physics are less likely to dropout of STEM.
- Female STEM attrition tends to be caused by changing to Non-STEM major, while URM STEM attrition is mostly due to their leaving UD altogether.

Statistical Multivariate Analysis Result

- After Backward stepwise selection explanatory variables left are: 1stTermGPA, Gender, Race, Residency, initial STEM category, First Generation status

	Partial OR (95% CI)	
	dropout of STEM vs. persist in STEM	dropout of UD vs. perist in STEM
1st Term GPA	0.6(0.5,0.7)***	0.3(0.2,0.3)***
Female vs. Male	1.7(1.4,2.1)***	1.3(1.1,1.7)*
Asian vs. White	0.8(0.6,1.2)	1.0(0.6,1.5)
Black vs. White	0.8(0.5,1.1)	0.8(0.5,1.3)
Hispanic vs. White	0.7(0.5,1.1)	0.7(0.5,1.1)
NRA vs. White	0.4(0.2,0.7)**	0.5(0.3,0.9)*
Other vs. White	0.7(0.4,1.1)	1.1(0.7,1.9)
In-State vs. Out-state	1.0(0.9,1.2)	0.4(0.3,0.6)***
Engineering vs. Biology	0.4(0.3,0.5)***	1.0(0.8,1.3)
Math&Physical vs. Biology	0.8(0.6,1.1)	1.1(0.8,1.8)
First-gen vs. Non-First-gen	1.4(1.1,1.8)**	1.6(1.2,2.2)**

Statistical Analyses Results Summary

Even after controlling for all other demographics, SES, and academic performance factors:

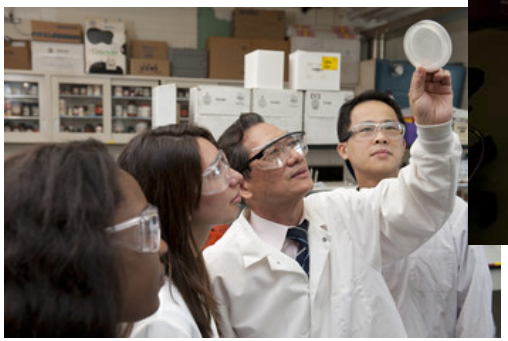
- Females are more likely to change to non-STEM major.
- First generation students are more vulnerable to STEM attrition by either dropout of STEM major or dropout UD altogether.
- The higher the first term GPA the higher the probability of persisting in STEM.
- Compared to Engineering majors, students initially majoring in Biological STEM disciplines are more likely to change to non-STEM major.

Study Limitations & Future Research Plans

- Explanatory variables only explain ~20% of model variation. Need to consider more variables directly related to students' experience with STEM at UD.
- Only one major per student was considered. STEM proportion may be underestimated or overestimated. Need thoughtful way to deal with double-major students.
- Identify capstone courses for each of the STEM majors in the system. Examine whether the performance on those courses plays role in STEM retention.
- Drill down to STEM category level. Examine the students' major migration across STEM categories and gender racial diversity within each STEM category.

Next Steps

- Align student interests with major
- Gateway versus gatekeeper courses
- Build early warning system for advisors and students
- Advising Task Force
- Student Success and Retention Task Force
- Hire Vice President for Enrollment Management



Discussion Questions

- How is STEM defined on your campus?
- Which variables do you use to predict student retention and success in STEM majors?
- Do you have specific initiatives on your campus that stop the leaky STEM pipeline?

Contact Us…

Di Chen
Institutional Research Analyst
302.831.2021
dchen@udel.edu

Heather Kelly
Director
302.831.2021
hkelly@udel.edu

http://www.udel.edu/IR/