Retention of Students in STEM Disciplines:
A Closer Look at Gender and Academic Performance

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Overview

- Background
  - STEM statistics
  - Underrepresentation of females
  - Impact of academic performance
- Research questions
- Data and variables
- Event history analysis (EHA)
- Results
- Discussion

STEM statistics

- The Department of Labor predicts significant growth (9 million) in STEM jobs from 2012-2022 (Vilorio, 2014).

- The six-year graduation rate for undergraduate students who started in 2009 was 62%; only 46% of STEM students got a degree in STEM fields after 6 years (CSRDE, 2016).

Underrepresentation of females

- In the 2013-14 academic year, 57% of baccalaureate degrees were awarded to women, but in STEM fields, women only earned 35% of the baccalaureate degrees (Ross, et al., 2012).

- Women's participation in STEM varies greatly across different STEM fields (U.S. Department of Education, NCES 2014).
  - ✓ Biological/biomedical science: 59%
  - ✓ Physical and technological science: 38%
  - ✓ Engineering: 19%
  - ✓ Computer and information science: 18%

Impact of academic performance

- The absolute grades in STEM courses are “one of the largest and most persistent factors” for attrition in STEM disciplines (Rask, 2010).
- The grading practice in STEM courses is more stringent than non-STEM courses (Rask, 2010; Cromley et al., 2015).
- It is important to examine the impact of both absolute and the relative grades compared to other courses.

Research Questions

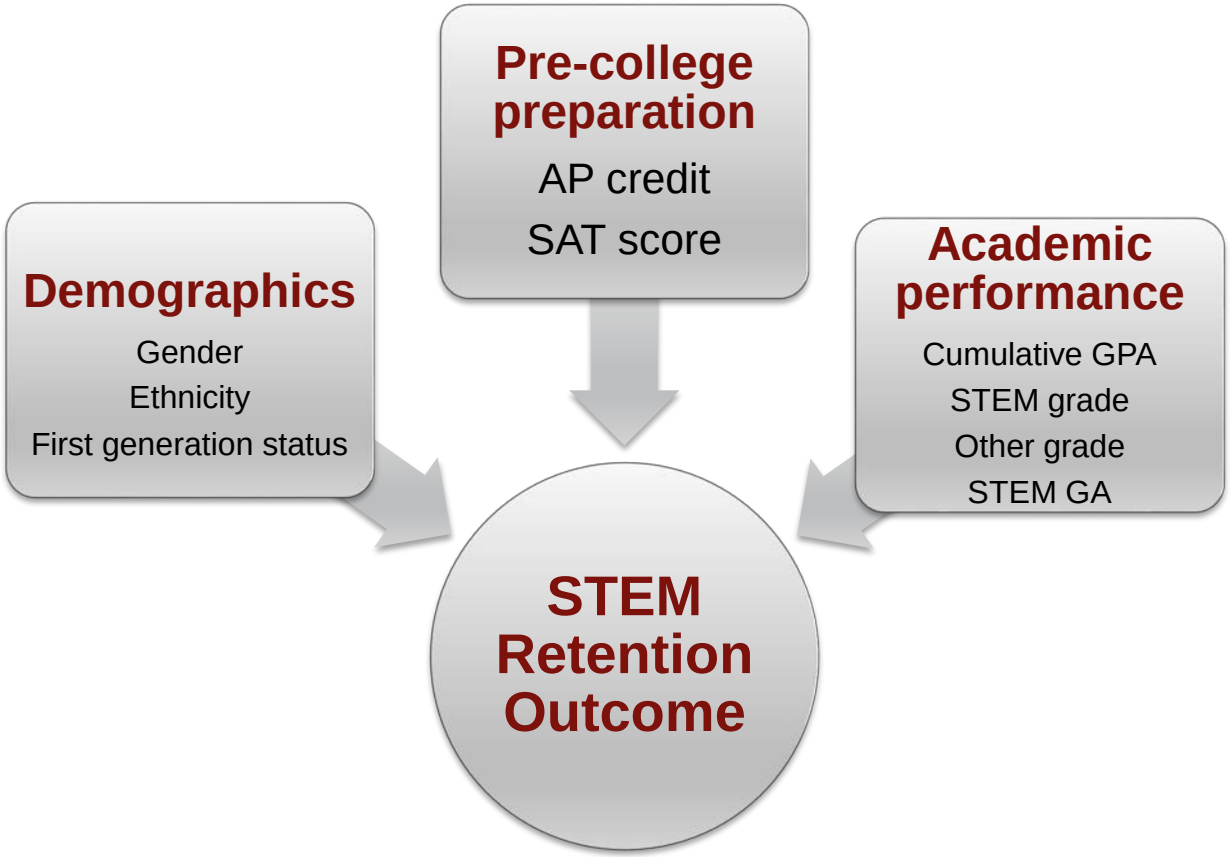
- How does the risk of dropping out from the STEM disciplines as a whole vary over time?
- What is the impact of course performance on university retention?
  - Absolute measure: performance in selected STEM courses
  - Relative measure: Grade Anomaly (GA) (Matz et al., 2017)
- Are females at higher risk of dropping out from STEM disciplines than males?
- Do grading practices impact female and male students in different ways?

Data

- First-time degree-seeking students in the fall cohorts from 2006 to 2009 who declared STEM major in the first semester.

- STEM Disciplines
  - NCES definition: computer and information science, engineering and engineering technologies, biological and biomedical science, mathematics and statistics, physical science, and science technology (as cited in Ginder & Mason, 2011)

A Conceptual Model



Variables

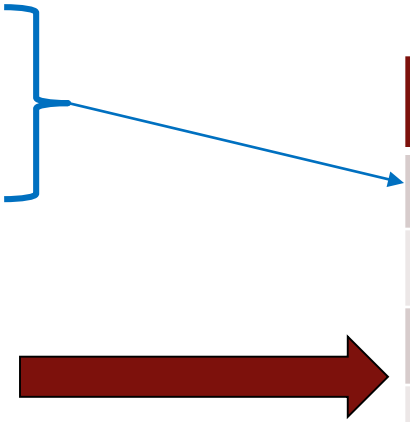
- Outcome variable
  - Time-dependent variable indicating whether the student dropped out from STEM fields.
  - 0 = remain enrolled in STEM fields or graduated with a STEM degree

    1 = exit university or switch to a non-STEM field
- Grade in selected STEM courses
  - Courses from biology, physics, chemistry, mathematics, statistics, computer science, and informatics.
  - If the student does not have enrollment in STEM courses in a semester, it is coded as ‘NE’ (not enrolled).

STEM grade anomaly

- GPAO (grade point average in other courses)
  - Cumulative GPA across all semesters including the current semester only excluding the course being analyzed.
  - A powerful predictor of students' course grade (Matz et al, 2017)
- STEM grade anomaly (STEM GA)
  - *STEM course grade – GPAO*
  - positive → grade bonus negative → grade penalty
  - Relative performance in each STEM course against all other courses
  - The impact of grade bonus/penalty in STEM courses on the decision to persist in STEM disciplines

ID	Term	Course	Grade
1	1	MATH1	3.3
1	1	CHEM1	3.7
1	1	ENG1	3
1	2	CSCI1	3.7
1	2	BIOL1	4
1	…	…	…
1	18	MATH2	3
2	1	MATH1	2.7
2	1	CHEM1	3
2	1	ENG1	3.3
2	2	ENG2	3.7
2	2	CHEM2	2



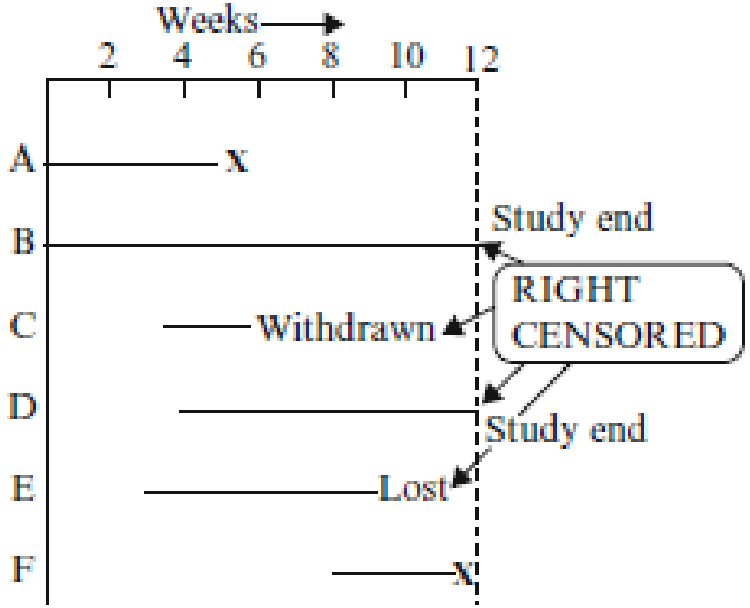
ID	Term	STEM grade	Other grade	Drop
1	1	3.5	3	0
1	2	3.85	.	0
1	…	…	…	0
1	18	3	.	0
2	1	2.85	3.3	0
2	2	2	3.7	1

- All students are tracked by enrolled terms, including fall, spring and summer semesters with a maximum of 18 terms.
- Person-term data set:
  3,053 students with 18,459 records

Event history analysis (EHA)

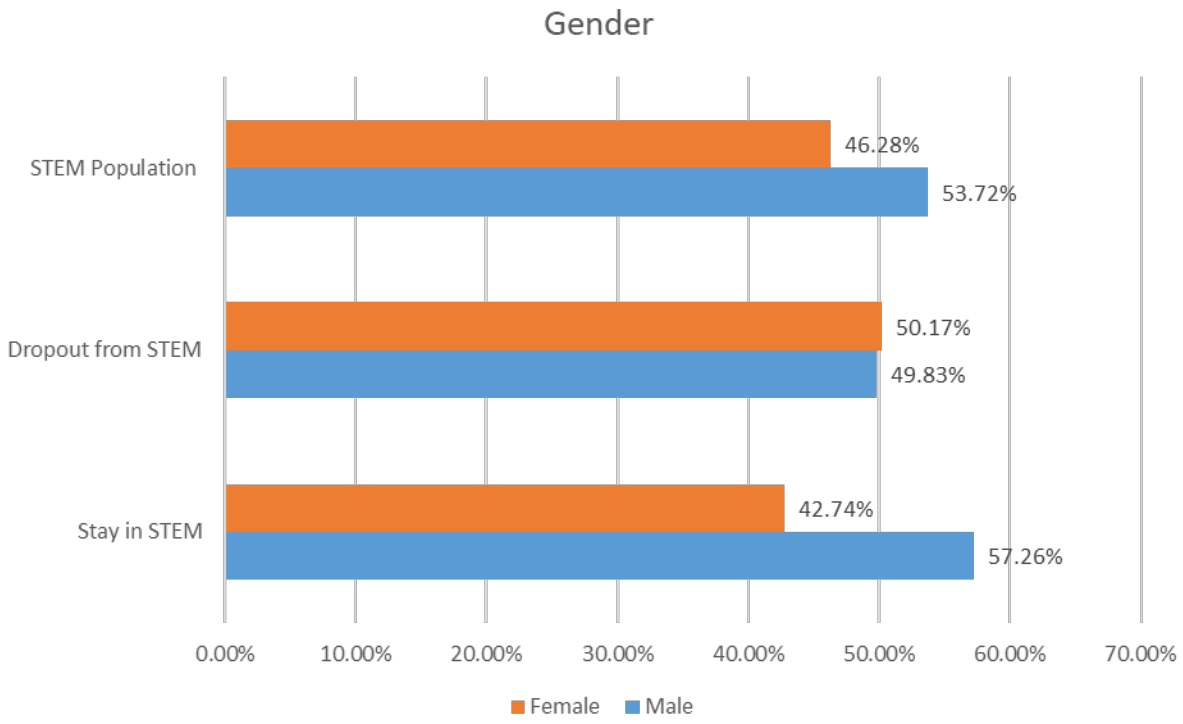
- Analyze the expected duration of time until the event happens.

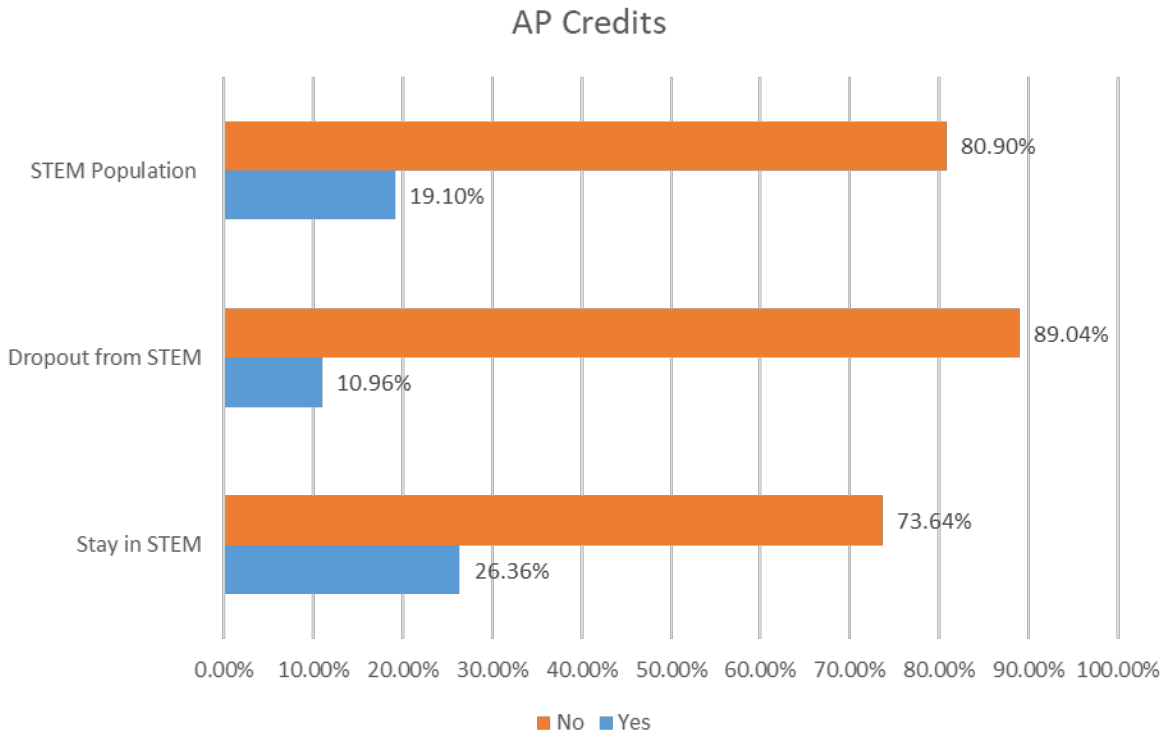
- Advantages
  - Allows for time-dependent covariates
  - Censoring

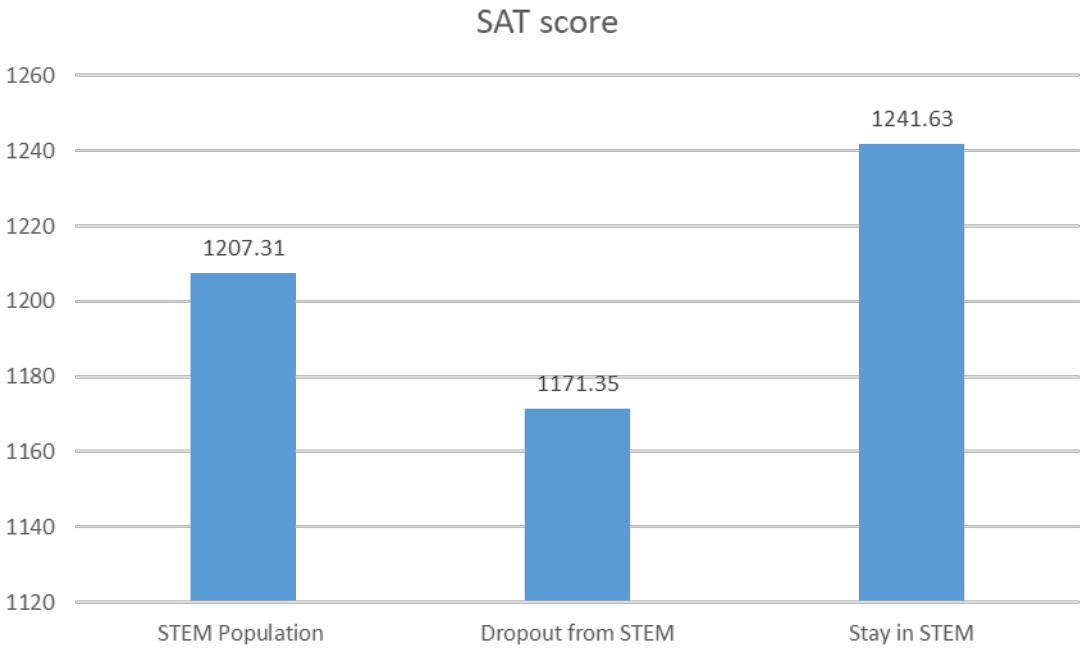


From Kleinbaum&Klein(2011)

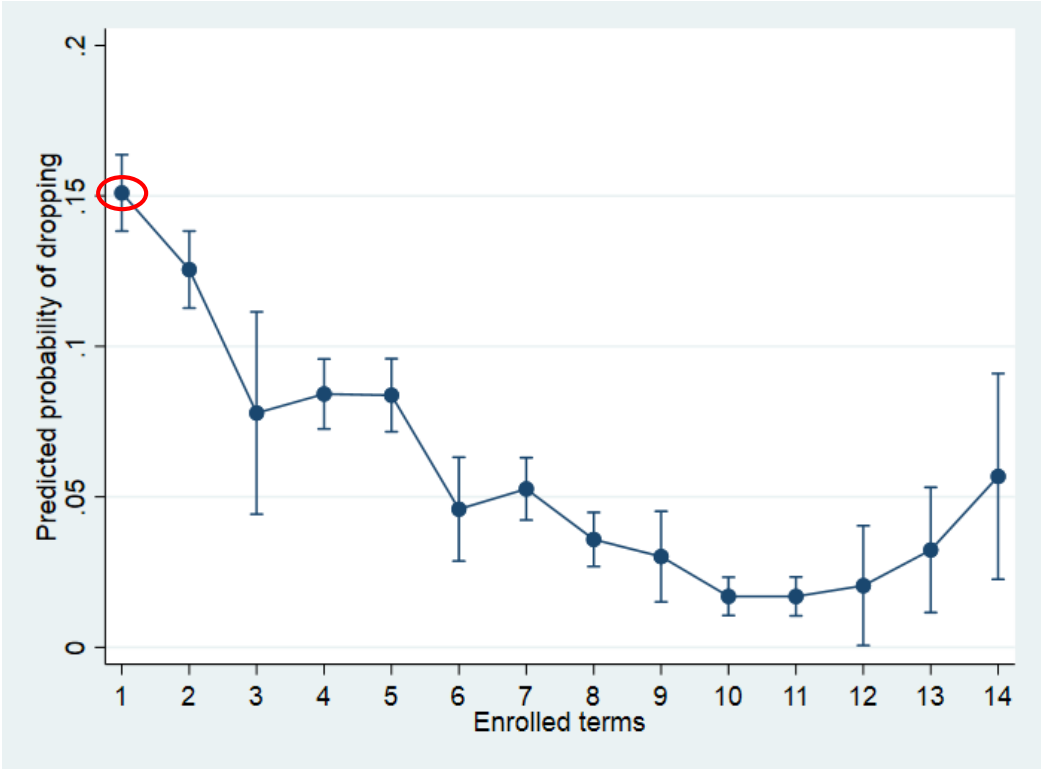
Results


Gender
STEM Population
Dropout from STEM
Stay in STEM
46.28%
53.72%
50.17%
49.83%
42.74%
57.26%
0.00%
10.00%
20.00%
30.00%
40.00%
50.00%
60.00%
70.00%
Female
Male


AP Credits
STEM Population
Dropout from STEM
Stay in STEM
80.90%
19.10%
89.04%
10.96%
73.64%
26.36%
0.00% 10.00% 20.00% 30.00% 40.00% 50.00% 60.00% 70.00% 80.00% 90.00% 100.00%
No
Yes


SAT score
1260
1240
1220
1200
1180
1160
1140
1120
1207.31
1171.35
1241.63
STEM Population
Dropout from STEM
Stay in STEM

RQ1: risk of dropout over time



RQ2a: Impact of absolute grade

The odds of dropping out from STEM for students with *Low* grades in selected STEM courses was 246% higher than students with *High* grades, $p < .001$.

Students with *Medium* grades in selected STEM courses had about 25% higher odds to drop out from STEM disciplines than their *High* grades counterparts, $p = .015$.

	Odds Ratio	Standard Error
First generation	1.11	0.13
Ethnicity		
URM	0.97	0.14
Other	1.07	0.25
White	1.16	0.13
Male	0.63***	0.04
AP	0.64***	0.06
SAT	1	0
Cumulative GPA	0.78***	0.03
STEM grade		
Low	3.46***	0.28
Medium	1.25*	0.12
Not enroll	8.96***	1.1
Other grade		
Low	2.26***	0.19
Medium	1.11	0.09
Not enroll	1.52*	0.28

****p < 0.001, **p < .01, *p < .05*

RQ2b: Impact of relative grade (STEM GA)

	Odds Ratio	Standard Error
First generation	1.22	0.14
Ethnicity		
URM	1.1	0.15
Other	1.23	0.28
White	1.2	0.13
Male	0.74*	0.04
AP	0.59*	0.06
SAT	1.00*	0
Cumulative GPA	0.61*	0.02
STEM GA	0.15*	0.02

**p < 0.001*

- For one point increase in the STEM GA, the odds of dropping out from STEM disciplines decreased by 85%, $p < .001$.
- STEM GA = STEM course grade – GPAO
- When STEM grades are close to or even higher than other grades, students tend to stay in STEM fields.

RQ3: Are females at higher risk of dropping out from STEM?

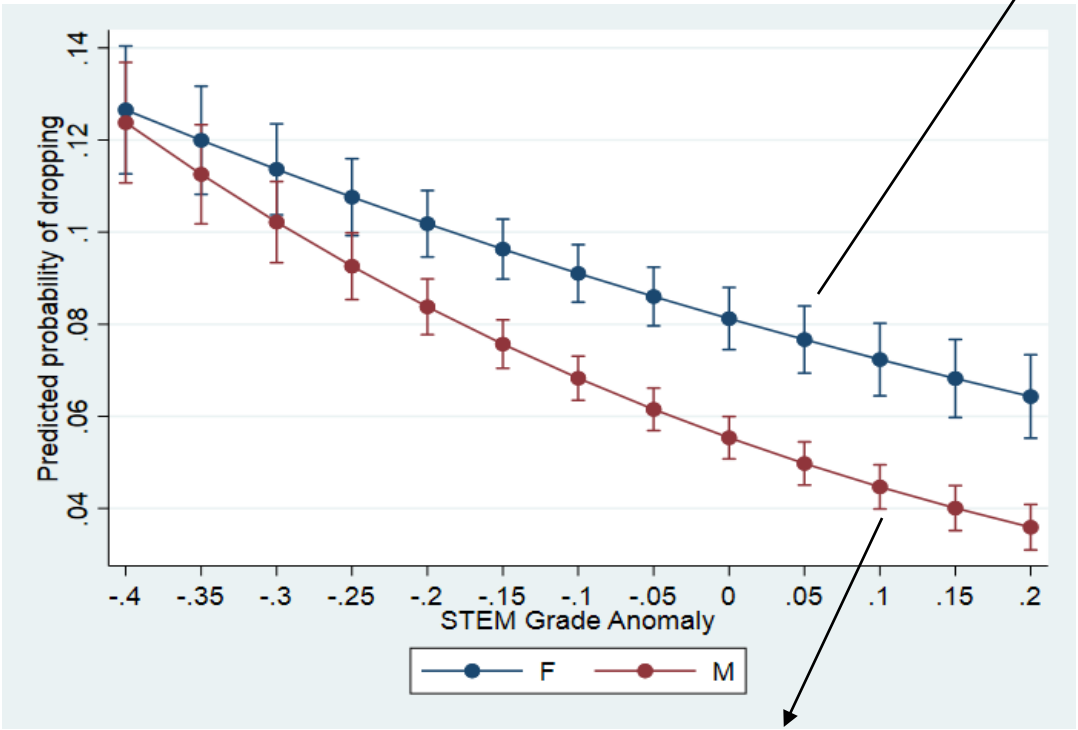
- Gender effect is significant.
- Male students' odds of dropping out from STEM were 37% smaller than that of females, $p < .001$.

	Odds Ratio	Standard Error
First generation	1.11	0.13
Ethnicity		
URM	0.97	0.14
Other	1.07	0.25
White	1.16	0.13
Male	0.63***	0.04
AP	0.64***	0.06
SAT	1	0
Cumulative GPA	0.78***	0.03
STEM grade		
Low	3.46***	0.28
Medium	1.25*	0.12
Not enroll	8.96***	1.1
Other grade		
Low	2.26***	0.19
Medium	1.11	0.09
Not enroll	1.52*	0.28

****p < 0.001, **p < .01, *p < .05*

RQ4: Interaction effect between gender and STEM GA

Females: one point increase in STEM GA was associated with 74% decrease in the odds of dropping out from STEM disciplines, $p < .001$.



Males: one point increase in STEM GA was associated with 91% decrease in the odds of dropping out from STEM disciplines, $p < .001$.

Summary

- The highest risk of dropout occurs after the 1st semester.
- Both absolute grade and relative grade have significant impact on retention in STEM disciplines.
- A gender gap is found between males and females on the risk of dropping out from STEM. Females are at a higher risk to leave STEM fields.
- A large grade penalty in STEM courses is a significant contributor to attrition in STEM for both females and males.
- Males are more sensitive to the relative grades

Discussion

- Short critical period to retain STEM students
- Gender inequity in STEM fields
- Consider STEM GA as a relative measure of academic performance for future work
- Employ longitudinal method to investigate retention
- Break the STEM fields into disciplines

Thank you!

Questions?

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