High School Course Access and Postsecondary STEM Enrollment and Attainment

Rajeev Darolia
Cory Koedel
Joyce Main
Felix Ndashimye
Junpeng Yan

Motivation & Research Questions

- Calls to improve the scope of the STEM workforce in the United States are common.
  - The U.S. is falling behind global competitors in terms of developing a workforce with the key skills needed to promote long-term economic prosperity (Committee on Prospering in the Global Economy of the 21st Century, 2007, National Academies of Science, Engineering and Medicine).
  - Occupations in STEM fields dominate contemporary lists of occupations with the largest forecasted growth, and STEM workers historically have higher earnings (Bureau of Labor Statistics, various reports).

- Calls to improve the diversity of the STEM workforce are also common, both to improve productivity (i.e., minimize lost opportunities for innovation) and equity.
  - Carnevale et al. (2016): African Americans are underrepresented as students in higher-paying majors and workers in higher-paying occupations.
  - The Obama Administration's "STEM for All" campaign, which included a focus on expanding opportunities for underrepresented students in STEM.

Motivation & Research Questions

- Our research question: Can policies that increase access to STEM courses in high school help to address STEM expansion and diversity goals?
  - Key outcomes: Initial STEM interest in college and STEM degree attainment from a 4-year college.

- Improved access to STEM coursework in high school, and especially improved access at schools that primarily serve under-represented minorities, has been advocated by policy groups, journalists, and the highest levels of government (Deruy, 2016; Randazzo, 2017; White House, 2016).

- We examine course-access effects overall, for different types of course access (e.g., advanced/regular), and for different student subgroups.

Preview of Findings

- We show that changes in STEM course access during high school do not lead to changes in initial postsecondary STEM enrollment or degree attainment.
  - Our estimates are precise enough to rule out modest impacts.
  - They are robust to different types of measures of course access.
  - A key reason is that the pass-through from course access to course taking is very small.
    - This finding is not consistent with the idea that there is pent-up demand for STEM coursework in high school.

- We find evidence of very modest effect heterogeneity by student race and gender within high schools, which we can see partly because our study is so well-powered.
  - If anything, the effect heterogeneity implies that the postsecondary STEM outcomes of women and underrepresented minorities are less responsive to changes in course access than white males.
    - Implication: global increases to course access will modestly exacerbate current diversity conditions in STEM.

- There is not evidence of effect heterogeneity between high- and low-URM high schools.
  - Although there are some troubling results from endogenous regressions.

Background

- There is a large literature examining various aspects of the STEM pipeline and, more generally, the factors that explain sorting to majors.
  - Arcidiacono (2004), Beffy et al. (2012), Gottfried and Sublett (forthcoming), Griffith (2010), Long, Conger and Iatarola (2012), Stinebrickner and Stinebrickner (2014)

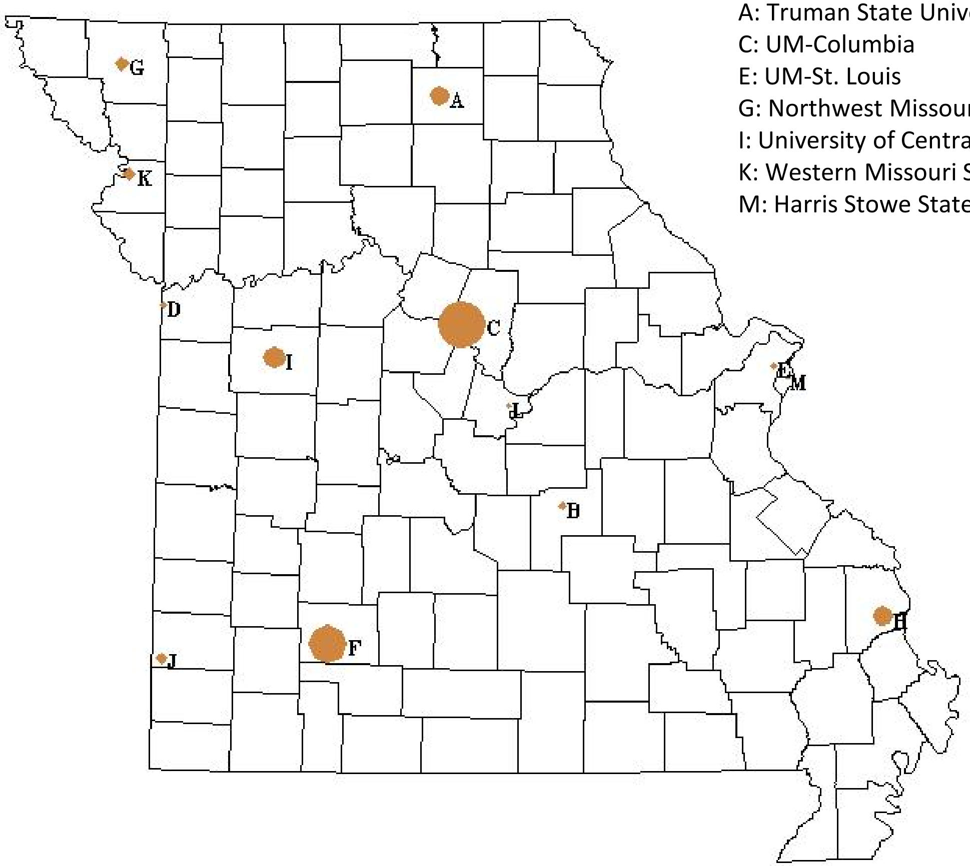
- And interventions aimed at improving STEM outcomes in college.
  - Access to information (Wiswall and Zafar, 2015)
  - Financial Aid (Castleman, Long and Mabel, 2017; Evans, 2017; Sjoquist and Winters, 2015)
  - AP course access & AP course taking in high school (Conger, Long, and McGhee, 2017)
  - Faculty diversity (Bettinger and Long, 2005; Carrell et al., 2010; Fairlie et al., 2014)
  - Grading standards (Butcher et al., 2014)

- There is also a large literature examining how high school curricula affect educational and earnings outcomes (some STEM focus).
  - Educational outcomes: Jacob, Dynarski, Frank and Scheneider (2017); Lilliard and DeCicca (2001); Allensworth, Nomi, Montgomery and Lee (2009)
  - Labor market outcomes: Rose and Betts (2004), Altonji (1995) Levine and Zimmerman (1995)

Postsecondary Data

- We use an administrative data panel of students from the 4-year public university system in Missouri (13 universities), merged with administrative records on high school course offerings, to study the effect of STEM course access in high school on postsecondary STEM outcomes.
  - 14 cohorts from 1996-2009; over 140,000 students.
  - Students indicate an initial major prior to enrollment (this is costless), and we use initial stated enrollment in STEM as our indicator of initial interest.
  - STEM attainment is assessed by 4-year degree completion in any STEM field at any system university within 6 years.
  - We use CIP codes to classify majors following traditional designations.
    - STEM includes: agricultural and animal science, biological science, computer science, engineering, engineering technology, mathematics, and physical science (there is also a small "other STEM" category).
  - These data include measures of the number of STEM courses completed during high school as part of each student's record.

Postsecondary Data

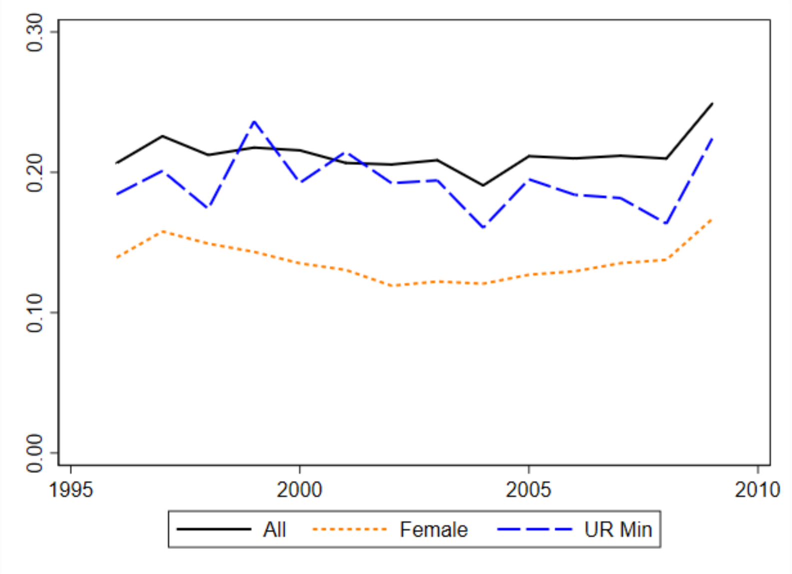


A: Truman State University
C: UM-Columbia
E: UM-St. Louis
G: Northwest Missouri State University
I: University of Central Missouri
K: Western Missouri State University
M: Harris Stowe State University

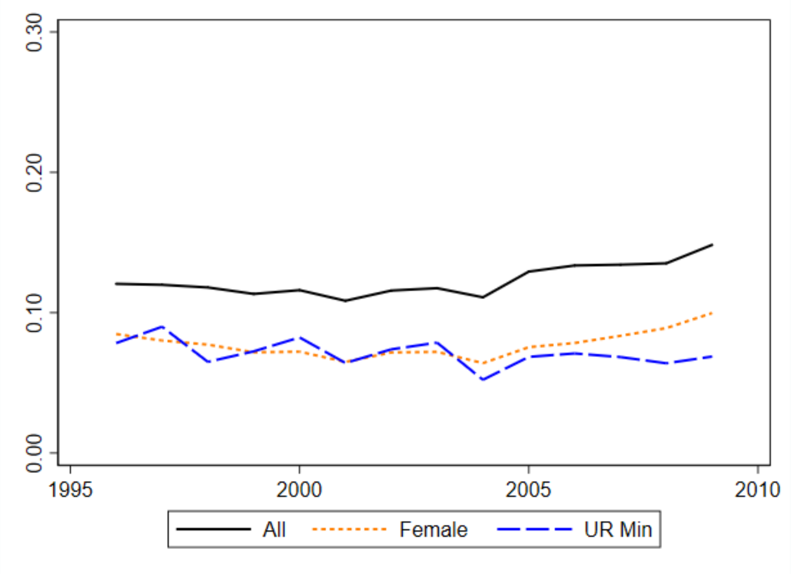
B: Missouri Science and Technology (UM-Rolla)
D: UM-Kansas City
F: Missouri State University
H: Southeast Missouri State University
J: Missouri Southern State University
L: Lincoln University

Postsecondary Data

Initial Major is STEM



Final Major is STEM



High School Data

- Student-level records are all contained within the higher-education data. We append measures of the high school curriculum to the student records using the K-12 administrative data.
  - The high school curriculum data are merged to students by the high school graduation year, and capture courses offered in STEM over the last three years of high school.
    - That is, we measure exposure to STEM courses during grades 10-12.
  - Our primary measure of course access averages the number of STEM courses offered per year of high school, per 100 students, during the last three years.
    - Repeated sections count as extra courses.
    - Extensions include:
      - “Topic availability” (repeated sections do not count)
      - Divisions by class type and level (science/math ; regular/advanced)
      - Unadjusted for student enrollment
  - There are almost 500 (498) high schools in the dataset.

Analytic Plan

- We estimate the causal effect of exposure to STEM courses in high school on STEM outcomes in college.
  - Our innovation is a data innovation: we build the data panel that previous studies have lacked to fully address selection bias concerns in the context of our evaluation.
  - The data panel facilitates the use within-high-school variation over time in STEM course availability for identification.
  - Our estimates are not biased by two well-understood endogeneity threats in observational data.
    - The courses students choose to take in high school are likely endogenous to their interests in college.
    - The course menus to which students are exposed across high schools are also likely endogenous.

- Remaining threats
  - There is no evidence of bias from endogenous changes to course-offerings over time within high schools.
  - There is no evidence that variation in STEM course access in high schools affects who matriculates into the 4-year public university system (and thus sample selection bias is not a concern).

Results: Primary

Table 4: STEM Major and Degree Attainment Models.

	Initial Major	Degree Attainment
A. Courses Taken		
Courses Taken	0.0142	0.0057
	(0.0007)***	(0.0005)***
B. Course Availability		
CA Per 100	**0.0004**	**0.0003**
	(0.0008)	**(0.0007)**
Individual controls & Year FE	X	X
HS Controls	X	X
HS FE	X	X
N	141,579	141,579

Results: Primary

- Interpretation
  - Taking the point estimates at face value, a one-unit increase in courses available increases initial STEM enrollment and attainment by 0.04 and 0.03 percentage points.
  - Converting to standard deviations of course availability (3.6) and moving to the upper bounds of the 95-percent confidence intervals, we can rule out effect sizes larger than 0.72 and 0.61 percentage points (or 3.4 and 5.1 percent of the sample means of STEM enrollment and attainment).
    - Our null findings are not driven by large standard errors in our preferred specification; we are not underpowered.

Results: Course-Type Heterogeneity

Table 5: STEM Major and Degree Attainment Models, with Course-Type Heterogeneity. Courses Available Only.

	Initial Major				Degree Attainment			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Advanced Math CA Per 100	-0.0014	-0.0013		**-0.0019**	0.0006	0.0004		**-0.0000**
	(0.0023)	(0.0023)		**(0.0024)**	(0.0017)	(0.0017)		**(0.0018)**
Standard Math CA Per 100		0.0007		**0.0003**		-0.0011		**-0.0014**
		(0.0021)		**(0.0022)**		(0.0018)		**(0.0019)**
Science CA Per 100			0.0009	**0.0011**			0.0007	**0.0009**
			(0.0011)	**(0.0012)**			(0.0010)	**(0.0011)**
Individual controls & Year FE	X	X	X	X	X	X	X	X
HS Controls	X	X	X	X	X	X	X	X
HS FE	X	X	X	X	X	X	X	X
N	141,579	141,579	141,579	141,579	141,579	141,579	141,579	141,579

Results: Other Types of Heterogeneity (Briefly)

- The findings shown thus far are also insensitive to different reasonable ways of measuring course exposure in high school.
  - Topic availability.
  - Course availability unadjusted for enrollment.

Effect Heterogeneity

- We explore two dimensions of effect heterogeneity
  - Between high schools by the URM enrollment share.
    - We estimate the models separately for subsamples of high schools with high URM enrollment shares.
  - Within high schools, between individual students by race and gender.
    - We add interactions in our main models between individual student race/ethnicity and gender and the course-access variable.
      - We compare white students to URM students (black and Hispanic) in the racial/ethnic comparisons.

Effect Heterogeneity: High School URM Enrollment Share

Table 9: STEM Major and Degree Attainment Models, by High School Racial/Ethnic Composition.

	Initial Major				Degree Attainment			
	Full Sample	Minority > 25%	Minority > 50%	Minority > 75%	**Full Sample**	Minority > 25%	Minority > 50%	Minority > 75%
A. Courses Taken								
Courses Taken	**0.0142**	0.0084	0.0082	0.0114	**0.0057**	**0.0014**	**0.0008**	**0.0015**
	(0.0007)* **	(0.0012)***	(0.0013)***	(0.0018)***	**(0.0005)*** **	**(0.0010)**	**(0.0012)**	**(0.0017)**
B. Course Availability								
CA Per 100	**0.0004**	-0.0022	-0.0061	-0.0061	**0.0003**	-0.0018	-0.0005	0.0005
	(0.0008)	(0.0014)	(0.0036)*	(0.0044)	**(0.0007)**	(0.0007)**	(0.0014)	(0.0014)
Indiv. & HS controls & Year FE	**X**	X	X	X	**X**	X	X	X
HS FE	**X**	X	X	X	**X**	X	X	X
N	**141579**	17206	8959	4069	**141579**	17206	8959	4069

Effect Heterogeneity: High School URM Enrollment Share

- Interpretation
  - High attrition rates from STEM fields have been well documented, as have differential attrition rates by race/ethnicity (e.g,. National Science Foundation, 2012).
  - A potential explanation for the racial/ethnic attrition gaps in other research is that different groups are differentially prepared to succeed in STEM (e.g., Arcidiacono, Aucejo, & Spenner, 2012)
  - Among students in high schools with large proportions of minority students, our results suggest that variation along at least this one dimension of preparation – high school STEM coursework – does not positively map to STEM success in college, even in models that embody endogeneity owing to students' own course choices in high school.
  - For the models with better causal purchase, the results are generally similar to our main findings, and if anything suggest negative effects of more course access.
    - I don't want to over-interpret this result, but explanations include variation in course quality or a response to better information about the difficulty of STEM.

Effect Heterogeneity: By Race/Ethnicity and Gender, Within High Schools

Table 10: STEM Major and Degree Attainment Models, with Race/Ethnicity Heterogeneity. Courses Available Only.

	Initial Major	Degree
	(1)	(2)
CA per 100	0.0017	0.0006
	(0.0011)	(0.0008)
CA per 100 X Female	-0.0013	-0.0001
	(0.0008)*	(0.0007)
CA per 100 X Underrepresented Minority	-0.0032	-0.0011
	(0.0011)***	(0.0008)
Indiv. & HS controls & Year FE	X	X
HS FE	X	X
N	141,579	141,579

Effect Heterogeneity: By Race/Ethnicity and Gender, Within High Schools

- Interpretation
  - For both women and underrepresented minorities, and in both models, the overall effects of increased course access, inclusive of the main coefficient, are small and statistically insignificant.
  - The differential effects relative to white men are best described broadly as small to moderate.
    - However, the direction of the findings is not encouraging about the prospects for using high school STEM access as a policy lever to promote STEM diversity in college.

Summary

- Our findings indicate that expanded access to STEM coursework in high school in and of itself is unlikely to expand the scope of postsecondary STEM training or improve diversity.
  - Our null results are precisely estimated and consistent across a variety of reasonable modifications to our measures.