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The Impact of High School Math and Science Coursework on Postsecondary STEM

ERDC
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ABOUT THE ERDC

The research presented here uses data from the Education Research and Data Center, located in the Washington Office of Financial Management. ERDC works with partner agencies to conduct powerful analyses of learning that can help inform the decisionmaking of Washington legislators, parents, and education providers. ERDC's data system is a statewide longitudinal data system that includes de-identified data about people's preschool, educational and workforce experiences.

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Executive Summary

This study estimates the net effects of high school math and science coursework on a student's college curricular outcome. The model estimates the likelihood of earning college STEM credits by taking into consideration mediating effects through pre-college academic performances from 3rd grade to high school. The key findings of this study are summarized as below:

- In high school, completing a high level math course beyond algebra II or geometry and earning credits in physics/chemistry significantly impacts a student's likelihood of earning college STEM credits.
    - Taking high-to-high math pathway increases the probability of earning college STEM credits by 11.9 percent, while taking standard-to-high and high-to-standard pathway increase the probability by 9.7 percent and 3.8 percent respectively.
    - A one standard deviation increase of the number of credits earned in physics/chemistry raises the probably of earning college STEM credits by 6.6 percent.
    - A one standard deviation increase in credits earned in biology increases the probability of earning college STEM credits by 1.9 percent.
- Compared to science coursework, the impact of most high school math pathways on college STEM credit completion is highly mediated by pre-college academic performance, such as high school GPA, 8th-grade math score, and high school graduation status.

Introduction

Policymakers and researchers often describe the pathway from education to career in science, technology, engineering or mathematics (STEM) disciplines as a "pipeline" which channels students from general education in elementary school to college degrees in STEM fields. When discussing STEM policy, policymakers tend to focus on identifying where students deviate from the pre-described STEM path, "leaks." However, little is known about where the leaks are, when they occur, and what the impacts are over the course of a student's education.

In 2015, the Washington State [Education Research and Data Center] received a Statewide Longitudinal Data System (SLDS) grant from the U.S. Department of Education to develop and expand research and data capacity in improving student educational outcomes. This report, funded by the grant, serves as the last study of a series of projects evaluating Washington students' STEM learning progression and outcomes. Two previous studies have portrayed the STEM course-taking pathways from high school to the first year in college (Chen, 2019a: Chen, 2019b). Differentials in math and science pathways are found to be correlated with the likelihood of gaining college STEM credits.

This study expands the scope of research relative to Chen (2019b) in an attempt to identify the determinants of a student's college STEM outcome. This study adds a full spectrum of pre-college experiences into the previous model to further examine the effect of a student's progression and achievement from 3rd grade to the end of high school. It specifically aims to answer the following research questions:

- What are the effects of high school course-taking in math and science on college STEM course completion?
- To what extent do pre-college academic performances from elementary to high school mediate the high school course-taking effects on college STEM course completion?

Data

The source data for this research comes from student administrative records from 3rd grade (generally enrolled in 2007) to postsecondary education (2017). The data source for K-12 records is the Comprehensive Education Data and Research System (CEDARS) from the Office of Superintendent of Public Institution (OSPI), which provides students' demographics, high school enrollment, course grade history, and completion. Student college attendance and STEM learning in Washington public higher education institutions comes from two resources: (1) Washington's Public Centralized Higher Education Enrollment System (PCHEES); and (2) the State Board for Community and Technical College (SBCTC). Student enrollments in out-of-the-state or private institutions are not included because their college coursework data is not collected and reported.

Due to limitations resulting from data quality and availability, the study cohort includes only 9th graders who entered high school in the 2013-2014 school year (the high school graduation class of 2016). These students must have subsequently enrolled in any Washington public institution in the 2016-2017 academic year and been enrolled in Washington public school system from 3rd to 10th grade.

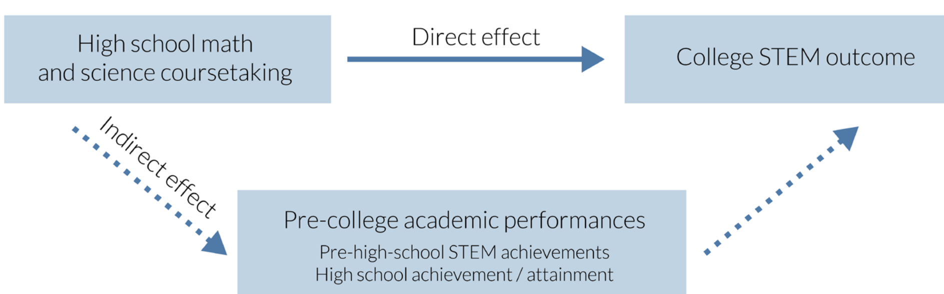
This sample is derived from the work of Chen, V. et al. (2018) which includes more details about the data and a discussion of data quality. Given the nature of this analysis, the sample was further constrained by data availability. 9th graders who do not have all test scores in math or science from 3rd to 8th grade are removed from the analysis since pre-high-school STEM learning outcomes are the key mediator variables in this study. Further, students whose data was incomplete or who had clearly erroneous values in the source administrative data were excluded. Additional information regarding sample selection is demonstrated in Appendix A.

The variables selected for this analysis are derived from student-level records found in the source administrative datasets. These variables represent three key categories of data: college STEM learning outcomes, high school coursework in math and science, and the other pre-college academic performances focusing on math and science. The c*ollege STEM course outcome* is a dummy variable identifying whether a student earned any college-level STEM course credit during the 2016-2017 academic year. *High school STEM course-taking* is measured by two sets of variables, categories of math course-taking pathways and the total numbers of credits earned in biology and in physics or chemistry. These variables summarize a student's overall coursework patterns in math and science over high school years. Pre-college academic performances include variables measuring a student's academic outcomes, including test score in math and science from 3rd to 12th grade, high school GPA, and obtaining high school diploma. Further details about variables used for analysis could be found in Appendix A.

Analytic Approach

This study applies the Karlson-Holm-Breen (KHB) method (Breen et. al., 2013; Breen et. al., 2015), which is a mediation analysis for non-linear probability estimation. It reports the sizes of direct effect of high school math and science course-taking and indirect (mediating) effect of pre-college academic performances on the probability of earning college STEM course credits. The causal pathway is used in this analysis is conceptualized in Figure 1.

Figure 1. Causal Pathway for Karlson-Holm-Breen Method



Summary of Findings

What are the effects of high school STEM coursework on earning college STEM course credit?

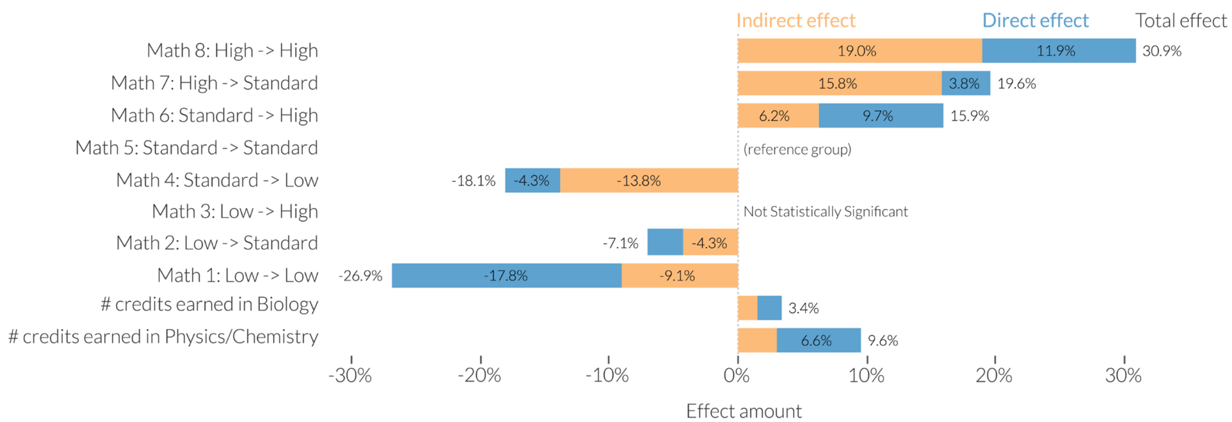
Figure 2 presents the decomposition of the effect of high school math and science course-taking on earning college STEM credits, with pre-college academic performances as the mediator. To simplify the interpretation on the probability scale, the results from KHB logit model are presented by average partial effects (APE) (Wooldridge, 2002). Appendix B contains the details of the logit coefficients (table B3a) and transformation to odds ratio (Table B3b).

Examining effects across high school math course-taking pathways, students remaining in the high math course sequence through high school are 30.9 percent more likely to earn college STEM credits than those in standard pathway. The second highest positive effect is found among students taking high-to-standard pathway (19.6 percent), followed by those who started with standard course sequence and progress to the high sequence (15.9 percent). Students who continuously remained in low math sequence are 26.9 percent less likely to earn college STEM credits.

While the high school math pathway clearly impacts student STEM course taking in post-secondary education, impact of high school science course-taking is more muted. The total effect of one standard deviation increase of number of credits earned in physics/chemistry contributes to a 9.6 percent increase in college STEM coursework. Similarly, a one standard deviation increase of biology credits resulted in only a 3.4 percent increase in STEM coursework at the post-secondary level.

Holding pre-college academic performances constant, the direct (net) effects of high school STEM pathways shrink but the direction and statistical significance remain the

Figure 2. The effects of high school STEM coursetaking patterns on earning college STEM credit, mediated by pre-college academic performances



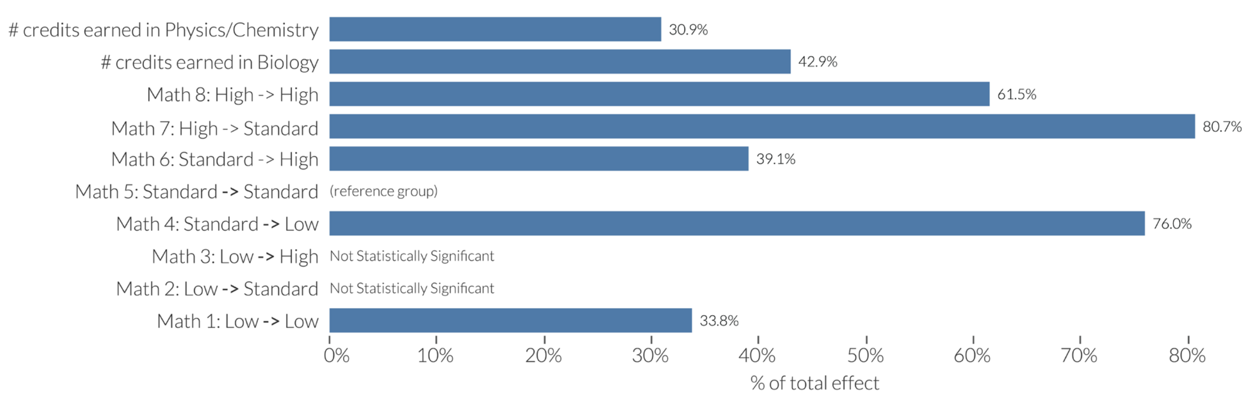
same across all variables. Taking high-to-high math course sequence remains the highest impact on earning college STEM credits (11.9 percent). The second highest direct effect comes from those starting with standard level and progressing to the high course level (9.7 percent), followed by those starting with high course level and continuing to a standard level (3.8 percent). Those who stay in low-to-low pathway are 17.8 percent less likely to earn college STEM course credit than those taking standard pathway. The direct effect of the number of earned science credits remains statistically significant, while a one standard deviation increase in the number of physics/chemistry and biology credits produces a 6.6 percent and 3.4 percent increase in post-secondary STEM course taking.

To what extent do pre-college academic performances mediate the effects of high school STEM course-taking?

The change of the effect sizes demonstrated in Figure 2 necessitates a discussion of the mediation effect of pre-college academic performances accumulated from early grade level to high school. Specifically, it is necessary to question to what degree the total effects of high school STEM course-taking are being mediated and if this effect is strictly important when modeling post-secondary outcomes. To test this, controls for math and science test scores from 3rd grade to high school, high school GPA and graduation were added to the model. The confounding percentages in Figure 3 represent the proportion of total effect attributable to pre-college academic performance.

Pre-college academic performances explained 80.7 percent and 76.0 percent of the total effects of high-to-standard and standard-to-low math pathways respectively. These two pathways represent downward math progression in high school implying that the downward progression course-taking pattern is largely affected by either STEM performance from 3rd grade to high school, or high school GPA or graduation status. This effect is further explained in Appendix B (table B4, Column 4). Additionally, pre-

Figure 3. Percent total effect of high school STEM course-taking explained by pre-college academic performances



(Note: All presented variables have statistically significant total effects. Math 5 is the reference category.)

college academic performances account for 61.5 percent of the total effect of high-to-high math pathway, 42.9 percent for credits earned in biology, 39.1 percent for standard-to-high pathway, and 30.9 percent for credits earned in physics/chemistry.

Discussions

This study aims to identify the determinants from a student's STEM learning progression that significantly impact a student's long-term STEM outcomes and compare the magnitude of the impact across those determinants. First, among the variables measuring high school course-taking pathways in math and science, achieving high level in math course (beyond algebra II and geometry) plays a paramount role in earing a college STEM credit within a year after high school. This is followed by the number of credits in physics/chemistry as the second critical predictor. Achieving a math course level beyond algebra II and geometry by the end of high school and taking course higher than algebra I in 9th grade is more likely to increase the math learning progression after high school. This finding implies that beginning more advanced math education earlier in a student's education pipeline may result in better STEM outcomes at the college level. This feeds into the policy discussion about algebra I in 8th grade, as recommended by the U.S. Department of Education. However, this study does not utilize information on student course taking at the middle school level. To further investigate this policy topic, course data of middle school students would need to be collected and added to the model.

The second finding shows that student pre-college academic performances from 3rd to 12th grade significantly mediate the effect of high school STEM course-taking, especially among those who experienced downward progression in math course sequence. In other words, the effect of not progressing in math course level on college STEM is largely explained by the other academic performance indicators rather than high school STEM course-taking pathways. This is a generally expected result based on the progressive nature of academic programs in Washington and may account for some of the leakage in the STEM pipeline. However, collinearity between non-STEM coursework and STEM coursework, specifically substitutability across many courses, is not part of this research and warrants future study.

Lastly, three major factors (high school GPA, gaining a high school diploma, and 8th-grade math score) significantly mediate the effect of high school STEM course-taking pathways. High school GPA is calculated by course grade, which is a cumulative form of course outcomes. Collinearity between GPA and STEM course level may mute the STEM-course taking effect, especially for those related with math level. The net effect of high school GPA on college STEM outcomes needs further investigation.

However, the results from this analysis can be generalized to a selective sample including 9th graders who enrolled in high school for at least two school year, took every state math and science assessment from 3rd grade to high school, and enrolled in Washington public institution in 2017 (a year after high school). The sampled students are more academically prepared for college, compared to those who enrolled in college but did not have full records (see “STEM pipeline” vs. “STEM incomplete” columns in Table B1). Whether or not such selection would have biased the findings is not fully analyzed. One possible solution is to apply multiple imputation to fill in missing values for the incomplete sample, by taking into account school mobility and excuses from state assessment. However, at the time this study was conducted, limited data was available to implement this approach.

Another limitation comes from the validity of using course credits earned in one year after the majority of cohort exited high school, to construct first-year college STEM credit earned. The fact that about 62 percent of Washington public high school graduates enrolled in college during the first year after graduation cannot fully represent all students' college going and course taking. More years of college data to measure college STEM course outcomes is needed. This is especially true when a research aims to examine STEM persistence and major choice toward degree completion.

Conclusion

This study finds that the net effects of high school math and science coursework on a student's college curricular choices was dependent on both the pathway and level of coursework completed pre-college. In high school, completing a high level math and earning credits in physics/chemistry significantly impacts a student's likelihood of earning college STEM credits. Some of these impacts are mediated by student academic performance as high level match classes tended to directly relate to high level academic performance. However, even after controlling for ability, both pathway and course taking effects remained positive and significant.

Even though the mediation analysis applied in this study identifies key mechanisms embedded in STEM pipeline to predict long-term STEM outcomes, several methodological considerations and data limitations need to be addressed for future research. Changes in course sequencing and starting grades for more advanced math classes, substitution effects between non-STEM coursework and STEM coursework, and Collinearity between GPA and STEM course level are each outside of the scope of this research and my act as confounds for the resulting analysis. While the results of this analysis are strong and suggestive, further research is clearly still necessary to produce actionable results.

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Appendix A. Technical Notes

Variable definition

Variable	Description
Earned college-level STEM credits in 2017	This variable is constructed by several approaches and differs by institution sector. First, remedial courses are removed from students' postsecondary coursework profiles. Second, the identification of STEM courses from public 2-year institutions is based on the guidelines from SBCTC, and the data is mainly from CTC Student Class and Student Transcript files. The STEM course data from public 4-year institutions comes from PCHEES data elements field of study and concentration. Once a STEM course is identified, a dummy variable indicating whether a student earned any course credit from a college-level STEM course in 2016-17 academic year. 1= yes; 0=no.
Female	A dummy variable identifying student gender. 1=female; 0=male
Race/ethnicity	Student race/ethnicity is extracted from OSPI 2013 CEDARS student enrollment data. The categories follow federal rollup described in [CEDARS data manual].
American Indian/Native American	A dummy variable identifying student race/ethnicity. 1=non-Hispanic AI/NA; 0=otherwise.
Asian	A dummy variable identifying student race/ethnicity. 1= non-Hispanic Asian; 0=otherwise.
African American	A dummy variable identifying student race/ethnicity. 1= non-Hispanic African American; 0=otherwise.
Hispanic	A dummy variable identifying student race/ethnicity. 1= Hispanic; 0=otherwise.
White	A dummy variable identifying student race/ethnicity. 1= non-Hispanic White; 0=otherwise.
Other	A dummy variable identifying student race/ethnicity. 1= non-Hispanic other racial group; 0=otherwise.
School program enrollment	Extracted from 2013 CEDARS student program data.
Immigrant	A dummy variable identifying whether a student's eligibility for Title III Immigrant federal funding. 1= yes; 0=otherwise.
Bilingual	A dummy variable identifying whether a student is in State Transitional Bilingual Instruction Program. 1= yes; 0=otherwise.
FRPL eligible	A dummy variable identifying whether or not a student is eligible for free- or reduced-price lunch in 2012-2013 school year is used to indicate a student's family income status. This is the only indicator available from CEDARS to proxy a student's socioeconomic status. 1= yes; 0=otherwise.
Limited English Proficiency	A dummy variable identifying a student's LEP status. 1= yes; 0=otherwise.
Special education	A dummy variable identifying whether a student was in special education program. 1= yes; 0=otherwise.
High school STEM course-taking	
Math: Low->Low	Took pre-algebra/foundation mathematics in 9th grade and ended with pre-algebra/foundation mathematics or algebra I before exited high school.
Math: Low->Norm	Took pre-algebra/foundation mathematics in 9th grade and ended with algebra II or geometry before exited high school.
Math: Low->High	Took pre-algebra/foundation mathematics in 9th grade and ended with algebra III, trigonometry, statistics/other non-core advance mathematics, pre-calculus, calculus

Variable	Description
Math: Norm->Low	Took algebra I in 9^{th} grade and ended with pre-algebra/foundation mathematics or algebra I
Math: Norm->Norm	Took algebra I in 9^{th} grade and ended with algebra II or geometry
Math: Norm->High	Took algebra I in 9^{th} grade and ended with algebra III, trigonometry, statistics/other non-core advance mathematics, pre-calculus, calculus
Math: High->Norm	Took algebra II or geometry in 9^{th} grade and ended with algebra II or geometry
Math: High->High	Took algebra III, trigonometry, statistics/other non-core advance mathematics, pre-calculus, calculus, and ended with this course level
Number of credits earned in biology	Total number of credits earned in biology through high school
Number of credits earned in physics/chemistry	Total number of credits earned in physics or chemistry through high school
Pre-college academic performances	
High school math test score	Standardized the highest scales score of math state assessment
High school science test score	Standardized the highest scales score of End-of-Class biology state assessment
High school GPA	Cumulative high school GPA as reported from P-210 research data
High school graduation status by 2016	A dummy variable identifying whether a student gained a high school diploma by end of 2015-2016 school year.
G8 math score	Standardized scale score of math test a student took in 8^{th} grade
G8 science score	Standardized scale score of science test a student took in 8^{th} grade
G7 math score	Standardized scale score of math test a student took in 7^{th} grade
G6 math score	Standardized scale score of math test a student took in 6^{th} grade
G5 math score	Standardized scale score of math test a student took in 5^{th} grade
G4 math score	Standardized scale score of math test a student took in 4^{th} grade
G3 math score	Standardized scale score of math test a student took in 3^{rd} grade

Application of Karlson-Holm-Breen (KHB) method

The generalized linear model with a logit link function used in the study is simplified as

$$\text{logit}(\Pr(Y=1))=b_{yx.z,w}X+ b_{yz.x,w}Z+ b_{ywi.x,z}W$$

where Y is a dichotomous outcome variable identifying whether or not a student earns any college STEM credit in 2017 academic year, X denotes high school course-taking in math and science, Z represents mediators or confounders from other pre-college academic performances/attainment, and W is for other covariates, such as student demographics and school program enrollments. $b_{yx.z,w}$ denotes the direct effect of X on Y, controlling for Z and W, refers to the indirect effect of Z on Y, controlling for X and W, and $b_{ywi,x,z}$ for the confounding effects from covariate w_i.

Appendix B. Supplemental Tables

Table B1. Summary statistics, by completeness of STEM pipeline variables

Variable	Study sample: STEM pipeline	STEM incomplete	Non-college going in 2017	Full
Dependent variable				
Earned college-level STEM credits in 2016-2017 academic year	.5085	.4697	N/A	.4911
Independent variable				
Demographics				
Female	.5233	.517	.4592	.4838
American Indian/Native American	.0091	.0124	.0209	.0167
Asian	.0947	.1217	.0446	.0696
African American	.0335	.0605	.0494	.0479
Hispanic	.1837	.1668	.2033	.1924
White	.6206	.5691	.6112	.6057
Other	.0584	.0695	.0706	.0677
School program participation				
Title I migrant	.0145	.0141	.0195	.0174
Bilingual	.0101	.0314	.0394	.0314
FRPL eligible	.3182	.3795	.4802	.4261
Limited English Proficiency	.0103	.0313	.0394	.0315
Special education	.0487	.0593	.1443	.1078
High school STEM course pathway				
Math: Low->Low	.0128	.0216	.0765	.0521
Math: Low->Standard	.0139	.0123	.0304	.0234
Math: Low->High	.0018	.0019	.0031	.0026
Math: Standard ->Low	.0111	.0393	.09	.0628
Math: Standard -> Standard	.2491	.2686	.3707	.3245
Math: Standard ->High	.2194	.2	.1268	.1611
Math: High-> Standard	.0831	.0812	.0788	.0802
Math: High->High	.4087	.3751	.2237	.2933
Number of credits earned in biology	.2126	.1088	-.1154	0
Number of credits earned in physics/chemistry	.3141	.203	-.1833	0
High school academic achievements				
Math test score	.5646	.4657	.3799	.4404
Biology test score	.388	.375	.095	.2179
GPA	.3667	.2925	-.227	0
High school graduation status by 2016	.9431	.836	.6212	.7311
Pre-high-school STEM achievement				
G8 math score	.3698	.3218	-.1117	.0847
G8 science score	.2765	.2266	-.1283	.0354
G7 math score	.3221	.3442	-.0972	.0856

Variable	Study sample: STEM pipeline	STEM incomplete	Non-college going in 2017	Full
G6 math score	.2782	.316	-.1199	.056
G5 math score	.2613	.2845	-.1064	.0549
G4 math score	.2741	.3634	-.0549	.0968
G3 math score	.2108	.3521	-.0857	.056
N	18,023	14,600	48,726	81,349

Table B2. Summary statistics, by whether or not earning college STEM credit in 2017

Variable	Earned STEM credit	Did not earn STEM credit
Demographics		
Female	0.54	0.51
	(0.50)	(0.50)
American Indian/Native American	0.01	0.01
	(0.07)	(0.11)
Asian	0.13	0.06
	(0.33)	(0.24)
African American	0.02	0.04
	(0.16)	(0.20)
Hispanic	0.15	0.22
	(0.35)	(0.42)
White	0.64	0.60
	(0.48)	(0.49)
Other race/ethnicity	0.06	0.06
	(0.23)	(0.24)
School program participation		
Title I migrant	0.01	0.02
	(0.10)	(0.13)
Bilingual	0.00	0.02
	(0.06)	(0.13)
FRPL eligible	0.25	0.39
	(0.43)	(0.49)
Limited English Proficiency	0.00	0.02
	(0.06)	(0.13)
Special education	0.02	0.08
	(0.12)	(0.28)
High school STEM course pathway		
Math: Low -> Low	0.00	0.03
	(0.03)	(0.16)
Math: Low- > Standard	0.00	0.02
	(0.06)	(0.15)

Variable	Earned STEM credit	Did not earn STEM credit
Math: Low -> High	0.00	0.00
	(0.03)	(0.05)
Math: Standard -> Low	0.00	0.02
	(0.05)	(0.14)
Math: Standard -> Standard	0.13	0.37
	(0.34)	(0.48)
Math: Standard -> High	0.22	0.22
	(0.41)	(0.42)
Math: High -> Standard	0.08	0.09
	(0.27)	(0.28)
Math: High -> High	0.56	0.25
	(0.50)	(0.43)
Number of credits earned in Biology	0.30	0.12
	(0.98)	(0.91)
Number of credits earned in physics/chemistry	0.60	0.02
	(0.99)	(0.89)
High school academic achievements		
Math score in high school	0.71	0.41
	(0.56)	(0.64)
Biology score	0.52	0.25
	(0.47)	(0.49)
GPA	0.64	0.08
	(0.80)	(0.75)
High school graduation status by 2016	0.99	0.90
	(0.11)	(0.30)
Pre-high-school STEM achievements		
G8 math score	0.69	0.04
	(0.78)	(0.74)
G8 science score	0.47	0.08
	(0.55)	(0.61)
G7 math score	0.60	0.04
	(0.73)	(0.74)
G6 math score	0.53	0.02
	(0.69)	(0.71)
G5 math score	0.48	0.03
	(0.66)	(0.73)
G4 math score	0.48	0.06
	(0.63)	(0.69)
G3 math score	0.39	0.03
	(0.57)	(0.72)
N	9,164	8,859

Standard deviations in parentheses.

Table B3a. Decomposition of total effect of high school STEM course taking patterns on earning college STEM credit into direct and indirect effects, via pre-high-school STEM outcomes, controlling for students' demographics

		Model
Key variables	Logit	Logit-APE
Math path 1: low->low:		
Total effect	-1.467***	-0.269***
	(-4.07)	(-4.08)
Direct effect	-0.971**	-0.178**
	(-2.69)	(-2.69)
Indirect effect	-0.496**	-0.0908
	(-2.74)	(.)
Math path 2: low-> standard:		
Total effect	-0.387*	-0.0708*
	(-2.01)	(-2.01)
Direct effect	-0.150	-0.0274
	(-0.78)	(-0.78)
Indirect effect	-0.237	-0.0434
	(-1.33)	(.)
Math path 3: low->high:		
Total effect	0.110	0.0201
	(0.26)	(0.26)
Direct effect	0.226	0.0414
	(0.53)	(0.53)
Indirect effect	-0.116	-0.0213
	(-0.65)	(.)
Math path 4: standard-> low:		
Total effect	-0.990***	-0.181***
	(-3.63)	(-3.63)
Direct effect	-0.237	-0.0434
	(-0.87)	(-0.87)
Indirect effect	-0.752***	-0.138
	(-4.12)	(.)
Math path 6: standard-> high:		
Total effect	0.869***	0.159***
	(17.05)	(17.59)
Direct effect	0.529***	0.0969***
	(10.40)	(10.53)
Indirect effect	0.339	0.0621
	(1.90)	(.)
Math path 7: high-> standard:		
Total effect	1.072***	0.196***
	(15.75)	(16.16)
Direct effect	0.207**	0.0380**
	(2.81)	(2.82)

	Model	
Key variables	Logit	Logit-APE
Indirect effect	0.865***	0.158
	(4.78)	(.)
Math path 8: high-> high:		
Total effect	1.687***	0.309***
	(35.27)	(40.83)
Direct effect	0.650***	0.119***
	(11.83)	(12.03)
Indirect effect	1.036***	0.190
	(5.71)	(.)
Number of credits earned in biology		
Total effect	0.184***	0.0337***
	(9.54)	(9.62)
Direct effect	0.105***	0.0192***
	(5.46)	(5.47)
Indirect effect	0.0790	0.0145
	(0.44)	(.)
Number of credits earned in physics/chemistry		
Total effect	0.523***	0.0957***
	(25.91)	(27.76)
Direct effect	0.361***	0.0661***
	(17.97)	(18.57)
Indirect effect	0.162	0.0296
	(0.91)	(.)
Confounding Ratio_math path 1	1.511	1.511
Confounding Percent_math path 1	33.81	33.81
Confounding Ratio_math path 2	2.583	2.583
Confounding Percent_math path 2	61.28	61.28
Confounding Ratio_math path 3	0.486	0.486
Confounding Percent_math path 3	-105.7	-105.7
Confounding Ratio_math path 4	4.170	4.170
Confounding Percent_math path 4	76.02	76.02
Confounding Ratio_math path 6	1.641	1.641
Confounding Percent_math path 6	39.07	39.07
Confounding Ratio_math path 7	5.171	5.171
Confounding Percent_math path 7	80.66	80.66
Confounding Ratio_math path 8	2.594	2.594
Confounding Percent_math path 8	61.45	61.45
Confounding Ratio_credits earned in biology	1.752	1.752
Confounding Percent_credits earned in biology	42.93	42.93
Confounding Ratio_credits earned in physics/chemistry	1.448	1.448
Confounding Percent_credits earned in physics/chemistry	30.93	30.93
N	17,800	17,800

z statistics in parentheses; APE: average partial effect; FE: fixed-effect model; math pathway reference group= standard-> standard; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B3b. Decomposition of total effect of high school STEM course-taking pathways on earning college STEM credit into direct and indirect effects, via pre-high-school STEM outcomes, controlling for students' demographics (coefficients transformed into *odds ratio*)

		Model
Key variables	Logit	Logit-APE
Math path 1: low->low:		
Total effect	0.231***	0.765***
	(-4.07)	(-4.08)
Direct effect	0.379**	0.837**
	(-2.69)	(-2.69)
Indirect effect	0.609**	0.913
	(-2.74)	(.)
Math path 2: low-> standard		
Total effect	0.679*	0.932*
	(-2.01)	(-2.01)
Direct effect	0.861	0.973
	(-0.78)	(-0.78)
Indirect effect	0.789	0.958
	(-1.33)	(.)
Math path 3: low->high		
Total effect	1.116	1.020
	(0.26)	(0.26)
Direct effect	1.254	1.042
	(0.53)	(0.53)
Indirect effect	0.890	0.979
	(-0.65)	(.)
Math path 4: standard-> low		
Total effect	0.372***	0.834***
	(-3.63)	(-3.63)
Direct effect	0.789	0.957
	(-0.87)	(-0.87)
Indirect effect	0.471***	0.871
	(-4.12)	(.)
Math path 6: standard-> high		
Total effect	2.383***	1.172***
	(17.05)	(17.59)
Direct effect	1.698***	1.102***
	(10.40)	(10.53)
Indirect effect	1.404	1.064
	(1.90)	(.)
Math path 7: high-> standard		
Total effect	2.922***	1.217***
	(15.75)	(16.16)
Direct effect	1.230**	1.039**
	(2.81)	(2.82)
Indirect effect	2.375***	1.172
	(4.78)	(.)

	Model	
Key variables	Logit	Logit-APE
Math path 8: high-> high		
Total effect	5.401***	1.362***
	(35.27)	(40.83)
Direct effect	1.916***	1.126***
	(11.83)	(12.03)
Indirect effect	2.819***	1.209
	(5.71)	(.)
Number of credits earned in biology		
Total effect	1.202***	1.034***
	(9.54)	(9.62)
Direct effect	1.111***	1.019***
	(5.46)	(5.47)
Indirect effect	1.082	1.015
	(0.44)	(.)
Number of credits earned in physics/chemistry		
Total effect	1.687***	1.100***
	(25.91)	(27.76)
Direct effect	1.435***	1.068***
	(17.97)	(18.57)
Indirect effect	1.176	1.030
	(0.91)	(.)
Decomposition of effects		
Confounding Ratio_math path 1	1.511	
Confounding Percent_math path 1	33.81	
Confounding Ratio_math path 2	2.583	
Confounding Percent_math path 2	61.28	
Confounding Ratio_math path 3	0.486	
Confounding Percent_math path 3	-105.7	
Confounding Ratio_math path 4	4.170	
Confounding Percent_math path 4	76.02	
Confounding Ratio_math path 6	1.641	
Confounding Percent_math path 6	39.07	
Confounding Ratio_math path 7	5.171	
Confounding Percent_math path 7	80.66	
Confounding Ratio_math path 8	2.594	
Confounding Percent_math path 8	61.45	
Confounding Ratio_credits earned in biology	1.752	
Confounding Percent_credits earned in biology	42.93	
Confounding Ratio_credits earned in physics/chemistry	1.448	
Confounding Percent_credits earned in physics/chemistry	30.93	
N	17,800	17,800

Exponentiated coefficients are presented as odds ratio in models; z statistics in parentheses; APE: average partial effect; FE: fixed-effect model; math pathway reference group= standard-> standard; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B4. Components of difference attributable to pre-college academic performances

Variable	Coef	Std_Err	% contribution of mediator to indirect effect	% total effect explained by confounders
Math 1: Low->Low				
High school math test score	-0.001	0.002	0.56	0.19
High school science test score	-0.010	0.005	10.73	3.63
High school GPA	0.003	0.006	-2.86	-0.97
High school graduate by 2016	-0.026	0.007	28.66	9.69
G8 math score	-0.041	0.006	45.37	15.34
G8 science score	-0.001	0.004	1.59	0.54
G7 math score	-0.003	0.004	3.04	1.03
G6 math score	-0.018	0.005	19.34	6.54
G5 math score	-0.001	0.004	0.68	0.23
G4 math score	-0.007	0.004	7.21	2.44
G3 math score	0.013	0.005	-14.33	-4.85
Total			100.00	33.81
Math 2: Low-> Standard				
High school math test score	-0.001	0.001	1.24	0.76
High school science test score	-0.004	0.002	8.86	5.43
High school GPA	0.001	0.004	-1.37	-0.84
High school graduate by 2016	0.001	0.004	-3.21	-1.96
G8 math score	-0.027	0.004	63.3	38.79
G8 science score	-0.001	0.002	2.01	1.23
G7 math score	-0.002	0.003	4.23	2.59
G6 math score	-0.013	0.003	29.03	17.79
G5 math score	0.000	0.003	1.12	0.69
G4 math score	-0.004	0.003	9.48	5.81
G3 math score	0.006	0.003	-14.7	-9.01
Total			100.00	61.28
Math 3: Low->High				
High school math test score	0.000	0.003	0.67	-0.7
High school science test score	-0.007	0.004	30.75	-32.5
High school GPA	0.015	0.010	-70.61	74.62
High school graduate by 2016	0.001	0.009	-5.06	5.35
G8 math score	-0.022	0.007	101.59	-107.36
G8 science score	-0.001	0.002	4.04	-4.27
G7 math score	-0.001	0.002	6.48	-6.85
G6 math score	-0.009	0.004	42.89	-45.33
G5 math score	0.000	0.001	0.83	-0.88
G4 math score	-0.001	0.002	6.41	-6.78
G3 math score	0.004	0.003	-17.99	19.01

Variable	Coef	Std_Err	% contribution of mediator to indirect effect	% total effect explained by confounders
Total			100.00	-105.7
Math 4: Standard ->Low				
High school math test score	-0.007	0.002	5.06	3.84
High school science test score	-0.010	0.003	7.44	5.65
High school GPA	-0.034	0.008	24.53	18.65
High school graduate by 2016	-0.060	0.010	43.41	33
G8 math score	-0.019	0.004	14.03	10.67
G8 science score	-0.001	0.002	0.51	0.39
G7 math score	-0.001	0.002	0.93	0.71
G6 math score	-0.007	0.002	5.31	4.04
G5 math score	0.000	0.001	0.16	0.12
G4 math score	-0.002	0.001	1.2	0.91
G3 math score	0.004	0.002	-2.58	-1.96
Total			100.00	76.02
Math 6: Standard ->High				
High school math test score	0.003	0.001	4.39	1.71
High school science test score	0.003	0.001	5.27	2.06
High school GPA	0.028	0.002	44.62	17.43
High school graduate by 2016	0.013	0.002	20.96	8.19
G8 math score	0.010	0.001	16.89	6.6
G8 science score	0.000	0.001	0.49	0.19
G7 math score	0.001	0.001	1.38	0.54
G6 math score	0.004	0.001	6.32	2.47
G5 math score	0.000	0.001	0.16	0.06
G4 math score	0.001	0.001	1.45	0.57
G3 math score	-0.001	0.001	-1.92	-0.75
Total			100.00	39.07
Math 7: High-> Standard				
High school math test score	0.008	0.002	5.32	4.29
High school science test score	0.012	0.002	7.5	6.05
High school GPA	0.044	0.003	27.98	22.57
High school graduate by 2016	0.005	0.002	3.16	2.55
G8 math score	0.065	0.008	40.91	33
G8 science score	0.002	0.004	0.96	0.77
G7 math score	0.004	0.006	2.65	2.13
G6 math score	0.020	0.005	12.71	10.25
G5 math score	0.001	0.004	0.44	0.35
G4 math score	0.006	0.004	4.05	3.27
G3 math score	-0.009	0.003	-5.68	-4.58
Total			100.00	80.66

Variable	Coef	Std_Err	% contribution of mediator to indirect effect	% total effect explained by confounders
Math 8: High->High				
High school math test score	0.012	0.002	6.09	3.74
High school science test score	0.014	0.002	7.4	4.55
High school GPA	0.053	0.003	28.19	17.33
High school graduate by 2016	0.013	0.002	6.74	4.14
G8 math score	0.071	0.008	37.23	22.88
G8 science score	0.002	0.004	0.83	0.51
G7 math score	0.005	0.007	2.46	1.51
G6 math score	0.023	0.006	11.86	7.29
G5 math score	0.001	0.005	0.41	0.25
G4 math score	0.007	0.005	3.76	2.31
G3 math score	-0.009	0.004	-4.98	-3.06
Total			100.00	61.45
Number of credits earned in biology				
High school math test score	0.001	0.000	4.64	1.99
High school science test score	0.001	0.000	5.47	2.35
High school GPA	0.008	0.001	58.46	25.1
High school graduate by 2016	0.004	0.001	28.55	12.26
G8 math score	0.001	0.000	4.47	1.92
G8 science score	0.000	0.000	0.42	0.18
G7 math score	0.000	0.000	-0.06	-0.03
G6 math score	0.000	0.000	-1.65	-0.71
G5 math score	0.000	0.000	0.06	0.02
G4 math score	0.000	0.000	-0.46	-0.2
G3 math score	0.000	0.000	0.09	0.04
Total			100.00	42.93
Number of credits earned in physics/chemistry				
High school math test score	0.004	0.001	11.84	3.66
High school science test score	0.004	0.001	12.26	3.79
High school GPA	0.006	0.001	21.87	6.76
High school graduate by 2016	0.005	0.001	18.12	5.61
G8 math score	0.007	0.001	24.37	7.54
G8 science score	0.000	0.001	0.85	0.26
G7 math score	0.001	0.001	1.94	0.6
G6 math score	0.003	0.001	9.13	2.82
G5 math score	0.000	0.000	0.27	0.08
G4 math score	0.001	0.001	2.73	0.84
G3 math score	-0.001	0.000	-3.37	-1.04
Total			100.00	30.93

Math pathway reference group= standard-to-standard

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