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Can Dual Enrollment Algebra Reduce Racial/Ethnic Gaps in Early STEM Outcomes? Evidence from Florida

Summary Research Report

Veronica Minaya

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Address correspondence to:

Veronica Minaya
Senior Research Associate
Community College Research Center
Teachers College, Columbia University
525 W. 120th St., Box 174
New York, NY 10027
212-678-3091
Email: vmm2122@tc.columbia.edu

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Abstract

Math is an integral subject in nearly all STEM disciplines, and early exposure to advanced math coursework may encourage high school students to enter and persist in STEM fields in college. This report examines whether taking college algebra through dual enrollment affects high school graduation, college enrollment, and early STEM outcomes. I use a fuzzy regression discontinuity methodological design and rich transcript-level data on one cohort of Florida public high school students tracked post-high school into Florida community colleges and universities to estimate the effects of taking dual enrollment algebra. I find that—among students on the margin of eligibility—taking dual enrollment algebra increases the likelihood that students enroll in a STEM program in college. I also find particularly strong effects on beginning college and persisting in college as a STEM major for Black and Hispanic students. I fail to detect an effect on overall rates of high school graduation and college enrollment. Broadly, these results suggest that encouraging Black and Hispanic students to take college-level math courses in high school may help to advance equity in STEM fields.

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1. Introduction and Overview

Racial/ethnic disparities in rates of undergraduate degree completion in science, technology, engineering, and math (STEM) fields are stark. Studies frequently find that Black and Hispanic students leave STEM programs at higher rates than White students (Anderson & Kim, 2006; Hill et al., 2010; Griffith, 2010; Huang et al., 2000; Kokkelenberg & Sinha, 2010; Shaw & Barbuti, 2010).[1] Since STEM degrees yield higher earnings returns than degrees in other fields of study (Altonji et al., 2012; Altonji et al., 2014) and because STEM jobs are expected to grow faster than non-STEM jobs,[2] high attrition rates in STEM programs among Black, Hispanic, and other underserved students may continue to contribute to broad racial/ethnic wage gaps across the nation (Gerber & Cheung, 2008).

Black and Hispanic students are as likely to enter STEM majors as their White peers (Garrison, 2013; Riegle-Crumb & King, 2010; Xie, Fang, & Shauman, 2015), but they are less likely to complete STEM degrees. Griffith (2010) argues that differences in preparation and the educational experiences of students explain much of this race/ethnicity persistence gap, as Black and Hispanic students often lack the opportunity to participate in advanced math coursework and develop their academic potential in terms of STEM skills. Students entering with better pre-college preparation are more likely to persist in and graduate with a STEM degree (Arcidiacono et al., 2016).

One way to narrow racial/ethnic disparities in STEM skills is to expose underserved students to advanced math coursework in high school through dual enrollment.[3] Dual enrollment has existed as a college acceleration opportunity for decades (Andrews & Marshall, 1991; Gerber, 1987; Mokher & McLendon, 2009) and has grown substantially since the 1990s, as educators and policymakers have sought ways to

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[1] The gap in STEM attrition rates between students from different racial/ethnic groups is very large. One third of White students and 42% of Asian-American students who started college as intended STEM majors graduated with STEM degrees within five years of entry, compared to 22% of Hispanic students, 18% of Black students, and 20% of Native American students (Higher Education Research Institute, 2010).
[2] The Bureau of Labor Statistics projects that STEM jobs will grow 9% between 2018 and 2028, faster than non-STEM jobs (5%).
[3] Dual enrollment (DE) is a type of course offering that enables high school students to enroll in a college course and earn both high school and collegiate credit simultaneously (Tobolowsky & Allen, 2016). After advanced placement courses, dual enrollment courses are the most common means by which high school students in the United States can earn college credit, with 1.4 million students participating in dual enrollment in 2010-11 (College Board, 2017).

improve the college readiness of high school graduates, lower the costs and debt burden of college (Karp, 2012), and motivate and engage high school students by exposing them to academically rigorous courses (An & Taylor, 2019). Descriptive and quasi-experimental empirical studies have documented that taking dual enrollment courses is associated with higher rates of college-going and credits attempted in the first semester of college, as well as better long-term outcomes such as college persistence and degree attainment (e.g., Allen & Dadgar, 2012; An, 2013; Berger et al., 2014; Blankenberger et al., 2017; Edmunds et al., 2020; Giani et al. 2014; Jones, 2014; Struhl & Vargas, 2012).

Participating in and completing college-level math coursework in high school may help students to improve their academic pre-college preparation and spur their interest in STEM fields, particularly for Black, Hispanic, and other underserved students. In fact, recent rigorous studies have found that taking dual enrollment math courses affects college choice (Hemelt et al., 2019) and improves college readiness and graduation rates (Speroni, 2011; Dougherty et al., 2017). Yet, there is no prior empirical work evaluating the effects of taking dual enrollment algebra on postsecondary STEM outcomes or on how these effects vary by race/ethnicity. In this report, I use longitudinal data on public students in Florida to examine whether enrolling in college-level algebra through dual enrollment affects high school graduation, college enrollment, and early STEM outcomes. I also examine whether Black and Hispanic students (combined into one group, called Underrepresented Minority [URM] students, for this analysis[4]) benefit from dual enrollment algebra differently than White students. I focus on dual enrollment algebra because this gateway course not only prepares students for more advanced math courses but also satisfies general education requirements and Florida's statewide requirements for an associate degree; it is also a requirement for entry into upper-division coursework at Florida public universities.

I use an administrative dataset with rich data—including student demographic and high school and college transcript information—on a cohort of students who were ninth-graders at Florida public high schools in 2007-08 and who took the math section of the state's college placement test (CPT). Students must earn a minimum score on the math

[4] I combine data on Black and Hispanic students (URM students) to maintain a large enough sample size to infer causality for such students in the regression discontinuity analysis.

section of the CPT (hereafter CPT math) to be eligible to take dual enrollment algebra. Using a fuzzy regression discontinuity design (FRDD), I exploit discontinuities in CPT math scores to test whether very similar students who do and do not take dual enrollment algebra experience different outcomes. Results suggest that taking dual enrollment algebra increases students' interest in pursuing a STEM major in college. I also find particularly strong effects on beginning and persisting in college as a STEM major for Black and Hispanic (URM) students. These results provide evidence that expanding access to dual enrollment algebra for Black and Hispanic students may be part of a useful strategy for reducing racial/ethnic disparities in STEM postsecondary education and employment.

1.1 Study Setting and Research Questions

The Community College Research Center partnered with the Florida Department of Education (FDOE) to examine the effects of taking college-level algebra through dual enrollment on high school graduation, college enrollment, and early STEM outcomes, as well as on how these effects vary by race/ethnicity (comparing outcomes of White students to those of URM students). Florida's academic dual enrollment program allows 6th to 12th graders to simultaneously earn credits toward high school graduation and an associate or bachelor's degree at a Florida public postsecondary institution. Dual enrollment algebra satisfies Florida requirements for a transfer-oriented associate degree and is a requirement for entry into the upper division of bachelor's degree programs at Florida public universities. To be eligible for dual enrollment algebra in Florida, students must have an unweighted GPA of at least 3.0 and a passing minimum score on the state's CPT math. These requirements largely limit participation in dual enrollment algebra to high-achieving college-ready students.

This study does not examine students who took dual enrollment algebra through Early and Middle College High School programs;[5] rather, it considers only students who took dual enrollment algebra in their junior or senior year of high school as dual

[5] These programs are also called collegiate high schools in Florida. There is strong evidence of effectiveness for students generally and underrepresented students in particular in EMCHS programs (What Works Clearinghouse, 2017), but these programs involve a coherent curriculum, advising, and other supports not typically available to students taking discrete dual enrollment courses.

enrollment algebra participants. I focus on this more common type of discrete dual enrollment course-taking because it represents the most popular dual credit delivery model in the state and thus has a greater potential to reach a broad range of students. Dual enrollment participation in the Florida College System has grown by 12% in recent years, from 50,054 students in 2011-12 to 56,245 students in 2015-16 (Florida Department of Education, 2016). About 7% of all Florida high school students (Fink, 2018), or perhaps a bit more, thus participate in dual enrollment currently.

This report shares findings on the characteristics of students in the study cohort who took dual enrollment algebra in Florida and the effects of dual enrollment algebra (hereafter, DE algebra) on high school graduation, college enrollment, and early STEM outcomes for students overall and by racial/ethnic group. The study addresses the following research questions:

1. Do the characteristics of Florida students who took DE algebra differ from those who did not? Do DE algebra participants have, on average, better college outcomes than non-participants?
2. What is the impact of DE algebra course-taking on high school graduation and college enrollment outcomes?
3. What is the impact of DE algebra on choice of major and early STEM outcomes? Are these effects heterogeneous across different racial/ethnic groups?

To answer these questions, I conduct a descriptive analysis and a rigorous, quasi-experimental FRDD analysis of administrative data collected by the FDOE on the demographic characteristics, college placement test scores, transcript information, and high school and college outcomes of students who were enrolled in a Florida public high school as ninth-graders 2007-08 and who took the math section of Florida's CPT. Students who took the CPT math were, on average, better prepared academically than other students.[6] Eligibility to take DE algebra is based on students' scores on the math CPT; in the FRDD analysis, I estimate the effect of taking DE algebra in grades 11-12 by

[6] As shown in the Appendix Table 1, high school students who took the CPT math were more likely to be female, White, U.S. citizens, and from a more affluent background than those who did not take the CPT math. The average student in the CPT math sample also had a higher cumulative GPA in ninth grade and was substantially more likely to participate in DE than non-test-takers (67% versus 9%).

comparing outcomes of those who scored just above and just below the CPT cutoff for eligibility.

1.2 Key Findings and Limitations

Descriptive statistics for DE algebra participants and non-participants. It is important to recognize that all of the descriptive findings that follow compare raw numbers of particular kinds of students who took the CPT math and their outcomes; the findings do not control for any student characteristics. It is also worth noting that DE algebra non-participants may have enrolled in other DE courses, including other DE math courses.[7]

- DE algebra participants were more likely than non-participants to be White, native English speakers, from more affluent backgrounds, and to attend predominantly White schools. White students made up the majority of DE algebra participants (76%); Black and Hispanic students constituted an additional 9% and 11%, respectively. Participants were about half as likely as non-participants to have limited English proficiency (LEP) and about a third less likely to receive free or reduced-price lunch (FRPL).

- DE algebra participants were substantially more academically prepared than non-participants. Given these differences in academic preparation, it is not surprising that DE algebra participants were more likely than non-participants to experience positive high school and college outcomes.

- White and URM DE algebra participants enrolled in and graduated from college at similar rates. In contrast, White non-participants had better college outcomes than URM non-participants. White non-participants were 6 percentage points more likely than URM non-participants to enroll in college, 5 percentage points more likely to persist from fall to spring in their first year, 12 percentage points less likely to take a remedial math course, 9 percentage points more likely to earn a bachelor's degree, and 6 percentage points more likely to complete an associate degree.

[7] Note that non-participants are students who took CPT math but did not participate in DE algebra in grades 11-12. Almost 60% of non-participants took other DE courses in grades 11-12; half of them enrolled in DE English, 11% took other DE math courses (i.e., intermediate algebra, calculus, or statistics), and 14% took DE courses in other subjects.

- DE algebra participants were twice as likely as non-participants to choose a STEM major at college entry and to persist in STEM from fall to spring in their first year of college; the differences were smaller among White students and larger among URM students.

- DE algebra participants graduated with a bachelor's or associate STEM degree at a higher rate than non-participants (9% versus 5%).

Effects of DE algebra on high school graduation and college enrollment outcomes. The findings in this and the next subsection are based on the quasi-experimental FRDD analysis. They consider only those students on the cusp of eligibility for participation in DE algebra.

- Taking DE algebra increased cumulative GPAs in grade 12, but taking DE algebra did not significantly affect on-time high school graduation.

- Taking DE algebra did not significantly affect college enrollment or the choice to attend a community college (which in Florida is called a state college) or a state university.

Effects of DE algebra on choice of major and early STEM outcomes.

- Taking DE algebra increased the likelihood of declaring a STEM major at college entry; the overall effects on STEM persistence are imprecise and insignificant.

- The effects of DE algebra on early STEM outcomes are driven only by URM students. Taking DE algebra increased the likelihood that URM students would choose a STEM major at entry and persist in their intent to major in STEM, but it did not induce White students to choose a STEM major.

Limitations. This is the first study to estimate the effects of participating in DE algebra on early STEM outcomes and to examine if these effects vary by race/ethnicity. However, it is important to note that the descriptive and FRDD analyses are limited to high-achieving students who were likely interested in participating in DE algebra in grades 11-12 and therefore took the math section of Florida's CPT. Furthermore, since in the FRDD analyses I estimate the effects of taking DE algebra only for students near the

CPT cutoff, these results provide limited evidence regarding the effects of DE algebra for higher- or lower-achieving students. Finally, given that I observe only high school students who attended in-state public colleges, college outcomes are censored for students who did not attend Florida public institutions.

1.3 Organization of This Report

The remainder of this report is organized as follows: Section 2 describes the data and empirical methodology used in this report. Section 3 provides a detailed descriptive analysis of student characteristics and academic outcomes. Section 4 presents the FRDD results. Section 5 concludes the report by discussing the main findings.

2. Data and Method

2.1 Data and Sample

This report uses FDOE data on all public high school students in the state who were ninth-graders in 2007-08 and who took the CPT math and tracks their postsecondary outcomes in the state's public education system through 2016-17. The state's administrative records provide students' demographic, degree, and transcript information on courses taken and grades received in high school and college.[8] The data include CPT scores as well as basic demographic information such as gender, race/ethnicity, age, U.S. citizenship, English language proficiency, and free and reduced lunch eligibility. School characteristics including school urbanicity, enrollment by race/ethnicity and free and reduced lunch eligibility in 10th grade, average reading and math Florida Comprehensive Assessment Test (FCAT) scores in 10th grade, and high school distance to the nearest college are obtained from 2008 Common Core Data, Florida Data Archives, and the Integrated Postsecondary Education Data System (IPEDS). District characteristics such as median household income are obtained from the American Community Survey.

[8] It is important to note that the college data include only students who attended community colleges (known as state colleges in Florida) and state universities. Therefore, students who attended private and out-of-state institutions are not included in the college data.

Strengths of these data include the detail of the college placement and academic records, which track students from ninth grade up to six years after their 12th-grade year as they transition from high school to college. The data also contain students' placement records—including test scores, subtests, and dates—as well as a unique identifier for DE courses from both high school and college transcripts. The main weakness of these data is that the postsecondary enrollment of students cannot be tracked if they enroll in out-of-state colleges or private institutions.

To be eligible for DE in Florida, students are required to have a minimum unweighted GPA of 3.0 and to earn a minimum-or-higher score on the math section of a common placement test, which is used to indicate that a student is ready for college-level coursework (Florida Statute 1007.271, 2010). Before October 2010, Florida used the ACCUPLACER/College Placement Test (CPT) for placement into college credit-bearing courses.[9] The FRDD analysis in this study exploits the course-specific CPT math score requirement for participation in college algebra. The CPT cutoff scores for placement into the college algebra course are obtained from college catalogs or, when unavailable, from state documentation on placement scores (Florida Department of Education, Articulation Coordinating Committee, 2006). Appendix Table A.2 provides a list of cutoff scores for placement into college algebra by college.[10]

I focus on DE participation in college algebra in grades 11 and 12 because that is when most Florida DE students enroll in DE courses. College algebra is a review of algebra designed to prepare students for more advanced math courses; it covers solving inequalities, linear and quadratic equations, complex numbers, and graphing functions. This challenging course satisfies the Florida math requirement for a transfer associate

[9] Even though SAT or ACT scores were also allowed for placement, I exploit only the variation in participation that comes from the discontinuity in CPT scores. The CPT is the most common test taken to participate in DE and where most of the variation in participation at the discontinuity is observed. Among all public school students in the 2007-08 high school freshman cohort who took DE algebra in grades 11-12 (6,196 students), 45% have CPT math scores, 17% have SAT math scores, and 14% have ACT math scores in the data. It is worth noting that the Florida College System institutions began administering the Postsecondary Education Readiness Test (PERT) in October 2010 as the new common placement test. The PERT was expected to be used as the primary college placement tool beginning with the academic year 2010-11, although the CPT was still accepted in some school districts.

[10] Six postsecondary institutions are excluded from the descriptive and FRDD analyses because these institutions used the same cutoff to determine eligibility to participate in both DE algebra and math remediation.

degree and is a requirement prior to entry into upper-division coursework at Florida public universities. I restrict the sample to students who enrolled in high school in both ninth and 10th grades, had no DE participation before 11th grade, and remained enrolled in high school through 11th grade.[11] The sample is also restricted to students who took the CPT math for the first time in grades 11 or 12 and thus likely intended to use these scores to become eligible to take DE algebra. The empirical approach in this report is to include in the sample all students and assign a value of zero on high school and college outcomes for students who did not graduate from high school on time and did not go to college.

2.2 Empirical Methodology

I first undertake a descriptive analysis of student characteristics and outcomes for DE algebra participants and non-participants for both the full sample of CPT math test takers and for the two race/ethnicity groups—URM students, who are Black and Hispanic students, and White students. I then use a Fuzzy Regression Discontinuity Design (FRDD) to estimate the causal effects of participating in DE algebra in grades 11 and 12 for students near the CPT cutoff, using normalized CPT scores as a forcing variable.[12] I compare outcomes for students with CPT normalized scores just below the CPT cutoff for college algebra to outcomes for students with normalized CPT scores just above the cutoff.

The logic behind using the FRDD is that students with normalized CPT scores very close to the cutoff on either side are comparable in terms of their observable and unobservable determinants of high school, college, and STEM outcomes, but those just above the cutoff are more likely to take DE algebra in their junior and senior years. In FRDD, threshold-crossing causes a discontinuity jump in the probability of taking a DE algebra course, but this jump is not from zero to one. The idea is that some students with normalized CPT scores below the cutoff participate in DE algebra and some students with scores above the cutoff do not. FRDD assumes that the potential outcomes of students just above the cutoff point would be similar to the outcomes of students just

[11] I also exclude schools that did not offer 11th or 12th grade; special education, alternative, virtual, and juvenile justice schools; schools with fewer than 15 students; and schools with 0% or 100% of DE students.
[12] The CPT math assesses basic mathematics competencies that are essential to perform college-level work. CPT math scores were normalized to use the zero cutoff on the normalized score for all observations.

below the cutoff point in the absence of DE participation. Thus, any "discontinuity" in the outcome measures at the cutoff can be attributed to the discontinuity in treatment effects of DE algebra.

3. Descriptive Analysis

This section describes the sample of CPT math test takers in grades 11 and 12 and presents a descriptive analysis of student characteristics and outcomes for DE algebra participants and non-participants by race/ethnicity group (White versus URM students).

3.1 Student Characteristics by Race/Ethnicity Group

Table 1 presents sample means for key variables in the full sample of ninth-graders who took the CPT math (8,921 students), the sample of students who took DE algebra in grades 11 and 12 (2,219 students), and the sample of those who did not take DE algebra (6,702 students). CPT test takers are disproportionately White, female, and from economically advantaged families (i.e., students who are less likely to receive free or reduced-price lunch [FRPL] and have limited English proficiency [LEP]). Among CPT test takers, 37% of students took DE algebra at 392 public high schools in 61 school districts in Florida.

In the sample, there are disparities in DE algebra participation across racial/ethnic groups and income. DE algebra students are more likely to be White, native English speakers, from a more affluent background, and to attend predominantly White schools than those who did not take DE algebra in high school. White students make up the majority of DE algebra participants in the CPT sample (76%), while Black and Hispanic students constitute an additional 9% and 11%, respectively. Students who took DE algebra were about half as likely to have LEP and 10 percentage points less likely to receive FRPL than those who did not take DE algebra.[13]

[13] Among URM students, the percentage of students with FRPL status was more than 50%, and about one quarter of these students had LEP. For White students, the corresponding figures are significantly lower, about 15% with FRPL status and 3% with LEP.

Table 1. Descriptive Statistics of CPT Test Takers by DE Algebra Participation

	All Test Takers	Took DE Algebra			Did Not Take DE Algebra		
		All	White	URM	All	White	URM
1. Student characteristics							
Female	0.62	0.61	0.60	0.63	0.62	0.62	0.64
White	0.61	0.76	1.00	0.00	0.56	1.00	0.00
Black	0.19	0.09	0.00	0.44	0.22	0.00	0.57
Hispanic	0.15	0.11	0.00	0.56	0.16	0.00	0.43
Age, ninth grade	15	14	14	14	15	15	15
LEP students	0.11	0.06	0.02	0.22	0.13	0.04	0.27
FRPL, ninth grade	0.29	0.21	0.13	0.50	0.32	0.17	0.56
U.S. citizen	0.90	0.94	0.96	0.84	0.89	0.93	0.83
Cum. GPA, ninth grade	3.10	3.46	3.47	3.43	2.99	3.12	2.77
Normalized first CPT math score	-0.13	0.06	0.07	0.06	-0.19	-0.14	-0.28
First CPT math score	75.54	94.12	94.36	93.18	69.47	74.91	60.69
2. School and district characteristics							
HS location:							
Town	0.07	0.09	0.09	0.12	0.06	0.08	0.04
Suburban	0.42	0.44	0.46	0.39	0.41	0.41	0.41
Rural	0.24	0.27	0.27	0.29	0.23	0.27	0.16
Urban	0.27	0.19	0.19	0.19	0.30	0.25	0.38
% of FRPL students in HS	0.37	0.34	0.32	0.42	0.37	0.33	0.44
% of White students in HS	0.55	0.65	0.70	0.46	0.52	0.63	0.35
% of Black students in HS	0.21	0.15	0.13	0.23	0.23	0.18	0.33
% of Hispanic students in HS	0.18	0.15	0.12	0.26	0.19	0.14	0.27
Total HS enrollment	875	881	821	1118	869	836	922
School distance to nearest college	5.90	6.41	6.59	5.71	5.73	6.71	4.15
School avg. FCAT math score	328.24	330.81	331.85	326.56	327.38	330.15	322.91
School avg. FCAT reading	308.94	313.91	315.98	305.53	307.30	312.21	299.34
Avg. household income in school district	$64,450	$62,425	$62,304	$62,909	$65,121	$64,323	$66,392
Number of students	8,921	2,219	1,686	447	6,702	3,753	2,564
Number of schools	573						
Number of school districts	70						

Note. Underrepresented minorities (URM) are Black and Hispanic students. Sample includes ninth-graders in 2007 in Florida and who were continuously enrolled through 11th grade in regular high schools. High schools with less than 15 students or with 0% or 100% of DE students are excluded. Sample consists of all high school junior and senior students who took the CPT for the first time between July 2009 and March 2011. Average high school percentage of FRPL; White, Black, Hispanic students in high school; and total high school enrollment are measured in ninth grade. Average FCAT scores are measured in 10th grade.

DE algebra participants were, on average, more academically prepared than non-participants. On a scale from 20 to 120 points, DE algebra participants scored an average of 94 points on the CPT math while non-participants scored 70 points.[14] DE algebra students, regardless of their racial/ethnic group, had higher ninth grade GPAs than their counterparts who did not take DE algebra (3.5 versus 3.0). White and URM participants were about equally prepared to take DE algebra. Given the differences in academic preparation between participants and non-participants, it is not surprising that DE algebra students were more likely to experience positive high school and college outcomes than those who did not take college algebra.

3.2 College and STEM Outcomes by Race/Ethnicity Group

Table 2 presents outcomes for DE algebra participants and non-participants. About 77% of students who took DE algebra immediately enrolled in college, while the corresponding enrollment rate for non-participants was 68%—a gap of 9 percentage points. Compared to non-participants, DE algebra participants were also substantially more likely to enroll in a university (43% versus 22%), less likely to attend a state college (Florida's equivalent of community colleges, 35% versus 46%), less likely to take a remedial course in college (1% versus 12% in English; 1% versus 19 % in math), and more likely to persist from fall to spring in their first year of college (74% versus 62%).

[14] The range of cutoff scores for DE algebra eligibility was between 83 and 98 in the sample of CPT math test takers in grades 11 and 12 (see Appendix Table A.2).

Table 2. Descriptive Statistics of Student Outcomes by DE Algebra Participation

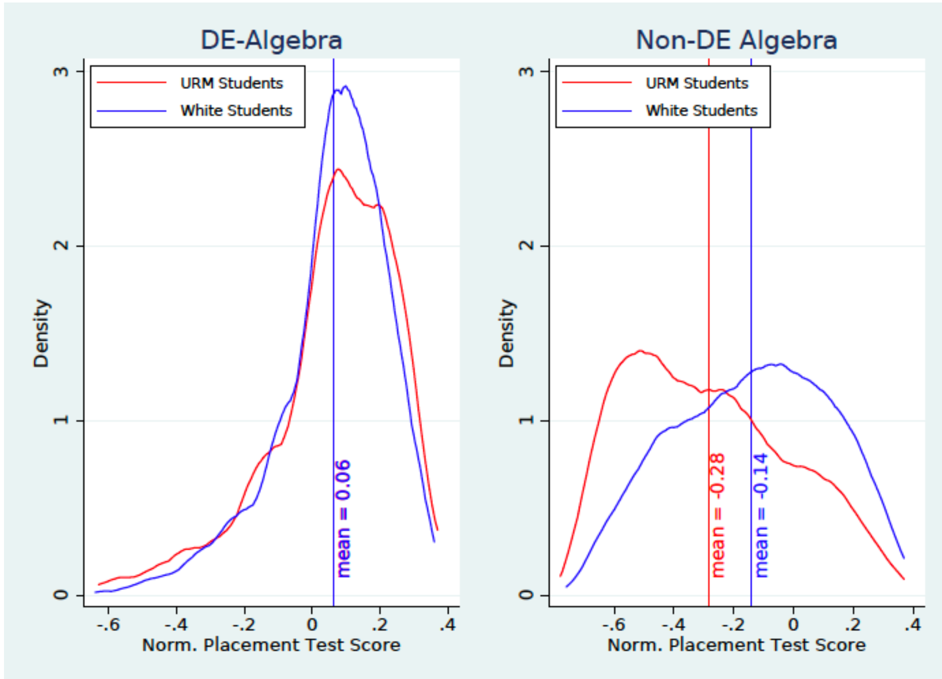
	All Test Takers	Took DE Algebra			Did Not Take DE Algebra		
		All	White	URM	All	White	URM
1. High school outcomes							
State cum. GPA, grade 12	3.06	3.26	3.31	3.09	2.99	3.11	2.81
On-time high school graduation	0.96	0.98	0.98	0.98	0.95	0.95	0.95
2. Year 1 college outcomes							
Immediate college enrollment	0.70	0.77	0.77	0.77	0.68	0.70	0.64
Immediate college enrollment in a state college	0.43	0.35	0.36	0.29	0.46	0.46	0.46
Immediate college enrollment in a university	0.27	0.43	0.41	0.49	0.22	0.24	0.19
Immediate full-time college enrollment	0.58	0.70	0.70	0.68	0.54	0.58	0.48
Transferred to a university	0.19	0.21	0.22	0.16	0.18	0.19	0.17
Persistence from fall to spring	0.65	0.74	0.74	0.73	0.62	0.64	0.59
Taken remedial English	0.09	0.01	0.00	0.02	0.12	0.07	0.20
Taken remedial Math	0.14	0.01	0.01	0.01	0.19	0.14	0.26
3. Year 1 STEM outcomes							
Enrolled in STEM, term 1 fall	0.08	0.12	0.11	0.15	0.06	0.07	0.05
Persisted in STEM from fall to spring	0.06	0.10	0.09	0.13	0.05	0.06	0.05
Enrolled in Non-STEM, Term 1 fall	0.22	0.31	0.31	0.31	0.19	0.19	0.17
Persisted in Non-STEM from fall to spring	0.19	0.28	0.28	0.28	0.16	0.16	0.14
Undeclared or undecided, term 1 fall	0.36	0.33	0.34	0.30	0.37	0.39	0.33
STEM credits attempted in UD courses, end of year 1	0	1	1	1	0	0	0
STEM credits attempted in LD courses, end of year 1	8	10	10	11	8	9	7
4. STEM and college attainment outcomes							
Earned a certificate within 3 years	0.03	0.04	0.04	0.04	0.03	0.03	0.02
Earned an associate degree within 3 years	0.27	0.36	0.36	0.38	0.24	0.26	0.20
Earned a bachelor's degree within 6 years	0.31	0.44	0.44	0.42	0.26	0.30	0.21
Earned any STEM degree	0.06	0.09	0.09	0.08	0.05	0.06	0.04
Number of students	8,921	2,219	1,686	447	6,702	3,753	2,564
Number of schools	573						
Number of school districts	70						

Note. Underrepresented minorities (URM) are Black and Hispanic students. Sample includes ninth-graders in 2007 in Florida who were continuously enrolled through 11th grade in regular high schools. High schools with less than 15 students or with 0% or 100% of DE students are excluded. Sample consists of all high school junior and senior students who took the CPT before 11th grade. College enrollment is measured in the fall after on-time high school graduation. Credits attempted in UD and LD courses refer to as upper-division and lower-division courses, respectively.

White and URM DE algebra students enrolled in and graduated from college at similar rates. In contrast, URM students who did not participate in DE algebra experienced much less desirable college outcomes compared to their White counterparts. Even though there were no significant differences in college enrollment (and full-time enrollment) between White and URM students who participated in DE algebra, White students were 7 percentage points more likely to enroll in a state college and 8 percentage points less likely to enroll in a university than their URM counterparts. As a result of these enrollment patterns, White students were also 6 percentage points more likely to transfer to a university. In terms of degree attainment, about 44% and 36% of White DE algebra participants earned a bachelor's degree in six years and an associate degree within three years of on-time high school graduation, respectively; the corresponding rates for URM students are 42% and 38%. Among those who did not participate in DE algebra, the descriptive analysis shows that White students were 6 percentage points more likely to immediately enroll in college, 5 percentage points more likely to persist from fall to spring in their first year, 12 percentage points less likely to take a remedial math course, 9 percentage points more likely to earn a bachelor's degree, and 6 percentage points more likely to complete an associate degree than their URM counterparts.

As previously noted, the disparities between White and URM students in college enrollment and graduation outcomes are consistent with their CPT math test score distributions for both DE algebra participants and non-participants. Figure 1 shows the distribution of normalized CPT math scores by race/ethnicity group for those who took and did not take DE algebra in high school. While White and URM DE algebra students have a similar test score distribution, White students who did not take DE algebra had higher CPT scores than their URM counterparts.

Figure 1. Distribution of Normalized CPT Math Scores by Race/Ethnicity Group



Note. Sample includes ninth-graders in 2007 in Florida who were continuously enrolled through 11th grade in regular high schools. High schools with less than 15 students or with 0% or 100% of DE students are excluded. Sample consists of all high school junior and senior students who took the CPT before 11th grade.

DE algebra students were twice as likely to intend to major in STEM and persist in STEM as those who did not participate in DE algebra, regardless of their race/ethnicity group. The proportion of DE algebra students who intended to major and persisted in STEM from fall to spring in their first year of enrollment was 12% and 10%, while the corresponding rates for non-participants were 6% and 5%, respectively. Additionally, URM DE algebra students were about 40% more likely to intend to major in and to persist in STEM than their White counterparts. This relative STEM advantage for URM students, however, did not translate into higher STEM graduation rates, as 9% of White students and 8% of URM students graduated with a STEM degree. That said, students who took a DE algebra course in high school graduated with a STEM degree at a higher rate than those who did not take DE algebra (9% versus 5%).

4. Fuzzy Regression Discontinuity Design (FRDD) Analysis

I begin the FRDD analysis by describing the analysis sample. Tables 3 and 4 present the descriptive statistics for the discontinuity sample, which includes students who fall within +/-0.15 of the normalized CPT math cutoff for participating in DE algebra. Table 3 indicates that the discontinuity sample is even more heavily White than the full sample of CPT math test takers presented in Table 1. However, excluding race/ethnicity and LEP status, this sample is similar to other test takers along most observable characteristics. Additionally, as shown in Table 4, the disparities in academic performance between DE algebra participants and non-participants are smaller in the discontinuity sample than in the full sample of test takers presented in Table 2. It is not surprising that the differences in outcomes are smaller, as this sample is more balanced in terms of prior academic performance.

In this section, I present estimates of the effect of participating in DE algebra on high school graduation, college enrollment, and early STEM outcomes. I present FRDD results obtained using four different regression discontinuity specifications using local linear and quadratic regressions with triangular kernels. The "main" specification is estimated using local linear regression with optimal bandwidths and robust confidence intervals proposed by Calonico et al. (2014), which leads to different sample sizes for each outcome. The "controls" specification is identical to the main specification, but it adds controls for student characteristics (gender, race/ethnicity, U.S. citizenship, age, LEP status, and FRPL status in ninth grade) and high school and district characteristics (race/ethnicity, FRPL status, FCAT 10th math and reading scores, school distance to the nearest college and total enrollment, and districts' average household income). The "BW = 0.15" specification uses observations within 0.15 score points of the normalized scores above and below zero at the cutoff and allows for a linear trend in distance from the cutoff. The "BW = 0.20" specification uses within 0.20 score points of the normalized scores above and below zero and allows for a second-degree polynomial in distance from the cutoff.

Table 3. Descriptive Statistics of Discontinuity Sample CPT Test Takers by DE Algebra Participation

	All Test Takers	Took DE Algebra			Did Not Take DE Algebra		
		All	White	URM	All	White	URM
1. Student characteristics							
Female	0.62	0.62	0.62	0.66	0.62	0.61	0.67
White	0.71	0.78	1.00	0.00	0.66	1.00	0.00
Black	0.12	0.08	0.00	0.46	0.14	0.00	0.50
Hispanic	0.12	0.10	0.00	0.54	0.14	0.00	0.50
Age, ninth grade	14	14	14	14	14	14	14
LEP students	0.09	0.05	0.02	0.20	0.11	0.05	0.29
FRPL, ninth grade	0.25	0.22	0.14	0.55	0.26	0.16	0.54
US citizen	0.92	0.94	0.97	0.84	0.90	0.93	0.81
Cum. GPA, ninth grade	3.31	3.44	3.44	3.42	3.23	3.27	3.12
Normalized first CPT math score	0.01	0.03	0.03	0.03	0.00	0.00	-0.01
First CPT math score	89.23	91.55	91.75	90.68	87.90	88.01	87.61
2. School and district characteristics							
HS Location:							
Town	0.08	0.10	0.09	0.16	0.07	0.08	0.04
Suburban	0.42	0.43	0.44	0.36	0.42	0.40	0.47
Rural	0.28	0.29	0.29	0.30	0.28	0.29	0.24
Urban	0.22	0.18	0.19	0.18	0.24	0.23	0.25
% of FRPL students in HS	0.36	0.34	0.32	0.43	0.36	0.34	0.43
% of White students in HS	0.60	0.66	0.70	0.50	0.57	0.64	0.38
% of Black students in HS	0.18	0.14	0.13	0.21	0.20	0.17	0.27
% of Hispanic students in HS	0.17	0.15	0.12	0.25	0.18	0.14	0.29
Total HS enrollment	879	841	786	1083	898	860	1000
School distance to nearest college	6.47	6.85	6.91	6.58	6.25	6.82	4.72
School avg. FCAT math score	329.49	329.92	331.01	324.92	329.21	330.45	325.86
School avg. FCAT reading	311.39	312.87	314.89	303.61	310.45	312.75	304.27
Avg. household income in school district	$62,891	$61,688	$61,915	$60,659	$63,575	$63,006	$65,088
Number of students	3,268	1,203	938	220	2,065	1,363	561
Number of schools	392						
Number of school districts	61						

Note. Underrepresented minorities (URM) are Black and Hispanic students. Sample includes 9th graders in 2007 in Florida who were continuously enrolled through 11th grade in regular high schools. High schools with less than 15 students or with 0% or 100% of DE students are excluded. Sample consists of all high school junior and senior students who took the CPT before 11th grade and scored within the +/- 0.15 bandwidth of the normalized score. College enrollment is measured in the fall after on-time high school graduation. Average high school percentage of FRPL; White, Black, Hispanic students in high school; and total high school enrollment are measured in ninth grade. School average of FCAT scores is measured in 10th grade.

Table 4. Descriptive Statistics of Discontinuity Sample Student Outcomes by DE Algebra Participation

	All Test Takers	Took DE Algebra			Did Not Take DE Algebra		
		All	White	URM	All	White	URM
1. High school outcomes							
State cum. GPA, grade 12	3.19	3.26	3.28	3.17	3.14	3.17	3.07
Credits earned in English, grade 12	0.82	0.82	0.84	0.78	0.82	0.81	0.84
Credits earned in math, grade 12	0.77	0.99	0.96	1.12	0.65	0.64	0.69
Credits earned in science, grade 12	0.54	0.63	0.64	0.60	0.49	0.47	0.52
On-time high school graduation	0.97	0.98	0.98	0.97	0.97	0.97	0.97
2. Year 1 college outcomes							
Immediate college enrollment	0.73	0.76	0.76	0.76	0.72	0.71	0.73
Immediate college enrollment in a state college	0.41	0.38	0.39	0.35	0.43	0.45	0.40
Immediate college enrollment in a university	0.32	0.39	0.38	0.41	0.28	0.27	0.33
Immediate full-time college enrollment	0.64	0.69	0.70	0.67	0.61	0.61	0.61
College credits attempted, term 1 fall	9	10	10	10	9	9	9
College credits earned, term 1 fall	9	9	9	9	8	8	8
3. Year 1 and year 2 STEM outcomes							
Enrolled in STEM, term 1 fall	0.09	0.10	0.09	0.12	0.08	0.07	0.10
Persisted in STEM from fall to spring	0.07	0.08	0.08	0.10	0.06	0.06	0.08
Enrolled in non-STEM, term 1 fall	0.25	0.30	0.30	0.29	0.22	0.22	0.24
Persisted in non-STEM from fall to spring	0.22	0.27	0.27	0.25	0.19	0.19	0.21
Undeclared or undecided, term 1 fall	0.37	0.35	0.36	0.33	0.38	0.39	0.35
Number of students	3,268	1,203	938	220	2,065	1,363	561
Number of schools	573						
Number of school districts	70						

Note. Sample includes ninth-graders in 2007 in Florida who were continuously enrolled through 11th grade in regular high schools. High schools with less than 15 students or with 0% or 100% of DE students are excluded. Sample consists of all high school junior and senior students who took the CPT before 11th grade and scored within the +/- 0.15 bandwidth of the normalized score. College enrollment is measured in the fall after on-time high school graduation. Credits attempted in UD and LD courses refer to as upper-division and lower-division courses, respectively.

4.1 FRDD Validation

I begin by presenting standard tests of the validity of the FRDD strategy. First, I perform balancing checks to test for discontinuities in the baseline characteristics around the normalized CPT math cutoff and examine whether students just above and just below the cutoff are similar in terms of their baseline observable characteristics. I focus on a set of available variables, including gender, race/ethnicity, age at ninth grade, LEP and FRPL status, and U.S. citizenship.

Table 5 and Figure 2 present balance checks for the discontinuity sample. Table 5 reports differences in means between students who were marginally eligible to participate in DE algebra and those who were not. Reassuringly, coefficients are all small in magnitude and insignificant, indicating that students at either side of the cutoff in the "main" bandwidth (0.15 and 0.20 bandwidths) are very similar to each other.

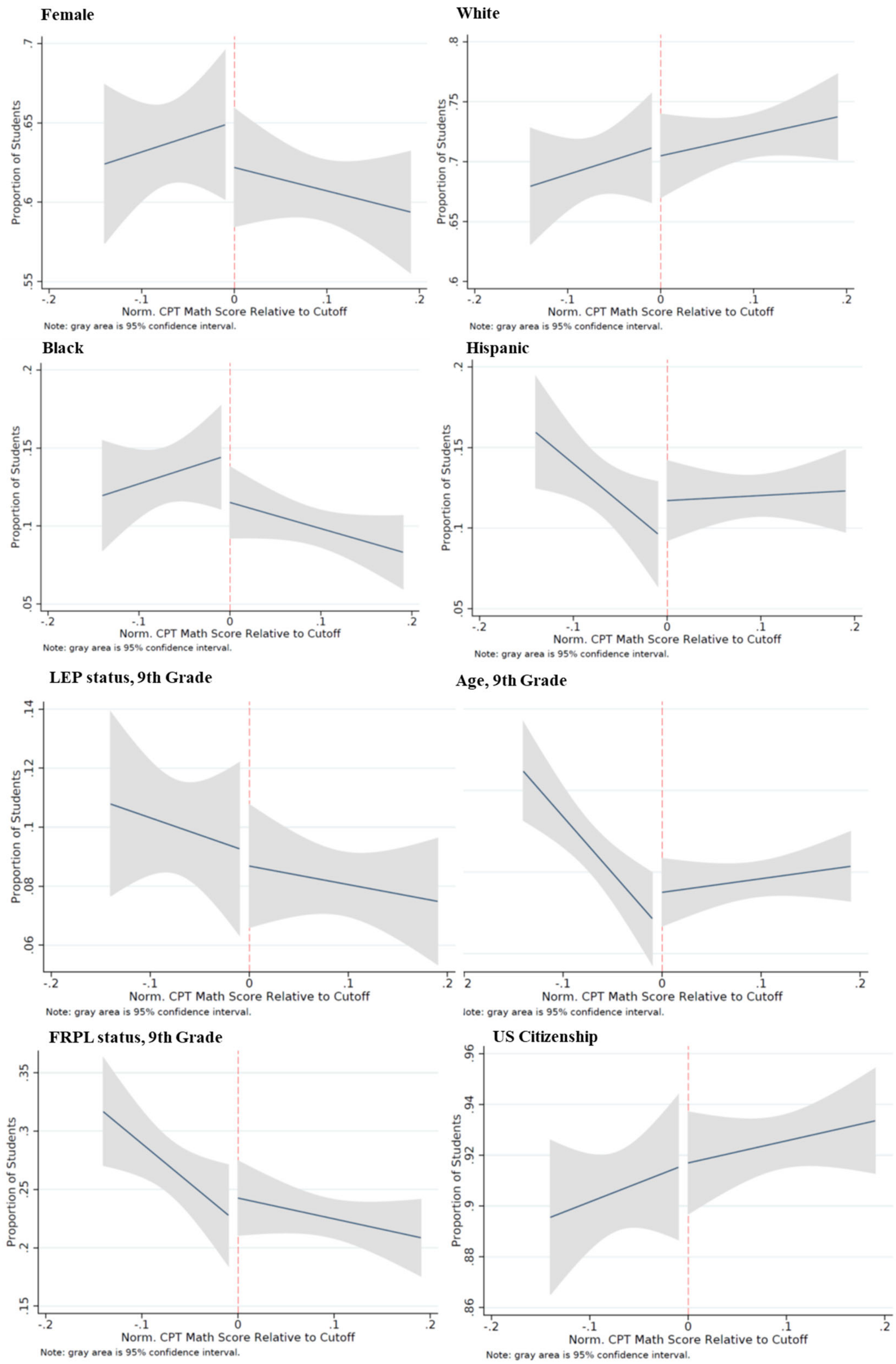
Table 5. Validity of the Fuzzy Regression Discontinuity Design

Dependent Variable	**Main**	**BW = 0.15**	**BW = 0.20**
Female	0.00	-0.02	-0.01**
	(0.04)	(0.04)	(0.05)
White	0.03	0.02	0.08
	(0.06)	(0.06)	(0.07)
Black	-0.06	-0.04	-0.07*
	(0.04)	(0.04)	(0.05)
Hispanic	0.01	0.01	-0.01
	(0.03)	(0.03)	(0.03)
Other race	0.01	0.02	0.01
	(0.02)	(0.02)	(0.02)
Age, ninth grade	0.01	0.02	-0.02
	(0.05)	(0.05)	(0.05)
LEP students	-0.01	-0.01	-0.02
	(0.03)	(0.03)	(0.03)
FRPL, ninth grade	0.04	0.03	0.05
	(0.06)	(0.05)	(0.06)
U.S. citizen	0.01	0.01	0.02
	(0.02)	(0.02)	(0.03)
Math remediation	0.01**	0.00	0.00
	(0.01)	(0.01)	(0.01)
Took college algebra in college	-0.03	-0.03	-0.03
	(0.03)	(0.02)	(0.03)
Number of students	**2,206**	**3,277**	**3,773**

Note. Standard errors are in parentheses and are clustered at the CPT math score. Sample includes 9th graders in 2007 in Florida who were continuously enrolled through 11th grade in regular high schools. High schools with less than 15 students or with 0% or 100% of DE students are excluded. Sample consists of all high school junior and senior students who took the CPT before 11th grade. Sample excludes postsecondary institutions that had a cutoff of 72 for college algebra. The "Main" specification uses mean square error (MSE) optimal bandwidth choice (Calonico et al., 2014); the "BW = 0.15" specification uses observations within 0.15 score points of the normalized scores above and below zero at the cutoff and allows for a linear trend in distance from the cutoff; the "BW = 0.20" specification uses within 0.20 score points of the normalized scores above and below zero and allows for a second-degree polynomial in distance from the cutoff.

*$p < .10$. **$p < .05$. ***$p < .01$.

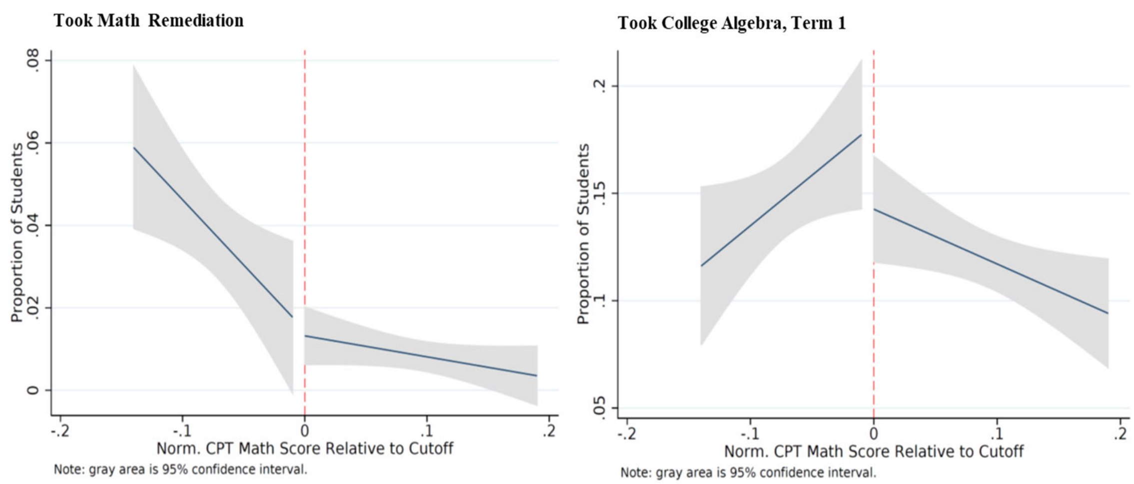
Figure 2. Covariate Balance of Basic Demographic Variables



Note. This figure shows means of demographic characteristics by distance relative to the cutoff.

Figure 3 shows balance checks for discontinuities in other treatments that may be sequential, such as math remediation and taking college algebra upon college entry; this check is particularly relevant in accounting for students who did not take college-level algebra in high school. These results indicate that threshold-crossing does not appear to affect other treatments that could explain college outcomes after first college enrollment. The magnitude of these coefficients is also very small and only significant at the 5% level for math remediation in one of the three specifications.[15]

Figure 3. Discontinuity in Other Treatments



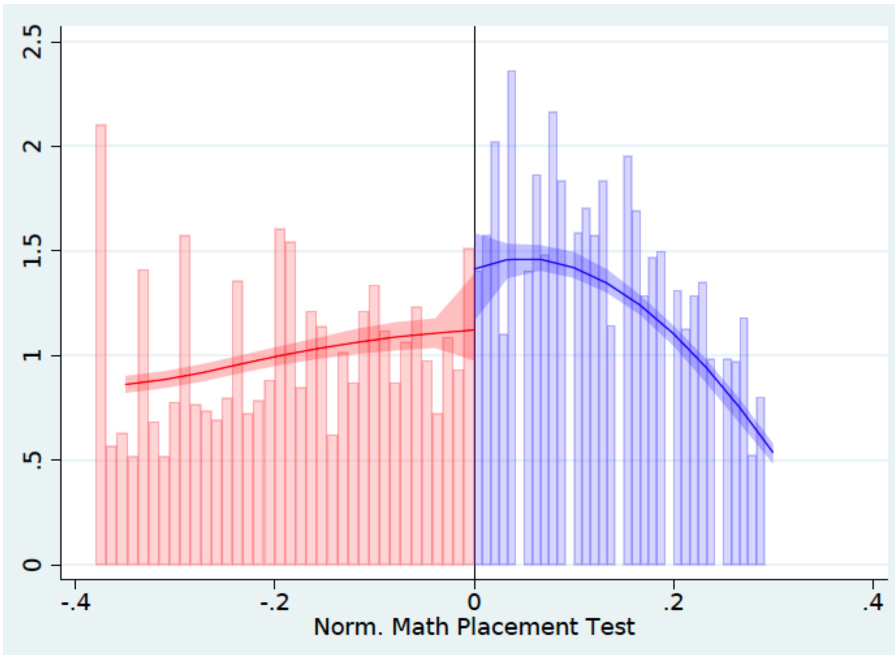
Note. This figure shows average proportion of students who took math remediation and college algebra upon first college enrollment by distance relative to the cutoff.

Manipulation of normalized CPT scores is highly implausible, not only because the state and community colleges administered and scored the CPT and were accountable for its integrity and security but also because of the low stakes involved at the cutoff for college algebra. High school students who scored below the cutoff could enroll in DE intermediate algebra, and with a minimum grade of C could then take DE college algebra. I am also using the first CPT scores available in the dataset, which minimizes the likelihood that students in the sample retook the test to become eligible. Still, to check for any signs of manipulation, I test for a discontinuity in the density of the normalized CPT

[15] It is worth noting that the state-mandated cutoff scores for placement into remedial math are lower than the ones used for college algebra (72 or higher on the Elementary Algebra section of the CPT math).

math scores. Figure 4 shows histograms and the density of the distribution of scores in the sample. I find no significant discontinuity in the density around the cutoff.

Figure 4. Distribution of CPT Math Scores and Manipulation Testing



Note. This figure shows the density of the distribution of normalized CPT scores close to the eligibility cutoff (at zero on the x-axis), as well as the local polynomial density estimate (the solid red and purple lines) and the robust bias-corrected confidence intervals (the shaded portions surrounding the red and purple lines) computed using the Stata command, rddensity (t = 1.43; p =.15).

4.2 FRDD Results

Figure 5 presents regression discontinuity estimates of the effects of threshold-crossing on DE algebra participation. Students just above the CPT threshold are 23 percentage points more likely to participate in DE algebra than students just below the cutoff, indicating the relevance of the cutoff for students' eligibility to participate in DE algebra in grades 11 and 12. The probability is slightly above zero to the left side of the cutoff, which may be a consequence of students below the cutoff taking and passing intermediate algebra in order to take college algebra in subsequent terms or years. Individual high schools and colleges may also make exceptions on a case-by-case basis and allow students below the cutoff to participate in DE algebra. Figure 6 illustrates the effects of threshold-crossing on URM and White students' participation in DE algebra.

This figure shows that the probability of participating in DE algebra jumps to about 40% for URM students and 50% for White students at the cutoff.

Figure 5. Effects of Threshold-Crossing on Participating in DE Algebra (First Stage)

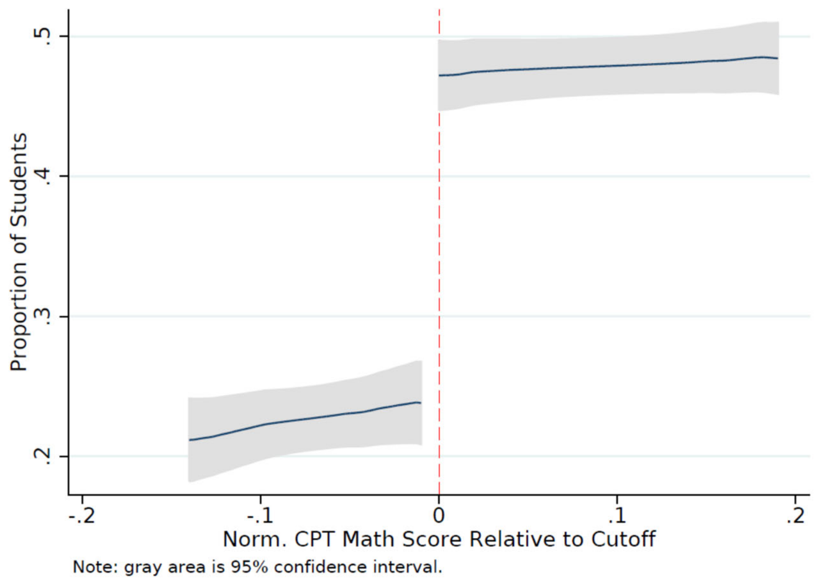


Figure 6. Effects of Threshold-Crossing on Participating in DE Algebra by Race/Ethnicity Group

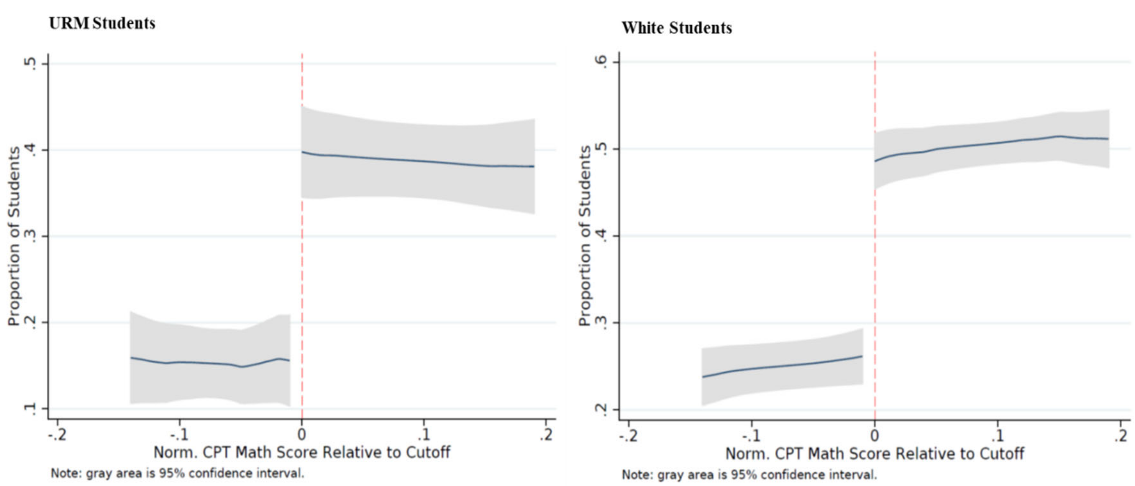
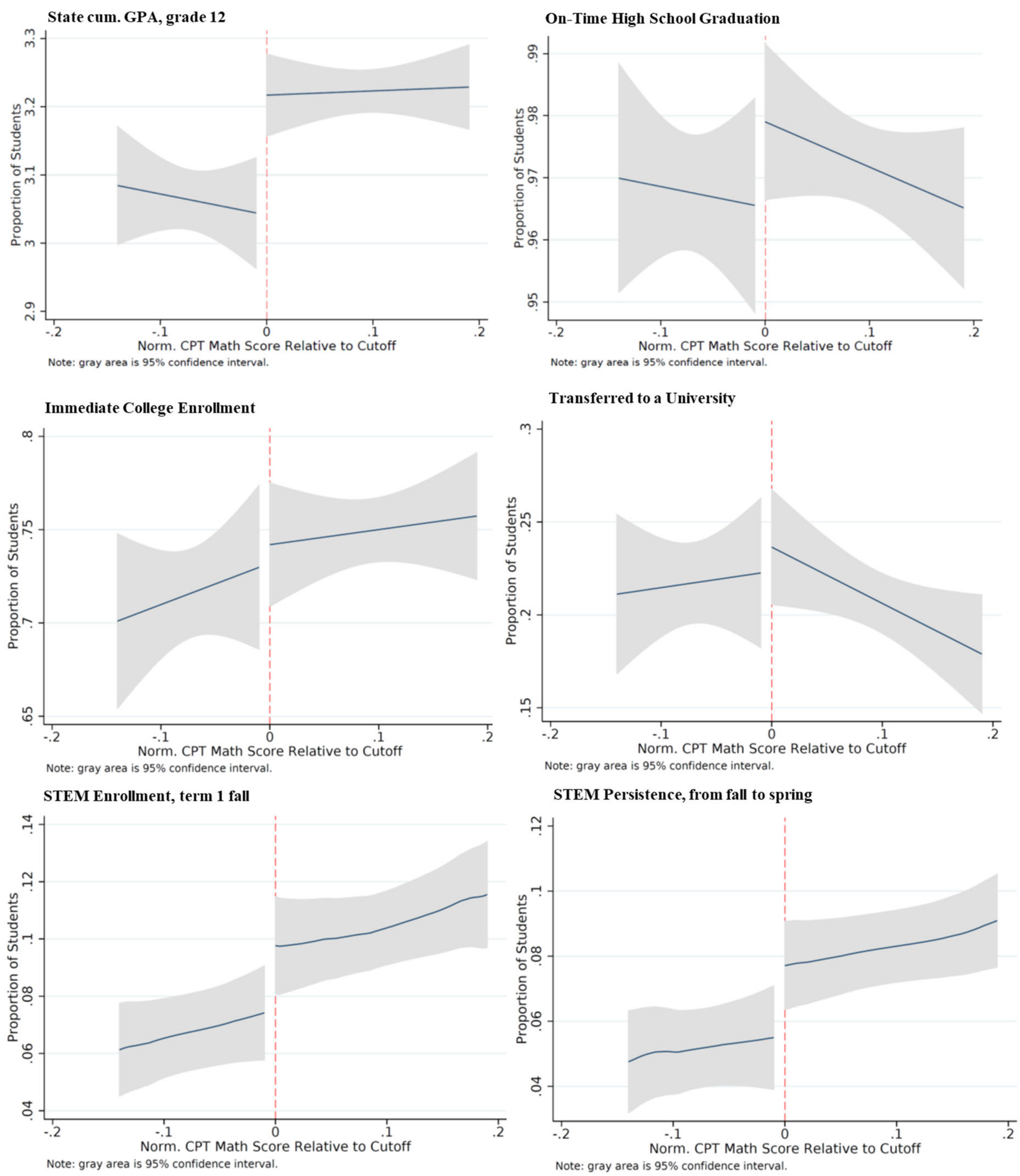


Figure 7 provides a graphical inspection of the impact of taking DE algebra on selected high school, college enrollment, and early STEM outcomes. To the extent that DE algebra benefits students, there should be a significant jump in mean outcomes at the cutoff. There is a significant discontinuous increase in the state cumulative GPA in grade

12 and a small increase in STEM enrollment upon first college entry. Because some ineligible students took DE algebra when granted an exception or after taking intermediate algebra, I use FRDD to scale up these differences in outcomes around the cutoff by the likelihood of participating in DE algebra.

Figure 7. Effects of Threshold-Crossing on Selected Student Outcomes (Reduced Form)



To complement these graphical analyses, Table 6 reports FRDD estimates of the effects of taking DE algebra in grades 11 and 12, where the normalized CPT math cutoff-crossing indicator is used as an instrument for participating in DE algebra in grades 11 and 12, and high school graduation, college enrollment, and early STEM outcomes are used as dependent variables. The results of the first stage regressions presented graphically in Figure 5 are shown in the first row of Table 6, which shows estimates using alternative bandwidths of the data and control variables for the main specification.[16]

Table 6. FRDD Estimates

Dependent Variable	Main		Controls		BW = 0.15		BW = 0.20	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Enrolled in college algebra [first stage]	0.23	(0.04)***	0.22	(0.03)***	0.23	(0.04)***	0.24	(0.04)***
1. High school outcomes								
State cum. GPA, grade 12	0.93	(0.29)***	0.94	(0.31)**	0.73	(0.3)***	0.87	(0.3)***
On-time high school graduation	-0.09	(0.08)	-0.10	(0.09)	-0.02	(0.08)	-0.10	(0.09)
2. College enrollment outcomes								
Immediate college enrollment	-0.12	(0.17)	-0.15	(0.15)	-0.02	(0.14)	-0.18	(0.19)
Immediate college enrollment in a university	-0.08	(0.15)	-0.05	(0.16)	-0.09	(0.15)	-0.05	(0.15)
Immediate college enrollment in a state college	-0.05	(0.15)	-0.17	(0.14)	0.05	(0.14)	-0.16	(0.18)
Immediate full-time college enrollment	-0.07	(0.1)	-0.16	(0.1)*	-0.06	(0.09)	-0.13	(0.12)
Transferred to a university	0.03	(0.07)	0.03	(0.07)	0.07	(0.08)	0.01	(0.08)

(table continues on next page)

[16] The control variables include student demographic, school, and district characteristics described earlier, but these estimated coefficients are not shown here for simplicity of presentation.

Table 6. FRDD Estimates (continued)

Dependent Variable	Main		Controls		BW = 0.15		BW = 0.20	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
3. STEM outcomes, year 1								
Undeclared/ undecided, Term 1 fall	-0.38	(0.12)***	-0.55	(0.13)***	-0.24	(0.14)***	-0.47	(0.15)***
Persisted undeclared/undecided from fall to spring	-0.33	(0.1)***	-0.43	(0.09)***	-0.22	(0.12)***	-0.41	(0.12)***
Enrolled in STEM, term 1 fall	0.09	(0.05)*	0.09	(0.04)***	0.07	(0.05)*	0.09	(0.05)
Persisted in STEM from fall to spring	0.10	(0.08)	0.11	(0.06)*	0.10	(0.08)	0.12	(0.09)
Enrolled in non-STEM, term 1 fall	0.16	(0.1)	0.12	(0.14)	0.06	(0.12)	0.15	(0.12)***
Persisted in non-STEM from fall to spring	0.06	(0.1)	0.02	(0.13)	0.00	(0.11)	0.05	(0.12)
Total credits attempted, term 1 fall	-1.00	(1.91)	-2.37	(1.67)	-0.45	(1.58)	-2.02	(2.21)
STEM credits attempted in LD courses, term 1 fall	-0.06	(0.54)	-0.85	(0.64)	0.25	(0.59)	-0.50	(0.57)
STEM credits attempted in UD Courses, term 1 fall	0.13	(0.16)	0.20	(0.18)	0.21	(0.16)	0.13	(0.16)
STEM credits attempted in LD courses, end of year 1	-1.47	(1.51)	-2.23	(1.71)	-0.73	(1.43)	-2.91	(1.93)
STEM credits attempted in UD courses, end of year 1	1	(0.6)	0.92	(0.67)	0.74	(0.59)	1.00	(0.59)
Number of students	**†**		**†**		**3,268**		**3,761**	

Note. Standard errors (SE) are in parenthesis and are clustered at the CPT math score. Sample includes ninth-graders in 2007 in Florida who were continuously enrolled through 11th grade in regular high schools. High schools with less than 15 students or with 0% or 100% of DE students are excluded. Sample consists of all high school junior and senior students who took the CPT before 11th grade. Sample excludes postsecondary institutions that had a cutoff of 72 for college algebra. Each cell represents a separate regression. The "Main" specification uses mean square error (MSE) optimal bandwidth choice (Calonico et al., 2014); the "Controls" specification includes gender, race dummies, U.S. citizenship, age, limited English proficiency (LEP), and free or reduced-price lunch (FRPL) status in 9th grade, high school characteristics (race, FRPL status, FCAT 10th math and reading scores, school distance to the nearest college and total enrollment), and districts' average household income; the "BW = 0.15" specification uses observations within 0.15 score points of the normalized scores above and below zero at the cutoff and allows for a linear trend in distance from the cutoff; the "BW = 0.20" specification uses within 0.20 score points of the normalized scores above and below zero and allows for a second-degree polynomial in distance from the cutoff.

† Sample size varies for each outcome.

**p* < .10. ***p* < .05. ****p* < .01.

Students on the margin of eligibility who took DE algebra were more likely to earn a higher state cumulative GPA in grade 12,[17] *although there is no evidence that DE algebra significantly affected on-time high school graduation. Among these students, DE algebra did not significantly affect college enrollment and choice of whether to attend a state college or a university.* The point estimates on the effect of DE algebra on college enrollment and choice are slightly negative but statistically insignificant. Therefore, I fail to detect a statistically significant effect of DE algebra on these outcomes for students at the margin of the cutoff.

For students on the margin of eligibility, taking DE algebra increased their likelihood of choosing a major at college entry. Students at the margin of the cutoff who took DE algebra were about 24–55 percentage points less likely than those who did not take DE algebra to be undecided at first college entry, depending on bandwidth size.

For students on the margin of eligibility, the effects of DE algebra on early STEM outcomes are positive and significant, though slightly imprecise across bandwidths. The likelihood of choosing a STEM major at college entry rises across the threshold by about 9 percentage points, indicating a substantial increase in STEM enrollment, from a mean below-threshold of about 8%. Effects are imprecise for STEM persistence from fall to spring in their first year of enrollment.

Estimating the effects of taking DE algebra using the full sample of students who were on the margin of eligibility masks substantial heterogeneity across race/ethnicity groups, particularly for early STEM outcomes. Table 7 shows FRDD estimates by race/ethnicity group. The results indicate that while taking DE algebra induced URM students to choose a STEM major at entry and persist in their intent to major in STEM, it did not induce White students to choose a STEM major.

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[17] I use the state average cumulative GPA, calculated on an unweighted 4.0 scale, to estimate average cumulative GPA in grade 12. This measure is used by the State of Florida to determine if the student has met the state high school graduation requirements.

Table 7. FRRD Estimates, by Race/Ethnicity Group

	White				URM			
	Main		BW = 0.15		Main		BW = 0.15	
Dependent Variable	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Enrolled in college algebra [first stage]	0.21	(0.05)***	0.20	(0.05)***	0.28	(0.03)***	0.28	(0.03)***
1. High school outcomes								
State cum. GPA, grade 12	1.07	(0.36)***	0.98	(0.35)***	0.24	(0.32)	0.21	(0.33)
On-time high school graduation	-0.12	(0.11)	-0.02	(0.1)	-0.06	(0.07)	-0.03	(0.07)
2. College enrollment Outcomes								
Immediate college enrollment	-0.26	(0.22)	-0.08	(0.2)	0.14	(0.15)	0.10	(0.17)
Immediate college enrollment in a university	-0.03	(0.24)	-0.05	(0.24)	-0.13	(0.28)	-0.14	(0.16)
Immediate college enrollment in a state college	-0.19	(0.26)	-0.04	(0.24)	0.23	(0.21)	0.23	(0.21)
Immediate full-time college enrollment	-0.16	(0.13)	-0.12	(0.14)	0.11	(0.17)	0.05	(0.19)
Transferred to a university	-0.02	(0.12)	0.07	(0.14)	0.15	(0.22)	0.11	(0.19)
3. STEM outcomes, year 1								
Undeclared/undecided, term 1 fall	-0.49	(0.2)***	-0.27	(0.19)***	-0.27	(0.08)***	-0.20	(0.11)***
Persisted undeclared/undecided from fall to spring	-0.30	(0.16)*	-0.15	(0.17)**	-0.43	(0.17)***	-0.39	(0.17)***
Enrolled in STEM, term 1 fall	-0.02	(0.08)	0.01	(0.11)	0.32	(0.07)***	0.18	(0.11)***
Persisted in STEM from fall to spring	0.06	(0.12)	0.07	(0.12)	0.36	(0.11)***	0.15	(0.1)***
Enrolled in non-STEM, term 1 fall	0.21	(0.12)	0.11	(0.15)**	-0.07	(0.16)	-0.04	(0.15)
Persisted in non-STEM from fall to spring	0.10	(0.12)	0.02	(0.14)	-0.12	(0.14)	-0.05	(0.13)

(table continues on next page)

Table 7. FRRD Estimates, by Race/Ethnicity Group (continued)

	White				URM			
	Main		BW = 0.15		Main		BW = 0.15	
Dependent Variable	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Total credits Attempted, term 1 fall	-2.39	(2.31)	-1.06	(2.31)	1.71	(2.27)	0.68	(2.31)
STEM credits Attempted in LD courses, term 1 fall	-0.90	(0.85)	-0.39	(0.85)	1.13	(1.51)	1.64	(1.31)
STEM credits Attempted in UD courses, term 1 fall	0.19	(0.18)	0.27	(0.19)	0.00	(0.18)	0.17	(0.18)
STEM credits Attempted in LD courses, end of year 1	-1.02	(1.95)	-0.31	(1.94)	-1.56	(2.94)	-1.02	(2.76)
STEM credits Attempted in UD courses, end of year 1	0.91	(0.43)**	0.82	(0.5)**	0.60	(1.06)	0.71	(0.97)
Number of students	†		**2,301**		†		**781**	

Note. Standard errors (SE) in parenthesis and are clustered at the CPT math score. Heterogeneous effects are calculated using only White and URM student samples. URM students are Black and Hispanic students. The “Main” specification uses mean square error (MSE) optimal bandwidth choice (Calonico et al., 2014); the “BW = 0.15” specification uses observations within 0.15 score points of the normalized scores above and below zero at the cutoff and allows for a linear trend in distance from the cutoff.

† Sample size varies for each outcome.

**p* < .10. ***p* < .05. ****p* < .01.

5. Conclusion

Prior research has shown that Black and Hispanic students are as likely to enter STEM majors as their White peers (Garrison, 2013; Riegle-Crumb & King, 2010; Xie, Fang, & Shauman, 2015), but they are too often lacking the opportunity to participate in the advanced math coursework that serves as a gateway to STEM programs. These disadvantages contribute to substantial and persistent inequities in completion of STEM degrees. One possible way to narrow racial/ethnic disparities in STEM is to expose URM students to advanced math coursework in high school through dual enrollment.

College algebra is a prerequisite course for students who pursue STEM majors (Herriott & Dunbar, 2009); it is a challenging course that satisfies both general education and Florida’s statewide requirements for a transfer associate degree. DE algebra may increase students’ knowledge about potential college majors and spur their interest in STEM, particularly for URM students. DE algebra may also help to prepare high school students for the academic rigor of STEM college courses and enable students to be more successful in their STEM postsecondary careers. The study I describe in this report provides insight into the effects of taking DE algebra on high school graduation, college enrollment, and early STEM outcomes.

First, I find that among students in the 2007-08 Florida public high school ninth grade cohort who took the math section of the state’s college placement test (CPT), DE algebra course takers were more likely to be White, native English speakers, from a more affluent background, and to attend predominantly White schools than those who did not take DE algebra in grades 11-12. DE algebra course takers were also substantially more academically prepared than the average student who did not take DE algebra. Therefore, it is not surprising to find that DE algebra course takers were more likely to experience positive high school and college outcomes than those who did not take DE algebra in high school.

Second, I use a fuzzy regression discontinuity design (FRDD) to exploit discontinuities in the scores of Florida’s college placement test in math for enrollment in DE algebra to estimate the effects of taking the course among students close to the cutoff for eligibility. Results suggest that participating in DE algebra did not alter the likelihood of on-time high school graduation, college enrollment, or college choice among such students. Yet taking DE algebra increased—by about 9 percentage points—the likelihood that students on the margin of eligibility would choose a STEM major upon college entry. This finding, which is consistent with the notion that early exposure to advanced math coursework allows students to learn about potential college majors and career choices, is driven entirely by URM students. For URM students—but not for White students—on the margin of eligibility, I find particularly strong effects of taking DE algebra on beginning and persisting in college as a STEM major (18–32 and 15–36 percentage point increases, respectively). These results provide evidence supporting efforts to expand access to DE algebra for URM students as a strategy for reducing racial/ethnic disparities in STEM postsecondary education and employment.

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Appendix

Table A.1. Descriptive Statistics for CPT Test Takers and Non-Test Takers

Student Characteristics	**Non-Test Takers**	**All CPT Math Test Takers**
Female	0.50	0.62
White	0.50	0.61
Black	0.21	0.19
Hispanic	0.23	0.15
LEP students	0.19	0.11
FRPL, 9th grade	0.47	0.29
US citizen	0.87	0.90
Cum. GPA, 9th grade	2.69	3.10
Dual enrollment experience		
Enrollment in DE	0.09	0.67
DE HS credits attempted, 11th grade	0.09	0.91
DE HS credits earned, 11th grade	0.08	0.89
DE HS credits attempted, 12th grade	0.20	1.54
DE HS credits earned, 12th grade	0.19	1.47
Number of students	144,521	8,921
Number of schools	1,606	573
Number of school districts	73	70

Note. Sample includes ninth-graders in 2007 in Florida who were continuously enrolled through 11th grade in regular high schools. High schools with less than 15 students and with 0 or 100 percent of DE students are excluded. The CPT sample consists of all high school junior and senior students who took the CPT for the first time between July 2009 and March 2011. Average DE credits attempted and earned are estimated using high school transcripts (where, e.g., a 1- or 1.5-credit DE course is equivalent to a 3-credit course in college).

Table A.2. List for Placement Into DE Algebra by College

Institution	Cutoff Score for DE Algebra	Institution	Cutoff Score for DE Algebra	Institution	Cutoff Score for DE Algebra
Institution 1	95	Institution 11	72	Institution 21	91
Institution 2	83	Institution 12	94	Institution 22	72
Institution 3	91	Institution 13	72	Institution 23	85
Institution 4	83	Institution 14	91	Institution 24	72
Institution 5	85	Institution 15	90	Institution 25	83
Institution 6	90	Institution 16	88	Institution 26	90
Institution 7	83	Institution 17	97	Institution 27	88
Institution 8	98	Institution 18	83	Institution 28	88
Institution 9	91	Institution 19	83		
Institution 10	95	Institution 20	85		

Source. College catalogs and Florida Department of Education, Articulation Coordinating Committee (2006).

Note. Postsecondary institutions that had a cutoff of 72 for college algebra were not included in the sample because these institutions used the same cutoff to determine both DE algebra participation and math remediation.