Who Benefits from High School Exit Exams? Examining Variations in Math Course-Taking by Abilities and Socioeconomic Status

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Abstract: Using the High School Longitudinal Study of 2009, the association between high school exit exams and mathematics course-taking patterns is explored. Exit exams are linked to a decreased likelihood of students taking *upward-bound* mathematics during their four years of high school. Exit exams are also associated with fewer mathematics credits earned. However, exit exams are linked to increased likelihood of students completing Precalculus or higher, but have no discernible association with completing Algebra II or higher. Importantly, significant disparities exist in these associations, with underprivileged, underperforming students often experiencing limited access to advanced math courses due to exit exams.
Keywords: math course-taking pattern; exit exam; on track; off track; equity

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Researchers and policymakers have focused on students' mathematics course-taking in high school as an indicator of college and career readiness such as advanced math completion and curricular intensity (e.g., Austin, 2020; Avery & Goodman, 2022; Goodman, 2019). Recently, there has been increased attention to students' *course-taking histories* in math and their effects on future attainments (e.g., Brown et al., 2018; Eisenhart & Weis, 2022; Finkelstein et al., 2012; Han et al., 2023; Irizarry, 2021). This involves questions about whether students follow the expected four-year hierarchical sequence of Algebra I- Geometry-Algebra II-higher-level courses (e.g., Trigonometry, Precalculus or Calculus) or deviate from a consistent linear progression. Research indicates that the experience of nonlinear progression in math course-taking, such as repeating the same-level mathematics, discontinuing coursework, or regressing to a lower-level course, varies across students and schools (Brown et al., 2018; Eisenhart & Weis, 2022; Fong et al., 2014; Han et al., 2023; Irizarry, 2021). These nonlinear progression experiences have long-term effects on students' later outcomes, such as course repetition and STEM major choices in college (Eisenhart & Weis, 2022; Ngo & Velasquez, 2020).

Recent qualitative or descriptive quantitative studies have explored the association between high school graduation requirements, state-mandated exit exam policies in mathematics, and students' nonlinear progression in math course-taking patterns (Eisenhart & Weis, 2022; Han et al., 2023; Roderick et al., 2013). Findings indicate that such policies do not exert uniform associations across different groups. For example, when schools require four years of mathematics for high school graduation, some students tend to make consistent upward moves from less to more difficult mathematics courses throughout high school years. On the other hand, others choose to follow an upward linear progression in mathematics from ninth to 11th grade, only to then opt for a lower level of math in their senior year, thereby missing opportunities to maximize their college readiness and STEM potential (Eisenhart & Weis, 2022; Han et al., 2023; Roderick et al., 2013).

Given that these prior studies were either qualitative or relied on descriptive statistics, it is important to investigate the link between exit exams and math course-taking, controlling for socio-demographics, prior achievement, and school characteristics. This would help determine if students with similar backgrounds are more likely to have better math course-taking outcomes in schools with exit exams compared to their counterparts in schools with no such exams. While numerous studies have examined the effects of high school exit exams on various outcomes, including academic achievement, graduation rates, and dropout rates, only a few studies have specifically investigated the association between these exams and students' mathematics course-taking patterns, particularly consistent upward move histories from less to more difficult throughout high school years (Caves & Balestra, 2018; Grodsky et al., 2009; Hemelt & Marcotte, 2013; Reardon et al., 2010).

Despite recent elimination or reduced weight of high school exit exams in some states, several states, including those with large public-school enrollments, such as Florida, Illinois, New York, and Texas, still require state-mandated high school exit exams. The stated goals of these policies are to improve student achievement, ensure mastery of rigorous standards, promote high-level math skills, and reduce achievement gaps. While supporters argue that these exams can positively impact student learning by guiding a normatively sequenced math curriculum, which encourages students to complete advanced math coursework and ultimately lead to improved academic outcomes (Schiller & Hunt, 2011), critics suggest that the narrow focus of state-mandated math curricula may limit opportunities for students to take a broad range of math subjects, thereby potentially hindering academic development (Heilig & Darling-Hammond, 2008; Holme et al., 2010; McNeil et al., 2008).

This study utilizes the High School Longitudinal Study of 2009 (HSLS:09), a nationally representative high school cohort dataset, to explore the associations between standards-based, test-driven reform initiatives, especially high school exit exams, and mathematics course-taking patterns. The objective of this research is to provide valuable insights into the potential benefits and drawbacks of such policies. The study explores students' consistent upward progress in mathematics coursework, their math credits, and the highest math level achieved, thereby examining both the quantity and quality of math course-taking, along with detailed course-taking histories. By investigating the association between exit exams and comprehensive mathematics course-taking outcomes, this study can contribute to developing a better understanding of the heterogeneous effects of this policy on mathematics learning outcomes. It also investigates whether these associations depend on students' academic performance and socioeconomic background, with the aim of assessing the extent to which the exit exam policy benefits disadvantaged students, as intended. While previous research has focused on gender and racial/ethnic disparities in math course-taking (Avery & Goodman, 2022; Goodman, 2019; Kelly, 2009; Riegle-Crumb, 2006; Riegle-Crumb & Grodsky, 2010), there is a lack of studies on the association between high school exit exams and socioeconomic inequalities (Bottia et al., 2022). The findings can inform the debate on the effectiveness of high school exit exams in promoting academic achievement and equity for all students.

Trends in High School Exit Exams

Under the No Child Left Behind (NCLB) Act, states are required to develop standards in core subjects at the high school level and administer tests in mathematics, English/language arts, and science to all students in at least one high school grade. Many states have taken additional initiatives to impose further accountability requirements at the high school level. Notably, these initiatives include high school exit exams and end-of-course exams that students must pass in order to receive a high school diploma (Hamilton et al., 2008). The adoption of high school exit exams in the United States saw a significant increase beginning in 2002, with 18 states mandating these exams for graduation that year (Zhang, 2009). Among these states, 10 used minimum competency tests, seven adopted comprehensive exams, and two implemented end-of-course exams. By 2004, this number had increased to 20 states. In 2004, more than half of all public-school students in the United States were required to pass exit examinations–such as minimum competency, standards-based, or end-of-course examinations–in order to graduate from high school. This number grew to 24 states by 2009 (Zhang, 2009). By 2009, only one state still used minimum competency exams, which typically set a low minimum standard and do not, in practice, generally assess materials that college-bound students study in tenth and eleventh grades (Bishop et al., 2000). Several states have shifted from minimum competency exams to comprehensive or end-of-course exams, requiring mandatory examinations in core subjects, including mathematics.

It was in this policy context that HSLS:09 ninth graders entered high school. The focus on standardized testing under NCLB and subsequent state policies aimed to improve educational outcomes and ensure accountability. However, these policies also sparked debates with regard to educational equity, as critics argued that high-stakes testing could disproportionately affect minority and low-income students, potentially increasing dropout rates and limiting opportunities for these groups (Hemelt & Marcotte, 2013). Moreover, the alignment of these tests with college readiness standards varied, raising concerns about the adequacy of preparation for post-secondary education (Conley, 2007).

However, starting in the late 2010s, the number of states requiring high school exit exams began to decline. By 2019, 13 states–Florida, Indiana, Louisiana, Maryland, Massachusetts, Mississippi, New Jersey, New Mexico, New York, Ohio, Texas, Virginia, Washington–required that students must pass these exit exams or achieve specific scores on ACT or SAT examinations (de Brey & Donaldson, 2024). Compared to 2009, when HSLS:09 ninth graders cohort began high school, about half of the states eliminated or scaled back high school exit examinations. This reduction was driven by concerns over the effectiveness and fairness of high-stakes testing, as well as a surrounding broader movement towards more holistic approaches to student assessment and graduation requirements. The changing landscape of educational policy highlights the ongoing evolution of strategies aimed at balancing accountability with educational equity, meaningful learning, and holistic student development (Darling-Hammond et al., 2016; Darling-Hammond et al., 2014).

Given the recent policy shifts, understanding the impact of exit exams on math course-taking can provide critical insights into how these assessments influenced educational trajectories. Our study aims to examine the association between exit exams and students' math course-taking patterns and how they may exacerbate or mitigate inequalities based on student achievement levels and socioeconomic status (SES). As states explore new assessment and accountability models, a topic that will, in all likelihood, have continued and future currency, our findings are poised to inform likely ongoing debates about the most equitable and effective ways to measure and support student progress (Darling-Hammond et al., 2016; Darling-Hammond et al., 2014). This relevance is underscored by the continued challenges related to balancing rigorous academic standards with the need for fair and inclusive educational practices.

Math Course-Taking Patterns and High School Exit Exams

In high school, mathematics follows a hierarchical sequence, where each stage builds on fundamental knowledge and enables students to progress to more advanced math levels. Course-taking sequences in math are particularly important, as consistent upward progress in math classes can provide students with significant advantages, preparing them for success in a wide range of advanced math courses (Domina & Saldana, 2012; Han et al., 2023; Riegle-Crumb, 2006; Teitelbaum, 2003). Completing advanced-level math courses is positively associated with key outcomes, such as college attendance, STEM career aspirations, college persistence, and degree attainment (Adelman, 2006; Horn & Kojaku, 2001; Wang, 2013). However, persistent inequalities exist in math performance, access to advanced courses, and achievement across groups, particularly among underrepresented minoritized and low-income students (e.g., Kelly, 2009; Riegle-Crumb & Grodsky, 2010).

Previous descriptive analyses using nationally or state representative transcript data have demonstrated that students' math course-taking patterns vary greatly, with only a small percentage following a four-year consistent upward linear sequence (Brown et al., 2018; Finkelstein et al., 2012; Han et al., 2023). Nonlinear progression is particularly prevalent among low-income, minoritized, and low-achieving students in urban public schools (Han et al., 2023; Irizarry, 2021). Those who deviate from linear progression in high school math are more likely to repeat mathematics courses in college (Ngo & Velasquez, 2020) and are less likely to choose STEM pathways in college compared to their counterparts who do not deviate (Eisenhart & Weis, 2022; Han et al., 2023).

Students' math course-taking sequences are influenced by a complex interplay of organizational rules, structural circumstances, and individual characteristics. These factors encompass grade level and ability level, which determine the progression and sequence of math courses available to a student, as well as the specific courses offered on-site, which can vary greatly between schools. The process of assigning students to particular courses entails multiple considerations, such as standardized test scores, previous academic performance, and crucially, recommendations from teachers and counselors. However, this process may be susceptible to subtle biases, including those based on gender and race, which could impact students' access to advanced courses (Avery & Goodman, 2022; Francis et al., 2019; Goodman, 2019; Irizarry, 2021; McFarland, 2006). Additionally, graduation requirements, which vary by state or district, can significantly influence the math courses students take, shaping their academic trajectories. These numerous factors, coupled with the diverse resources and opportunities available in different schools and districts, contribute to the varied patterns observed in high school math course-taking.

Recently, scholars have also suggested that standards-based education reforms and test-driven accountability policies, such as exit exams and credit requirements for high school graduation, primarily influence math coursework (e.g., Goodman, 2019; Kim et al., 2019; Papay et al., 2010; Roderick et al., 2013). Despite the recent elimination of high school exit exams in some states, a significant number of students are still affected by these exams. States have moved towards more rigorous standardized exams that assess mastery of a specific high school course, rather than minimum competency across multiple subjects. These exams are aligned with state standards and assess proficiency in core academic subjects like math and science (Center on Education Policy, 2008). Advocates of these reforms argue that they encourage both students and educators to strive for higher levels of preparedness for college and career paths, particularly benefiting socially disadvantaged students. They also assert that these reforms promote more stringent curriculum standards, thus enhancing the value of high school diplomas in the eyes of colleges and employers (Bishop et al., 2000). However, critics have highlighted potential drawbacks, including a trend towards a narrower curriculum focus (Holme et al., 2010).

Furthermore, these standards-based, test-driven reforms have been found to exhibit varying effects across different levels of mathematics and student demographics (e.g., Goodman, 2019; Papay et al., 2010). State-level reforms altering the minimum number of math courses for high school graduation significantly influence completed coursework, especially in basic math courses like Prealgebra, Algebra, and Geometry, contributing to the reduction of racial achievement gaps (e.g., Goodman, 2019). In contrast, such reforms have little effect on advanced math courses beyond Geometry, such as Algebra II, Precalculus, and Calculus (e.g., Goodman, 2019). High school exit exams can also potentially impact a student's math coursework sequence, steering them towards taking only the math courses that provide an advantage in passing the exams (Eisenhart & Weis, 2022; Han et al., 2023; Reardon et al., 2010; Roderick et al., 2013). Nevertheless, there has been limited research exploring the extent to which exit exams correlate with mathematics course-taking patterns, access to advanced math courses, and course repetition, particularly when considering varying student groups and levels of achievement (Kim et al., 2019; Reardon et al., 2010; Schiller & Muller, 2003).

Research on the association between exit exams and math coursework patterns has yielded mixed findings. Recent studies drawing on Michigan high school data, for instance, show mixed findings on the effects of the Michigan Merit Curriculum (MMC) policy, which mandates four math credits, including Algebra I, Algebra II, and Geometry, along with passing standardized tests at the end of each course (Jacob et al., 2017; Kim et al., 2019). Consistently, Jacob et al. (2017) and Kim et al. (2019) found that the MMC policy had little effect on American College Testing (ACT) math scores. However, Kim et al. (2019) found that after the policy, students took more, and higher-level math courses compared to their pre-policy peers. This effect was most notable among students who were less academically prepared students and those attending schools with a larger proportion of economically disadvantaged students. Importantly, the study revealed that the policy had no discernible impact on high-achieving students or schools that served a higher proportion of students from more advantageous socioeconomic circumstances. These findings suggest that the introduction of the high school graduation exam may contribute significantly to narrowing the disparity in course enrollment among students from varying socioeconomic backgrounds, primarily by improving outcomes in schools with a higher concentration of economically disadvantaged students.

However, other studies suggest that high school exit exams may exacerbate social class-based inequalities (Reardon et al., 2010; Schiller & Muller, 2003). Extensive state-mandated testing appears to increase students' enrollment in higher-level mathematics courses, but such extensive testing did not reduce gaps in math course-taking patterns across different SES student groups (Schiller & Muller, 2003). Failing math sections of exit exams may decrease the likelihood of taking higher-level math courses the following year, but this does not significantly affect high school course-taking, achievement, persistence, or graduation for students near the passing score (Reardon et al., 2010). High school exit exam policies may negatively impact very low-achieving students, exacerbating educational inequalities. Moreover, low-income urban students who just fail the math exams are more likely to drop out of the school in the year following the test (Papay et al., 2010).

Longitudinal multi-site ethnographic studies have explored the effects of high school exit exams on STEM learning opportunities for socioeconomically disadvantaged and minoritized students in urban schools (Eisenhart & Weis, 2022; Weis et al., 2015). These studies indicate that state-mandated high school exams do not effectively reduce achievement gaps between groups and may lead schools to focus less on high-level math courses. Schools under intense exam pressure suggest that some teachers may shift attention away from high-level math courses, while other teachers may skip key portions of the curriculum, such as Trigonometry in an Algebra II/Trigonometry course (Eisenhart & Weis, 2022; Weis et al., 2015). So too, some schools no longer offer important four-year college gatekeeping math courses, such as Precalculus and Calculus (Eisenhart & Weis, 2022; Weis et al., 2015). This suggests that the presence of high-stakes exams has limitations in improving access to high-level math courses, particularly for low-income students in undercapitalized urban schools. In addition, school guidance counselors in such schools are overwhelmed with tasks related to accountability mandates and with students in crisis who are at risk of failing state-mandated high school exit exams, with consequent result that students who are *on* *track* to graduate are left entirely on their own to select their classes for senior year (Eisenhart & Weis, 2022; Nikischer et al., 2016). As a result, high-achieving students who want to study STEM majors after high school often take easier or non-college prep classes in their senior year to boost their GPA (Eisenhart & Weis, 2022). Such a slight difference at a point in time in mathematics course-taking sequences in high school can limit their future educational attainment (Eisenhart & Weis, 2022; Roderick et al., 2013; Sadler et al., 2014). However, more privileged students may have an advantage in passing the exams due to their access to a wider range of educational resources, leading to the accumulation of advanced math credits.

The primary contribution of the present study, compared to prior research, lies in its provision of national-level empirical evidence on the effects of high school exit exams on math course-taking patterns, while controlling for both student and school background characteristics. Previous qualitative studies have highlighted the potential widening of the gap in the highest level of math coursework based on SES due to exit exams. However, there has been a notable absence of empirical evidence to determine whether this finding holds true nationally after accounting for these background characteristics. Despite the increased recognition of the importance of consistent upward moves in mathematics course-taking sequence throughout high school years on future educational attainments (Eisenhart & Weis, 2022; Han et al., 2023; Roderick et al., 2013), there remains a lack of empirical examination on the degree to which high school exit exams are associated with students' mathematics course-taking histories throughout high school years, such as consistent upward moves throughout four years of high school.

Research Questions

This study extends prior research on exit exams and inequality in math course-taking, aiming to examine the association between exit exams and students' math course-taking patterns and how it may exacerbate or reduce inequalities based on student achievement levels and SES. This study contributes to the literature by examining not only diverse math course-taking outcomes but also math course-taking *histories* throughout high school years. We focus on three key questions:

First, is the existence of high school exit examinations associated with students' mathematics course-taking patterns, including linear progression throughout the high school years?

Second, does the association between high school exit examinations and mathematics course-taking patterns vary by prior student achievement levels?

Third, does the association between high school exit examinations and mathematics course-taking patterns vary by student SES levels?

Methodology

Data

We used the latest nationally representative high school cohort dataset, HSLS:09, which offers detailed information on student background, test scores, and high school transcripts. Our analysis focused on students in public schools who had complete transcript information from ninth grade through 12th grade as our study focuses on high school math course-taking sequences. We excluded those who transferred to different schools since the new school might have different graduation requirements, and those who left their first high school early.[1] The analytic sample size was 16,280.

HSLS:09 has limitations in examining the connection between state high school graduation requirements (specifically, exit exam policies) and student outcomes due to the absence of crucial information regarding the test-taking timing of high school exit exams and their subsequent results.

[1] In HSLS:09, a total of 17,320 public high school students had complete transcript information for all four years. We excluded 60 students who transferred and dropped out, and 420 who transferred and completed high school. Additionally, 560 students who attended one school through four years but left their first school early were also excluded.

Nevertheless, we opted to use this dataset as it offers detailed information on the course-taking sequences of the most recent nationally representative high school cohort.

Variables

From the HSLS transcript data, we established four dependent variables that can measure both the quantity and quality of math course-taking, along with detailed course-taking histories: a) a binary variable, *course-taking sequence*, indicating if a student followed a consistently upward trajectory in their math courses during high school; b) a continuous variable representing *the total number of math credits* a student earned; c) a binary variable indicating whether a student *completed Algebra II or above*; and d) a binary variable indicating whether a student *completed Precalculus or above*. To create the *course-taking sequence* variable, we followed several steps. First, we set up a hierarchical sequence of math courses. Following prior research on math course-taking in high school (e.g., Brown et al., 2018; Kelly, 2009; Riegle-Crumb, 2006; Schiller & Muller, 2003), the number of categories were reduced from thirteen to seven; Prealgebra, Algebra I, Geometry, Algebra II, Trigonometry, Precalculus and Calculus. Using this hierarchical sequence of math courses, we collected the highest level of math coursework per semester from the Fall of ninth grade to the Spring of 12th grade from transcript data. Using the eight semester time points (t) of math coursework a student took, we mapped an individual student's *curricular flows*. The *up* sequence indicates that a student took math in a hierarchical sequence during high school; that is, the level of math in $t + n$ (semester) is higher than the level of math in t.

In our analytic sample of HSLS:09 public school students, about 43% of students took their mathematics courses with upward movement into more advanced math courses during high school (we refer to this as being *on track*). For example, our designation *on track* would include the following: a) students took Algebra I in ninth grade, Geometry in 10th grade, Algebra II in 11th grade, and either Trigonometry or Precalculus in 12th grade; b) students who took Geometry in ninth grade, moved to Algebra II in 10th grade, Precalculus in 11th grade, and Calculus in 12th grade; and c) students who took Prealgebra in ninth grade, moved to Algebra I in 10th grade, Geometry in 11th grade, and Algebra II in 12th grade. However, about 57% of students did *not* show evidence of such upward moves (we refer to this as being *off track*). This proportion of off-track students in our analytic sample is quite consistent with prior research that has examined mathematics course-taking sequences using data from nationally representative high school students (including high school dropouts) in both public and private schools (Han et al., 2023). Consistent with prior research (Han et al., 2023; Brown et al., 2018; Finkelstein et al., 2012), non-upward sequence patterns over Grades 9-12 are very diverse, as evidenced in the following pattern instances; a) Algebra I – No Math – No Math – No Math; b) Geometry – Algebra II – No Math – No Math; c) Algebra I – Geometry – Algebra II – Algebra II; and d) Algebra I – Geometry – Prealgebra – Trigonometry. These examples indicate that approximately 57% of U.S. public school students exhibit the following mathematics course-taking patterns: 1) downward then upward moves, 2) staying on the same level of math courses, and 3) stopped taking math altogether. *Off-track* mathematics course-taking sequences tend to occur either in 11th or 12th grade, although some students experienced *off-track* sequences as early as ninth grade (Han et al., 2023).

We also examined the *number of math credits* a student earned as an outcome measure. This was measured by the total number of math Carnegie units a student *earned* at the end of high school. For example, suppose that a student earned four credits by taking Algebra I – Geometry – Algebra II – Prealgebra sequence. In this example, however, the additionally earned math credits in 12th grade (i.e., Prealgebra) do not necessarily improve students' math proficiency (Teitelbaum, 2003). Therefore, in this study, we also employed whether students complete Algebra II or above, and Precalculus or above at the end of high school as outcome measures. Researchers have long been interested in equity in overall degree attainments as well as STEM degree attainments (e.g., Riegle-

Crumb & King, 2010). Prior research has shown that Algebra II is a key course for admittance into most four-year colleges and universities and attainment of a bachelor's degree (Adelman, 2006; Attewell & Domina, 2008), while Precalculus or above is a key course for degree attainment in STEM fields (e.g., Burkam & Lee, 2003; Maltese & Tai, 2011; Tyson et al., 2007). While past research has explored the effect of state exams on AP calculus enrollment (e.g., Avery & Goodman, 2022), there remains a gap concerning the association between exit exams and Precalculus, a recommended prerequisite for AP calculus. In our analytic sample in HSLS:09, about 95% of public-school students attended high schools that offered advanced courses (i.e., Algebra II and Precalculus or above, respectively) on-site. Such advanced courses are available across differentially located high schools; however, inequality in the highest level of math completed is persistent over the past three decades (Domina & Saldana, 2012). For a comprehensive assessment about differences in math outcomes between exit exam and non-exit exam groups, it is imperative to examine these different mathematics course-taking outcomes. In our analytic sample, students earned, on average, 3.64 credits in mathematics; 80% of students completed Algebra II or above; and 33% of students completed Precalculus or above.

The key independent variable in our study is the high school exit exam policy. This refers to mandatory tests that students must pass to receive a high school diploma (Zhang, 2009). By 2009, 23 states had implemented high school exit exam policies on mathematics using either comprehensive or end-of-course exams.[2] Two states (i.e., Arkansas and Oklahoma) were in the process of phasing in exit exams, while the rest did not have a mandatory exam policy (Zhang, 2009).

[2] States with high school exit exams include Alabama, Alaska, Arizona, California, Florida, Georgia, Idaho, Indiana, Louisiana, Maryland, Massachusetts, Minnesota, Mississippi, Nevada, New Jersey, New York, North Carolina, Ohio, South Carolina, Tennessee, Texas, Virginia and Washington. One state (i.e., New Mexico) adopted a test policy for evaluating minimum competency of students. This state is not classified into the states with high school exit exams in our study.

Additional individual and school background variables in the analyses come from the HSLS:09 dataset: gender; the composite score of SES; race/ethnicity; standardized ninth grade math achievement score; and the math course a student took in the first year of high school, as well as their track placement. Prior research has shown that a student who began high school by taking Algebra I or higher is considered *on time* for reaching Algebra II or above by the end of high school (Riegle-Crumb, 2006). We therefore controlled for the first year of math a student took. We also included the indicator of track placement (general (reference), remedial, advanced, and honors/college). Following the approach adopted by prior studies (e.g., Domina & Saldana, 2012; Teitelbaum, 2003), we used standardized ninth grade math achievement scores as a proxy for a student's academic performance at the beginning of high school.

We also included high school urbanicity because prior research has shown that school characteristics (e.g., urbanicity and school types) are associated with student mathematics course-taking (Kelly, 2009). Because the number of years of mathematics required to meet high school graduation influences students' math outcomes (Teitelbaum, 2003), we included it as a school-level control variable. Since individual schools may require students to exceed state requirements, we included a school-level mathematics graduation requirement.

Statistical Techniques

First, we used multilevel modeling to explore the interrelationships among high school exit exams, student characteristics, and mathematics course-taking outcomes. HSLS:09 employs a stratified, two-stage random sample design with primary sampling units defined as schools selected in the first stage and students randomly selected from the sampled schools in the second stage. The multilevel model is appropriate for this sample design, with student-level covariates represented as Level 1 and school-level covariates as Level 2. While our preference would be to analyze the random variations in the relationships between high school exit exams and mathematics outcomes across different states, we must acknowledge that the HSLS:09 dataset does not possess the necessary statistical power to conduct such analyses effectively. This limitation stems from the fact that the HSLS:09 data were not originally structured to accurately represent public school students at the state level. Consequently, it is not feasible to estimate three-level models where students are nested within schools and, in turn, within states. As a result, our analysis focuses on two-level hierarchical models, with individual students as the units at level 1 and schools as the units at level 2. The exit exam variable was included at the school level. All student variables (Level 1) were grand-mean centered, and school-level variables (Level 2) are uncentered. For course-taking patterns and completion of advanced math courses, we employed hierarchical generalized linear models (HGLMs) and for the number of credits completed, we used hierarchical linear models (HLMs).

Previous studies have shown that covariates included in our multilevel models are simultaneously related to the likelihood of attending a school with a state exam policy and to mathematics course-taking patterns (Carnoy & Loeb, 2002; Jacob, 2001). Thus, the estimated results from HLMs may lead to an overestimation of the coefficients and standard errors of exit exams (Guo & Fraser, 2015). To address this limitation in the multilevel analysis, we further adopt inverse probability weighting (IPW) (Hirano et al., 2003). IPW builds on propensity score matching that employs a predicted probability of group membership – exit exam versus non-exit exam groups – based on observed predictors which are used for matching (Rosenbaum & Rubin, 1983). IPW yields this matching by assigning differential weights to individuals based on the inverse probability of attending a high school in states with high school exit exams at given other covariates. Individuals are assigned smaller (larger) weights if their observed status of exit exams is overrepresented (underrepresented), given their covariates. To do so, first, we estimated the propensity score, which is each student's likelihood of attending school with state exam policy given his or her vector of observed covariates using logistic regression. We then calculated propensity score weighting estimates (Guo & Fraser, 2015, p. 244). Finally, applying these obtained weights, we estimated the average differences of the math course-taking outcomes between exit exam and non-exit exam groups. For IPW estimation, we checked for the balance of the covariates in both the exam and non-exam groups by comparing how far apart they were before and after the sample was weighted using the estimated IPW. Table 1 presents absolute standardized differences between exam and non-exam groups before and after matching. The absolute standardized differences for all covariates after IPW were less than 0.1, indicating that the bias was substantially reduced and we had well-balanced covariates (Stuart et al., 2013).

Table 1
Covariate Balance between Treatment and Control Group: Absolute Standardized Difference Before and After Matching

	Inverse-probability weighting (IPW)	
Covariates	Before matching	After matching
Math requirement (ref. = 4 years)		
Below 3 years	0.23	0.00
3 years	0.14	0.01
Race (ref. = White)		
Black	0.01	0.01
Hispanic	0.11	0.00
Asian	0.00	0.00
Native/Indian	0.04	0.00
Socioeconomic status (SES)	0.07	0.00
Female (ref. = male)	0.02	0.00
Ninth grade math score	0.06	0.00
Started math coursework (ref. = Prealgebra)		
Algebra 1	0.26	0.00
Geometry	0.02	0.01
Algebra 2 or above	0.32	0.00
Rigor level (ref.= general)		
Remedial	0.06	0.01
Advanced	0.10	0.01
Honors/College	0.06	0.00
Urbanicity (ref. = urban)		
Suburban	0.10	0.02
Rural	0.07	0.01

School mean SES	0.15	0.00

Note. *N*=16,280

The associations between educational policies and education outcomes can be misleading, as they often have distributional associations (e.g., Jacob, 2001). Thus, we conducted subsample analyses to estimate heterogeneity in the associations between exit exams and mathematics course-taking across different groups by ninth grade math score and SES (e.g., Grodsky et al., 2009; Penner et al., 2015). Using ninth grade math standardized test scores and SES, we created four quartiles: bottom-, lower-middle-, upper-middle-, and top-quartiles. We then ran models using IPW techniques across the four quartiles, respectively. Balance checks before and after IPW across four subgroups are conducted (see Appendix Table A2).

This study attempted to address the endogenous issue of observable confounding factors that increased internal validity of the analysis, but our estimation strategies still have limitations. Above all, when there are unobservable differences in characteristics between students at schools with state exam policies and those at schools without such policies, IPW may obscure the relationship we attempt to investigate. In other words, IPW does not take into account unobservable confounders that may affect estimates, leading to an overestimation or underestimation of the actual effect. Nevertheless, given the limitations inherent in observational data, we are unable to address all these issues comprehensively. Exit exams are generally given later in high school. *Off-track* mathematics course-taking sequences also tend to occur either in 11th or 12th grade (Han et al., 2023). However, our data do not allow us to examine whether off-track math course-taking sequences occur after they take high school exit exams. The timing of exit exams varies among subjects and students. For instance, in New York state, students have the opportunity to take Regents exams (high school exit exams) from grades 9 to 12. Therefore, the associations between high school exit exams and on-track/off-track math course-taking sequences should be interpreted with caution.

Since there were many cases with missing data for student background variables, such as ninth grade math achievement scores and SES, the multiple imputation by chained equation technique was used to replace missing values, in order to retain as many cases as possible. We estimated the coefficients and standard errors from 20 imputed datasets in order to enhance the power of our analysis (Graham et al., 2007).

Results

Associations Between High School Exit Exams and Mathematics

Table 2 presents results from multilevel models examining the associations between exit exams and mathematics course-taking outcomes. All student-level control variables except for race/ethnicity were significant predictors of mathematics course-taking outcomes. After controlling for prior achievement and school characteristics, there are no differences in math course-taking outcomes between Whites and minoritized students (defined as Black and Latinx), while students from higher SES background are more likely to achieve better mathematics course-taking outcomes. For instance, as shown in panel A of Table 2, a one standard deviation increase in SES is associated with increase in the odds of taking mathematics with an *up* sequence (considered *on track*) by 13% ($\exp(\beta) = 1.13$, $p < .001$). Results in panel B indicate that higher SES students tend to earn more math credits ($\beta = .14$, $p < .001$). Likewise, results in panel C and D show that a one standard deviation increase in SES is associated with increase in the likelihood of completing Algebra II or above and Precalculus or above by 48% ($\exp(\beta) = 1.48$, $p < .001$) and 46% ($\exp(\beta) = 1.46$, $p < .001$) respectively. Results in panel D indicate that girls are more likely than boys to achieve better mathematics course-taking outcomes, with girls being 25% more likely to complete Precalculus (exp(β) = 1.25, p < .001).

Consistent with prior research (Domina & Saldana, 2012; Frank, et al., 2008; Schiller & Hunt, 2011; Kelly, 2009), results also indicate that prior achievement is associated with mathematics course-taking outcomes. When students have positional advantage in ninth grade in terms of standardized test scores, they are more likely to take advanced level of mathematics with *up* sequences and earn more credits in math. For instance, as shown in panel A of Table 2, a one standard deviation increase in ninth grade math standardized score is associated with increase in the odds of taking mathematics with an *up* sequence throughout high school years by 4% (exp(β) = 1.04, p < .001). Likewise, results in panel D indicate that a one standard deviation increase in ninth grade math standardized score is associated with increase in the odds of completing Precalculus or above by 10% (exp(β) = 1.10, p < .001).

Finally, the findings indicate that students who attended schools in states with high school exit exams are less likely to take mathematics with *upward* sequences (classified as *on track* for our purposes), even after taking into account student- and school-level characteristics, such as race/ethnicity, SES, ninth grade math scores, and the first-year high school math course taken. Likewise, students who attended schools in states with high school exit exams earned fewer math credits. For instance, as presented in panel A of Table 2, students at schools with high school exit exams have less odds of taking mathematics with consistent upward moves by 24% (exp(β) = .76, p < .001). In such states, as shown in panel B, students earn .19 fewer math credits compared to students in schools without these policies (β = –.19, p < .001).

Table 2

Results of Hierarchical Logit Models and Hierarchical Linear Model to Explain Variation in Math Sequence, Math Credit, and Highest Coursework for Public Schools in HSLS:09-Full Sample

	Panel A Up			Panel B Math credits		Panel C Algebra 2 or above			Panel D Precalculus or above		
	β	*OR*	*SE*	*β*	*SE*	*β*	*OR*	*SE*	*β*	*OR*	*SE*
Intercept	-0.34***	0.71	0.09	3.90***	0.05	4.54	93.88	78.81	-1.53***	0.22	0.13
School-level											
Exam policy	-0.27***	0.76	0.08	-0.19***	0.04	-0.05	0.95	0.10	0.34***	1.41	0.11
Math graduation requirement (ref. = 4 years)											
Below 3 years	0.01	1.01	0.15	-0.54***	0.09	-0.96***	0.38	0.18	-0.41	0.66	0.22
3 years	0.08	1.09	0.08	-0.34***	0.05	-0.39***	0.67	0.10	-0.09	0.92	0.11
School mean SES	0.26*	1.30	0.12	0.09	0.06	0.52***	1.68	0.15	0.08	1.08	0.16
Urbanicity (ref. = urban)											
Suburban	0.24**	1.27	0.09	0.03	0.05	0.23*	1.25	0.11	0.17	1.18	0.13
Rural	0.17	1.18	0.10	0.08	0.05	0.31**	1.37	0.12	0.05	1.05	0.14
Student-level											
Race (ref. = White)											
Black	0.01	1.01	0.07	0.09**	0.03	0.07	1.08	0.09	-0.13	0.88	0.10
Hispanic	0.05	1.05	0.05	-0.01	0.02	0.00	1.00	0.07	-0.05	0.95	0.07
Asian	0.10	1.11	0.08	0.17***	0.04	0.32*	1.37	0.13	0.74***	2.10	0.10
SES	0.12***	1.13	0.03	0.14***	0.01	0.39***	1.48	0.05	0.38***	1.46	0.04
Female (ref. = male)	0.10**	1.11	0.04	0.10***	0.02	0.35***	1.42	0.05	0.23***	1.25	0.05
Ninth grade math score	0.04***	1.04	0.00	0.02***	0.00	0.07***	1.07	0.00	0.10***	1.10	0.00
Started math coursework (ref. = Prealgebra)											
Algebra 1	0.11	1.11	0.07	0.03	0.03	1.24***	3.46	0.08	1.23***	3.40	0.14
Geometry	-0.25***	0.78	0.08	-0.04	0.04	2.00***	7.36	0.11	2.88***	17.90	0.15
Algebra 2 or above	-2.09***	0.12	0.11	-0.06	0.05	-	-	-	2.47***	11.84	0.16
Rigor level (ref. = general)											
Remedial	-0.72***	0.49	0.12	0.02	0.06	-0.99***	0.37	0.14	-1.28***	0.28	0.26
Advanced	0.29***	1.33	0.08	0.35***	0.04	0.03	1.03	0.12	0.58***	1.78	0.10
Honors/College	0.19**	1.21	0.07	0.15***	0.04	1.08***	2.95	0.18	1.33***	3.79	0.10
N											
Students		16, 280		16, 280			16, 280			16, 280	
Schools		758		758			758			758	
Variance Components											
School-level											
Intercept	0.85*			0.49*		0.90*			1.17*		
Residual				1.08							
Intraclass Correlation Coefficient (ICC)	0.18			0.17		0.20			0.29		

Note: *β*= Coefficient, *OR*= Odds Ratio, *SE* =Standard Error. * *p* <.05, ** *p* < .01, *** *p* < .001

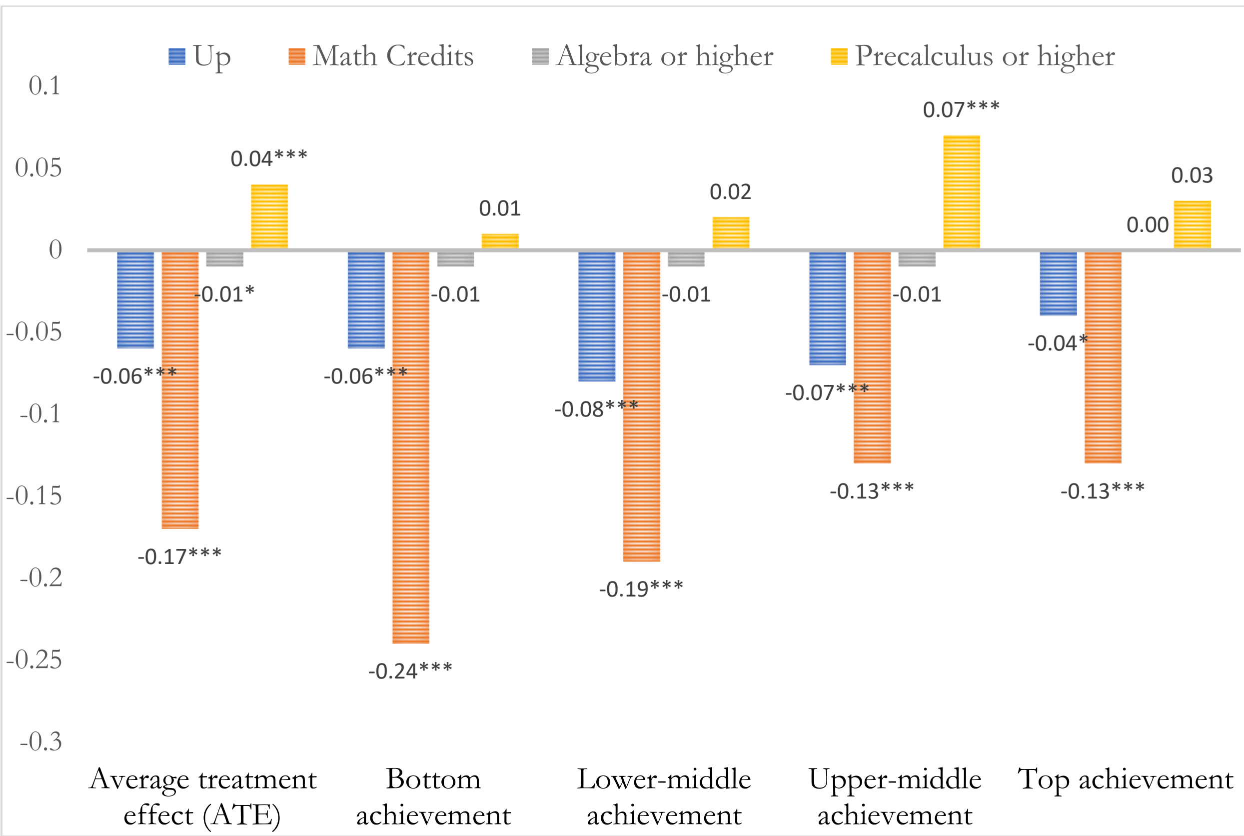
However, the analyses of the highest math levels reveal inconsistent findings. As presented in panel C and D, while there was no significant association between exam policies and the probability that students completed Algebra II or above, exam policies had positive associations with the probability that students completed Precalculus or above. As shown in panel D of Table 2, students who attended schools in states with high school exit exams were more likely to complete Precalculus or above by 41% ($\exp(\beta) = 1.41$, $p < .001$), after controlling for individual and school-level characteristics, such as race, gender, SES, prior math achievement, and school-level math credit requirement for graduation.

Additionally, although examining the association between the number of years of mathematics requirements and student outcomes was not a major purpose of this study, it is nevertheless worthwhile to examine these results. As described in the methods section of our study, we took into account a school-level requirement for the number of years students must complete in mathematics. Consistent with prior research (Teitelbaum, 2003), analytic results in Table 2 show that students who attended schools with higher graduation requirements in mathematics tended to earn higher mathematics credits and complete advanced levels of mathematics. When schools required students to earn three credits in mathematics, for example, as shown in panel B, students earned .34 units lower in math credits than students enrolled at schools that required them to earn four credits in mathematics ($\beta = -.34$, $p < .001$). Similarly, as shown in panel C, when schools required students to earn three credits in mathematics, students were less likely to complete Algebra II or above by 33%, compared to students enrolled at schools that required them to earn four credits in mathematics ($\exp(\beta) = .67$, $p < .001$). However, results in panel A indicate that the rigorous mathematics credit requirement was not associated with students' upward mathematics course-taking patterns.

Next, we utilized IPW to examine the association between high school exit exam policy and the mathematics course-taking outcomes to address potential endogeneity issue. Figures 1 and 2 present average differences in math course-taking outcomes between exit exam and non-exit exam groups.

Figure 1

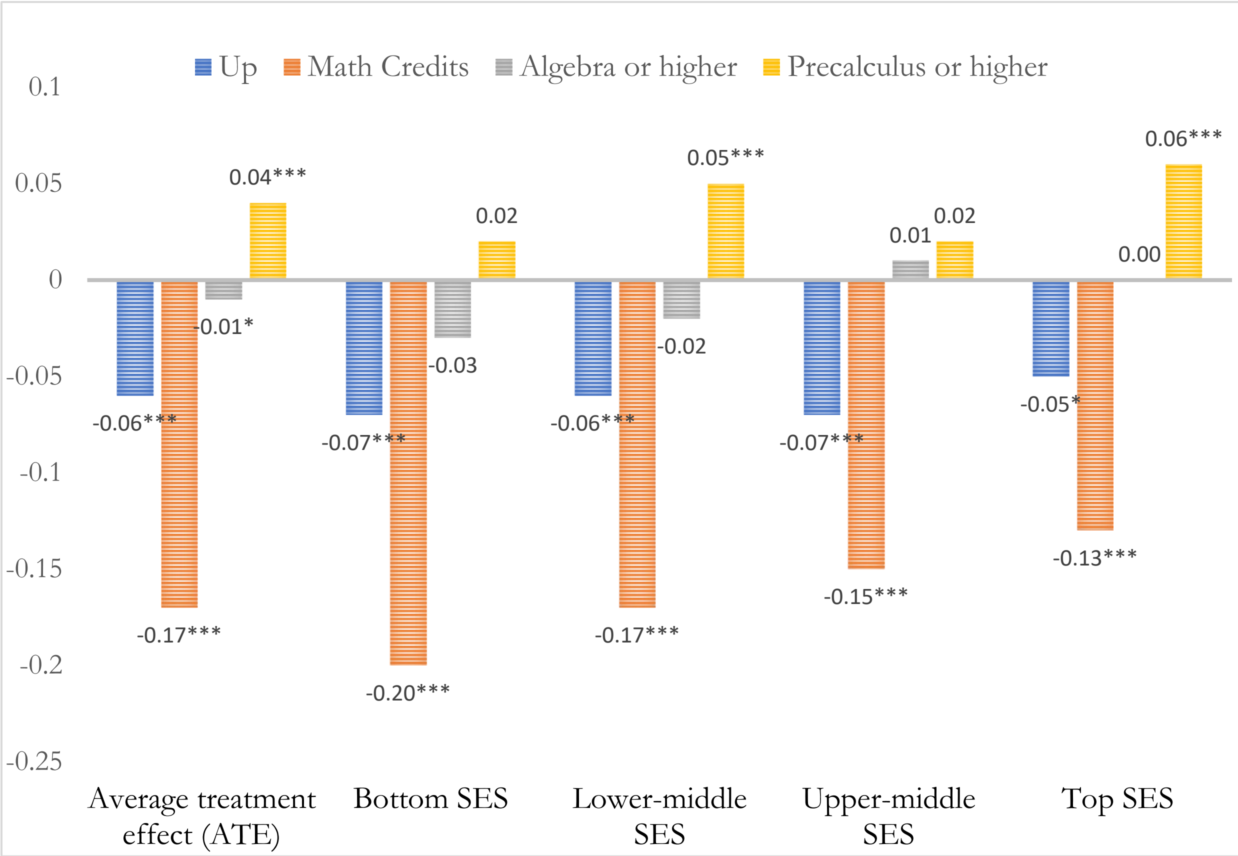
Average Treatment Effect (ATE) of High School Exit Exams, by Prior Achievement



* p <.05, ** p < .01, *** p < .001

Figure 2

Average Treatment Effect (ATE) of High School Exit Exams, by SES



* p <.05, ** p < .01, *** p < .001

Consistent with multilevel analyses, the results from the full sample of IPW analyses in Figures 1 and 2 reveal the significant negative association between high school exit exams and the likelihood of taking mathematics with upward moves ($ATE = -.06$, $p < .001$), and the number of credits earned ($ATE = -.17$, $p < .001$). There is also a significant, although very small, negative association between high school exit exam and the likelihood of completion of Algebra II or above ($ATE = -.01$, $p < .05$). Finally, we find a significant positive association between high school exit exams and the completion of Precalculus or above ($ATE = .04$, $p < .001$).

Variations in the Associations Between High School Exit Exams and Math Course-Taking by Prior Performance and SES Quartiles

Next, we assessed if these associations vary across student prior achievement and SES levels (see Figures 1 and 2, respectively). For IPW estimation by performance and SES quartiles, we checked for the balance of the covariates in both the exam and non-exam groups in each subgroup by comparing how far apart they were before and after the sample was weighted using the estimated IPW. Table A2 presents absolute standardized differences between exam and non-exam groups before and after matching by performance and SES quartiles, respectively.

Once we disaggregate students by their ninth-grade standardized test scores and SES, it becomes clear that the negative associations between high school exit exams and the probability of taking mathematics with an *upward* sequence and the number of credits earned occur across all students. As shown in Figure 1, for example, the estimated differences by exit exam in the likelihood of taking mathematics with upward moves are –.06, –.08, –.07, and –.04 for bottom, lower-middle, upper-middle, and top quartile achievement groups, respectively. Similarly, as presented in Figure 2, the estimated differences between exit exam and non-exit exam groups in the likelihood of taking mathematics with upward moves are –.07, –.06, –.07, and –.05 for bottom, lower-middle, upper-middle, and top quartile SES, respectively.

However, subsample analyses reveal that the positive effect of high school exit exams on the completion of Precalculus or above varied across prior achievement scores and SES. For example, as shown in Figure 1, the positive effect of exit exams occurs primarily among upper-middle-quartile achieving students ($ATE = .07$, $p < .001$), whereas the effect of high school exit exams on the completion of Precalculus or above is not statistically significant among bottom-, lower-middle-, and top-quartile achieving students. This indicates that neither relatively low performing students nor highest achieving students' likelihood of finishing Precalculus or above were influenced by high school exit exam policies. We also found that the positive effect of high school exit exams on the completion of Precalculus or above varied across SES. As shown in Figure 2, the positive effect of exit exams occurs primarily among lower-middle (ATE = .05, p < .001), and top-quartile SES students (ATE = .06, p < .001), whereas the effect of high school exit exams on the completion of Precalculus or above is not statistically significant among bottom-, and upper-middle-quartile SES students.

To check the robustness of our findings from the multilevel and IPW analyses, we conducted subsample analyses. HSLS:09 was originally designed to be representative of ninth-grade students in the 2009 across the United States (i.e., a national design), but the design was augmented with additional sample public schools to render them state-representative within 10 states. We replicated multi-level and IPW analyses using a subset of 10 state representative samples in HSLS:09. The results of multilevel analyses are presented in Appendix Table A1 and the IPW analyses results are presented in Appendix Tables A3. The analyses reveal mostly consistent findings across both the full sample and the subsample analyses. For example, as shown in Table A3 in Appendix, in these ten states, high school exit exams showed a significant negative effect on upward math course-taking (ATE = –.11, p < .001) and math credits earned (ATE = –.42, p < .001), while having a positive effect on the completion of Precalculus or higher-level courses (ATE =.06, p < .001). The detailed results indicate that the negative effect on math credits earned is particularly severe, ranging from –.25 (p < .001) to –.54 (p < .001) across various SES and achievement quartiles.

In sum, our findings indicate that when exit exams exist, students differentially benefit depending on their location in the structure of opportunity—in this case, specifically as linked to their position with regard to prior achievement (here defined as ninth grade standardized test scores) as well as SES.

Discussions and Conclusions

While ethnographic studies have described the negative influence of exit exams on students' mathematics course-taking patterns in underresourced urban schools (Eisenhart & Weis, 2022; Weis et al., 2015), there are few quantitative studies on this topic. Our study examined the degree to which high school exit exams are associated with both the quantity and quality of math course-taking, along with detailed course-taking histories. Our study shows that students attending public schools in states with high school exit exam policies exhibit notably less linear and appropriately scaffolded trajectories (*off track*) from ninth grade to 12th grade compared to similar students in states without such policies. Our findings align with the results obtained from the California sample (Reardon et al., 2010), revealing that low-performing students in states with exit exam policies, who are more likely to fail a state math exam, tend to either repeat the same level in the next semester or, at worst, drop out of math coursework entirely. Moreover, our longitudinal analysis throughout high school years reveals that exit exams also exhibit a negative correlation with the number of mathematics credits earned. When students retake the same level of math due to low grades or failure on state exit exams, students do not earn additional credit for that repeated math course, resulting in a lower total of mathematics credits earned throughout high school in states with exit exams.

More importantly, our study found consistent negative links between state exit exams, consistent upward progression, and earned credits, regardless of prior math achievement and SES. Our findings suggest that the detrimental impact of exit exams on math course-taking sequences extends beyond students who fail state math exams. While our study is unable to directly test mechanisms for this negative correlation, prior qualitative research provides some potential explanations. Even students who are less likely to fail these exams, including high-achieving students in urban underresourced schools, often lack pragmatic guidance and support in selecting math courses with consistent upward progression (Eisenhart & Weis, 2022; Nikischer et al., 2016; Weis et al., 2015). As a result, many of these students end up with *off-track* sequences in their senior year, as counselors and teachers tend to prioritize support for students at risk of failing high school exit exams that are linked to high school graduation (Eisenhart & Weis, 2022; Nikischer et al., 2016; Weis et al., 2015). Similarly, in Chicago public schools, numerous students opt for an easy senior year by not taking math, science, or AP courses, focusing solely on meeting requirements for graduation without exceeding them (Roderick et al., 2013, p. 11). While these prior qualitative studies revealed students' lived experiences in math course-taking patterns in particularly located schools in the structure of opportunity, it is difficult to generalize these findings to a national level. Our study provides empirical evidence supporting findings from these previous qualitative studies, highlighting the negative impacts of exam policies on the consistent upward progression of math courses for average- or well-performing students.

Our study revealed that the associations between exit exams and student outcomes vary depending on different mathematics course-taking outcomes. Our study found that exit exams have a *positive* association with the likelihood of completing Precalculus or above, while it has an insignificant association with completion of Algebra II or above. Although we cannot assess what produces these associations, as secondary quantitative data used in our study cannot readily account for this, it is arguably the case that the existence of a high school exit exam policy may work to "normalize" expectations and actualization of higher-level math taking for increased numbers of particularly located (and privileged, on a range of dimensions) students. In other words, the very existence of exit exams may "up the ante" by encouraging more students who occupy *particular locations* in the structure of opportunity to work towards passing these exams, thereby moving to the next level (see, for example, Domina & Saldana, 2012). This could explain why it is that students who attended schools in states with high school exit exams were, as noted above, more likely to complete Precalculus or above, after controlling for individual and school level characteristics. As the vast majority of students complete Algebra II, to begin with, we would not expect a commensurate difference between exit exam and non-exit exam groups at this level, which is, in fact, what we find.

Consistent with the results of high school exit exams, we found that rigorous math credit requirements were positively associated with completion of advanced math courses. This gives credence to our argument that exit exam requirements may work to normalize what schools do and what they expect. In other words, if exit exams are available, this normalizes higher level math taking patterns by virtue of the fact that schools expect increased numbers of students to sit these examinations and move to the next level.

Our study revealed varying associations between exit exams and student outcomes based on students' prior math performance and SES, regarding different mathematics course-taking outcomes. As discussed above, the negative associations between state exit exams, trends on upward course-taking sequences and earned credits are consistent across subgroups by prior math achievement and SES. Our main finding, however, is that there is substantial distributional association between the high school exit exam and completion of Precalculus or above across student prior achievement and socioeconomic status dimensions. In other words, although we observe some benefit to exam policy for particularly located students, this policy could be differentially experienced, with the no significant positive outcomes for those who arguably must benefit the most from high school exit exams policy. Lower SES and lower-achieving students' completion of advanced level of mathematics courses (i.e., Precalculus or above) did not vary across the existence of exit examinations, whereas higher SES and higher-achieving students are more likely to complete advanced level of mathematics courses than comparable students who attended schools in states without such policies.

Our results suggest that these exit exam policies fail to improve the most disadvantaged students' learning in mathematics while giving increased opportunity for more highly capitalized students to pull away and *distinguish* themselves in relation to those most disadvantaged. Although exit exam policies are largely geared towards increasing opportunities and options for those most disadvantaged in the United States, such policies perhaps unwittingly appear to offer those most advantaged to pull away even further from the group that was intended to be the primary beneficiary. In line with this, there is clearly a need for in-depth qualitative research on structural barriers and the negative associations between exit exams and these most disadvantaged students' mathematics learning, as well as the ways in which those most advantaged are able to capitalize upon intensified curricular demands. If this is the case, the question arises: who was intended to benefit most from this exit exam and who actually benefits? Most importantly, what can we do to alter the arc of capital accumulation via this particular set of exit exam policies?

Our findings hold significant implications for district administrators, principals, guidance counselors, and teachers, particularly in underresourced urban public schools. While these stakeholders have traditionally focused on achievement scores, test pass rates, and highest levels of math achievement, little attention has been given to students' detailed experiences, such as their specific math course progression histories throughout their four years of high school and how they are linked to highest math course completion (Finkelstein et al., 2012). In states with exit exam policies, it is important for administrators, principals, counselors, and teachers to pay attention to students' consistent upward course-taking histories alongside their performance in mathematics. They should develop strategies to facilitate consistent upward progression in math courses for students. By understanding and addressing consistent upward course-taking patterns, they can gain deeper insights into performance issues in mathematics and potentially alter the current trajectory of capital accumulation associated with this exit exam, particularly in math.

Our study has a limitation concerning the variation in rigor and content of mathematics curriculum across schools, districts, and states. The specific topics being studied and their level of difficulty play a significant role in student's learning opportunities. However, the high school transcript data available in HSLS:09 do not provide us with the means to capture these variations across schools and states (Oakes, 2005; Schmidt et al., 2011). Even though the majority of students in states with high school exit exams are more likely to take Precalculus or above, for example, our study cannot tell if high and middle SES students are exposed to the *same* Precalculus content.

Second, our study did not take into account different types of high school exit exams (e.g., comprehensive or end-of-course) and the varying grade levels in which a student can take an exit exam. Specific math subjects tested vary across states. For example, some states (including Indiana, Michigan, and New York) test certain subjects such as Algebra I, Algebra II, and Geometry (Zhang, 2009). Future studies should investigate the degree to which this varying profile of state exam policies affects student mathematics course-taking outcomes.

In addition, future research needs to critically examine recent shifts in high school exit exam policies, particularly the implementation of diversified diploma options and alternative assessment methods, on student outcomes and educational equity. The evolving landscape of educational policies, marked by a decline in high school exit exams and changes in their nature, necessitates longitudinal comparative studies to elucidate their nuanced effects on mathematics course-taking patterns and overall student achievement within varying sociocultural contexts. It is pivotal to investigate the types of individual characteristics, background factors, and school resources that contribute to the differential effects of exit exams on students from diverse socioeconomic backgrounds and with varying levels of prior academic achievements. Such research is essential for developing informed policies that can better address educational disparities and foster more equitable learning environments for all students.

Third, in our multilevel models, we included a high school exit exam indicator at school level rather than state level due to a limitation of sampling design in HSLS:09 data set. Thus, our results should be interpreted with caution. Future studies can benefit from using state-level longitudinal data and implementing rigorous quasi-experimental design (e.g., regression discontinuity) to compare student outcomes within states over time. These studies can assess pass or fail effects of state exit exams on student outcomes, including consistent upward course-taking moves. Furthermore, qualitative studies are needed to investigate the factors that explain different timing of off-track sequences, considering that even average- or well-performing students may experience such sequences. This approach will enhance our understanding of the issues of interest and build upon and expand the findings presented here.

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Appendix

Table A1

Results of Multi-level Models to Explain Variation in Math Course-Taking, Subsample of Ten States

	Up			Math Credit		Algebra II or Above			Precalculus or Above		
	β	*OR*	*SE*	*B*	*SE*	*β*	*OR*	*SE*	*β*	*OR*	*SE*
Intercept	-0.25*	0.78	0.12	4.10***	0.07	4.50	90.26	78.35	-1.67***	0.19	0.16
School-level											
Exam policy	-0.47***	0.63	0.11	-0.38***	0.06	0.13	1.13	0.14	0.63***	1.88	0.15
Math graduation requirement (ref. = 4 years)											
Below 3 years	0.09	1.10	0.19	-0.60***	0.11	-1.34***	0.26	0.21	-0.70**	0.50	0.27
3 years	0.07	1.07	0.12	-0.30***	0.07	-0.62***	0.54	0.14	-0.23	0.80	0.16
School mean SES	0.17	1.18	0.15	-0.01	0.08	0.64***	1.90	0.19	-0.06	0.94	0.20
Urbanicity (ref. = Urban)											
Suburban	0.16	1.18	0.12	-0.03	0.07	0.07	1.07	0.14	0.00	1.00	0.16
Rural	0.11	1.12	0.13	0.06	0.07	0.26	1.30	0.15	0.11	1.11	0.17
Student-level											
Race (ref. = White)											
Black	-0.02	0.98	0.10	0.08	0.05	0.01	1.01	0.12	-0.23	0.80	0.13
Hispanic	0.02	1.02	0.07	0.00	0.03	-0.01	0.99	0.09	-0.02	0.98	0.09
Asian	0.12	1.13	0.10	0.12**	0.05	0.23	1.26	0.17	0.65***	1.91	0.12
SES	0.10*	1.10	0.04	0.15***	0.02	0.42***	1.53	0.06	0.38***	1.47	0.05
Female (ref. = Male)	0.02	1.02	0.05	0.09***	0.02	0.39***	1.48	0.07	0.20***	1.22	0.06
Ninth grade math score	0.04***	1.04	0.00	0.02***	0.00	0.07***	1.07	0.00	0.10***	1.11	0.00
Started math coursework (ref. = Prealgebra)											
Algebra I	0.01	1.01	0.10	-0.02	0.05	1.08***	2.95	0.11	0.71***	2.02	0.18
Geometry	-0.35***	0.71	0.11	-0.09	0.06	1.89***	6.59	0.15	2.48***	11.89	0.19
Algebra II or above	-2.21***	0.11	0.14	-0.16**	0.06	-	-	-	2.14***	8.53	0.20
Track placement (ref. = General)											
Remedial	-0.88***	0.41	0.17	0.03	0.08	-0.90***	0.41	0.19	-1.26***	0.28	0.38
Advanced	0.47***	1.60	0.10	0.32***	0.05	0.13	1.14	0.16	0.59***	1.80	0.12
Honors/College	0.15	1.16	0.10	0.10*	0.05	0.72***	2.05	0.22	1.17***	3.22	0.12
N											
Students		9,005		9,005			9,005			9,005	
Schools		447		447			447			447	
Variance components											
School-level											
Intercept	0.88*			0.53*		0.91*			1.17*		
Residual				1.08							
Intraclass correlation coefficient (ICC)	0.19			0.19		0.20			0.29		

Note: *β*= Coefficient, *OR*= Odds Ratio, *SE* =Standard Error. * p <.05, ** p < .01, *** p < .001

Table A2

Covariate Balance Check; Absolute Standardized Difference Before and After Matching Across Achievement and SES Quartile in Total Sample

	Ninth Grade Mathematics Score Quartile in Total Sample (*N*=16,280)								SES Quartile in Total Sample (*N*=16,280)							
	Bottom Quartile		Middle Quartile		Upper Middle Quartile		Top Quartile		Bottom Quartile		Middle Quartile		Upper Middle Quartile		Top Quartile	
Covariates	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Math requirement (ref. = 4 years)																
Below 3 years	0.26	0.01	0.15	0.00	0.21	0.01	0.30	0.03	0.24	0.01	0.22	0.01	0.23	0.00	0.24	0.01
3 years	0.10	0.00	0.16	0.00	0.15	0.00	0.14	0.01	0.05	0.01	0.12	0.00	0.16	0.01	0.21	0.01
Race (ref. = White)																
Black	0.01	0.01	0.05	0.00	0.04	0.01	0.02	0.01	0.04	0.01	0.00	0.01	0.04	0.00	0.01	0.01
Hispanic	0.12	0.01	0.10	0.01	0.14	0.00	0.06	0.01	0.11	0.01	0.13	0.01	0.12	0.00	0.05	0.01
Asian	0.00	0.01	0.06	0.01	0.02	0.00	0.02	0.00	0.02	0.01	0.03	0.01	0.01	0.00	0.02	0.01
Native/Indian	0.00	0.01	0.05	0.01	0.06	0.00	0.05	0.00	0.03	0.00	0.03	0.00	0.07	0.01	0.02	0.00
SES	0.08	0.02	0.01	0.00	0.09	0.01	0.03	0.01	0.07	0.01	0.02	0.01	0.02	0.01	0.05	0.01
Female (ref. = male)	0.05	0.01	0.08	0.01	0.01	0.01	0.03	0.00	0.06	0.00	0.00	0.00	0.01	0.01	0.00	0.01
Ninth grade math score	0.05	0.01	0.04	0.00	0.01	0.00	0.02	0.00	0.06	0.01	0.04	0.01	0.00	0.00	0.04	0.00
Started math coursework (ref. = Prealgebra)																
Algebra 1	0.27	0.02	0.26	0.00	0.30	0.01	0.19	0.03	0.31	0.00	0.28	0.00	0.24	0.00	0.18	0.01
Geometry	0.05	0.01	0.02	0.01	0.02	0.01	0.07	0.03	0.07	0.01	0.02	0.01	0.05	0.00	0.01	0.02
Algebra 2 or above	0.33	0.01	0.32	0.01	0.37	0.00	0.25	0.00	0.38	0.01	0.33	0.00	0.34	0.00	0.22	0.00
Track placement (ref.= general)																
Remedial	0.10	0.01	0.05	0.00	0.10	0.00	0.05	0.01	0.09	0.01	0.11	0.01	0.03	0.01	0.04	0.00
Advanced	0.07	0.00	0.13	0.01	0.10	0.01	0.07	0.02	0.13	0.00	0.17	0.00	0.09	0.01	0.01	0.01
Honors/College	0.16	0.01	0.03	0.01	0.05	0.00	0.16	0.00	0.04	0.00	0.01	0.01	0.01	0.01	0.15	0.00
Urbanicity (ref. = Urban)																
Suburban	0.10	0.03	0.06	0.01	0.11	0.01	0.11	0.02	0.08	0.03	0.09	0.02	0.06	0.02	0.14	0.01
Rural	0.04	0.01	0.04	0.00	0.03	0.01	0.15	0.02	0.06	0.01	0.04	0.02	0.09	0.01	0.08	0.01
School mean SES	0.14	0.01	0.11	0.00	0.11	0.00	0.20	0.00	0.16	0.02	0.12	0.00	0.07	0.01	0.20	0.01

Table A3

Results of Inverse-Probability Weighting, Average Treatment Effect of Exam Policy on Math Course-Taking, Subsample of Ten States

		Up	Math credit	Algebra II or above	Precalculus or above
Average Treatment Effect (ATE)		-.11*** (.01)	-.42*** (.03)	-.02 (.01)	.06*** (.01)
Ninth Grade Achievement Quartile	Bottom	-.11*** (.03)	-.54*** (.08)	-.03 (.03)	.02 (.02)
	Lower-Middle	-.14*** (.03)	-.40*** (.07)	.00 (.02)	.02 (.02)
	Upper-Middle	-.12*** (.03)	-.34*** (.06)	.00 (.02)	.09*** (.02)
	Top	-.05* (.03)	-.26*** (.06)	.01 (.01)	.08** (.02)
SES Quartile	Bottom	-.13*** (.03)	-.51*** (.08)	-.05 (.03)	.04 (.02)
	Lower-Middle	-.10*** (.03)	-.38*** (.07)	.00 (.02)	.08*** (.02)
	Upper-Middle	-.13*** (.03)	-.39*** (.06)	.02 (.02)	.03 (.02)
	Top	-.09*** (.03)	-.25*** (.05)	-.01 (.01)	.10*** (.02)

Note: Standard errors in parentheses. * $p < .05$, ** $p < .01$, *** $p < .001$