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A critical validation of high-stakes testing: Lessons from the effect of high school exit exam policy on rigorous mathematics coursework in the United States*

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Abstract

This study examines the impact of the exit testing policy on students' advanced-level course-taking in mathematics in the United States. Using three cohorts of a national dataset, we conducted a difference-in-difference model to reveal whether using high school exit exam policies contributes to students' completion of rigorous coursework in mathematics. The analysis shows no evidence that the probability of students completing Algebra II or above and Precalculus or above increased in states with high school exit exam policies. With regard to the expanding trend of rigorous high school exit exam requirements across the United States, this study suggests a need to revisit the effects of high school exit exam policies and offers critical insight into their risk.

Keywords: high school exit exams, exit testing policy, school accountability, high-stakes test, mathematics coursework

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Introduction

In the United States, many states have implemented mandatory exit exam policies as a high school graduation requirement for students. In these states, students must pass exit examinations to graduate from high school, and schools are required to offer rigorous and standardized instruction for their students' graduation. Despite differences in state-mandated high school exit exams, such policies have attracted considerable attention from researchers and policymakers in recent decades, in terms of school accountability (e.g., Ou, 2010; Wang et al., 2006; Welton & Williams, 2015). From a mathematics education perspective, the growth in the number of states with high school exit exam requirements is particularly remarkable. While only nine states implemented such exams in mathematics in 2002, 26 states enacted the exit exam policy in 2012. This figure accounts for nearly 70% of all public school students in the United States (Center on Education Policy, 2012). Given the importance of school accountability as the purpose of the exit testing policy and the significant impact of mathematics coursework on college and career readiness, it is essential to examine the effects of high school exit exam requirements on students' course-taking in mathematics. For example, Adelman (2006) reported that completing Algebra II served as a substantial milestone for college admission and graduation. Similarly, Maltese and Tai (2011) found that advanced-level course-taking in STEM fields increased the probability of earning a STEM degree in the future.

However, it remains unclear whether using high school exit exam policies contributes to students' completion of rigorous mathematics coursework. Certainly, implementing high school exit exam requirements is associated with more opportunities for advanced-level mathematics coursework. The exit testing policy also facilitates the introduction of normative and standardized curricula in local high schools. Conversely, opponents contend that it will increase students' focus on passing the high-stakes test and decrease their interest in more rigorous coursework unrelated to the exit exam requirements. This ongoing debate continues, given the different analytical strategies used in previous studies (Holme et al., 2010; Planty et al., 2007; Reardon et al., 2010). Thus, although prior research has contributed to understanding how high school exit exams could work for students in the realigned school context, the influence of the exit testing policy on students' completion of rigorous mathematics coursework still remains unclear. In particular, as earlier research has analyzed short-term and single-state datasets, it is open to criticism for questionable generalizability of the results and limitations of not considering potential bias from time and state-variant properties in the analysis.

To fill these gaps, we question the extent to which the use of high school exit exam requirements for mathematics has helped students access more advanced-level coursework in mathematics, as intended. We draw on a difference in difference (DD) approach with two-way fixed effect, and three cohorts of a nationally representative dataset—the National Education Longitudinal Study of 1988 (NELS:88), the Education Longitudinal Study of 2002 (ELS:02), and the High School Longitudinal Study of 2009 (HSLS:09). More specifically, we draw inferences about the effect of the high school exit exam policy on mathematics attainment by comparing mathematics course-taking patterns before and after implementing exit test policies, as well as between states with

and without the high school exit exam requirements. By exploring the effects of the policy based on cross-states comparisons with longitudinal data, this study fulfills a need to revisit the effects of high school exit exam policies and offers critical insight into their risk.

Literature review

Policy context

As part of education reform efforts for a state responsibility to provide more equalized educational opportunities and examine student achievements in the United States, exit testing policies were widely adopted and spread since 1969, as a form of minimum competency examinations (Resnick, 1980). After diagnosing "educational disarmament" from the federal report, *A Nation at Risk* (National Commission on Excellence in Education, 1983), however, this approach came under attack due to the low-level examination standards. Thus, many states were required to respond to these pressures by increasing the academic standards in their exit tests and supporting accountability systems (Hamilton, 2003). As a result, the new initiative on exit testing policies has focused on the goal of college and career readiness, and high school exit examinations have been modified to be increasingly rigorous. Especially, despite controversial issues, including the increased drop-out rates among at-risk students and the growth of practical strategies for better accountability rankings (Holme et al., 2010), the federal and state governments have touted high school exit exam policies as a powerful tool for students' academic outcomes in terms of accountability requirements of the No Child Left Behind act (Center on Education Policy, 2012).

Indeed, although many states continue to modify their exit testing policies for political, educational, and financial reasons, the overall trend of more rigorous high school exit exams remains unchanged. For instance, several states have eliminated their high school exit exam requirements, while others have implemented new exit examinations or established new cut scores. However, these changes are hardly seen as evidence of a sweeping reform of the current exit testing policies. Rather, during the 2011-12 school year, 25 states implemented high school exit exams, affecting nearly seven out of 10 public school students in the United States. This figure is particularly significant because it encompasses a majority of the historically marginalized students, including 71% of African Americans, 85% of Hispanics, 71% of low-income students, and 83% of English Language Learners (Center on Education Policy, 2012).

Importantly, studies on raising high school exit exam standards have determined that potential benefits of exit testing policies, including the overall improvement of school performance, may stand based on the growing inequality for the historically marginalized students (Holme et al., 2010). For example, Dee and Jacob (2006) found that high school exit exam requirements in Minnesota resulted in an increased dropout rate in urban and high-poverty school districts, as well as a decreased dropout rate in suburban and low-poverty school districts. Ou (2010) also showed that students who barely failed the high school exit exams were more likely to drop out than those who barely passed, even if they were provided with retest opportunities. Furthermore, she

reported that the dropout propensity of barely-failed students was more severe among limited-English-proficiency, racial-minority, and low-income students.

Together with the trend of rigorous high school exit exam requirements, the expanded access to advanced-level coursework is another key issue related to the exit testing policy. As the rigorous form of high school exit exam requirements is firmly established, the importance of completing advanced courses such as Algebra II increases in general. Using data for students who completed the California High School Exit Examination (CAHSEE) requirements, for example, Becker et al. (2009) found a significant difference in pass rates on the CAHSEE mathematics test when comparing students who took more advanced mathematics courses with those who did not. Their findings also revealed a steady increase in the proportion of students taking mathematics courses beyond Algebra I. In a similar vein, Burris and Welner (2005) showed that the passing rate on the first Regents exam in a suburban school district in New York state had been remarkably increased by dismantling tracking and offering the high-track curriculum to all students.

High school exit examinations in mathematics and school outcomes

Scholars studying the trend of more rigorous exit tests have found a lack of evidence for the significant impact of high school exit examinations on students' mathematics achievement. For example, drawing on the National Assessment of Educational Progress (NAEP) data, Grodsky et al. (2009) analyzed achievement trends in reading and mathematics from 1971 to 2004. Their analysis shows no evidence for any effect of high school exit examinations on student achievement in either reading or mathematics, regardless of their levels of achievement. Moreover, using state-level data, Jacob et al. (2017) examined the effect of exit testing policies on student outcomes and reached a similar conclusion. They estimated the influence of the Michigan Merit Curriculum (MMC) policy, a statewide college-preparatory policy emphasizing academic preparation in mathematics and science, on student achievement. They found no evidence that the policy was significantly associated with mathematics performance, although it had a positive impact on students' performance in science.

Furthermore, given that state exit examinations align with higher curriculum standards (Holme et al., 2010; Planty et al., 2007), implementing such exams can influence the pattern of students' course-taking. Several studies suggest that high school exit examinations have a positive effect on the pattern of mathematics course-taking. For instance, using the Michigan Transcript Study (MTS) and the Michigan Consortium for Educational Research (MCER) data, Kim et al. (2019) scrutinized the effect of the MMC policy on high school students' academic outcomes. They found that post-MMC cohorts took more mathematics courses, although there was no evidence for the significance of the policy on mathematics achievement. Students in the post-policy period were more likely to complete higher-level mathematics courses, and it had the most significant effect among the least prepared students. In another study using data from (a) high schools in Chicago, (b) data from the National Student Clearinghouse, and (c) the 2000 US Census, Allensworth et al. (2009) examined the effect of a Chicago policy that mandated college-preparatory coursework for the students in the state of Illinois. The study demonstrated that more students in the ninth grade completed Algebra and

English I courses, although there was no positive impact on student achievement or college enrollment.

Conversely, some studies indicate adverse effects of high school exit examinations on students' course-taking in mathematics. For example, using a regression discontinuity design and longitudinal data from four California public school districts, Reardon et al. (2010) found no significant effect of failing in exit examinations on mathematics course-taking in the following year. Further, drawing on the National Education Longitudinal Study of 1988-92 (NELS:88-92), the National Longitudinal Study of Schools (NLSS) data, and hierarchical linear modeling, Schiller and Muller (2003) analyzed the effect of state exit testing policies on students' mathematics course-taking. Students placed in the lower-level courses in ninth grade in states with more rigorous high school graduation requirements were less likely to take advanced-level mathematics courses than their counterparts in other states. Their study also demonstrated that African American and socioeconomically disadvantaged students in these states tended to take lower-level mathematics courses than their counterparts in other states.

Despite a better understanding of the influence of an exit testing policy on high school graduation and consideration for marginalized students, prior research has several limitations. First, many of the existing studies of high school exit examinations analyzed the effects of high school exit exam policies, such as the California High School Exit Examination (CAHSEE) policy or the Michigan Merit Curriculum (MMC) policy in each state. The results of these studies are limited because it is unclear whether they apply to other states or are valid only within those states. More importantly, such an approach could be inappropriate to determine to what extent the exit exam policy is effective because it does not compare the results to states that did not implement policies simultaneously. In addition, much of the literature on the impacts of high school exit exam policies examined only the short-term effects of the policies. There may be differences in its short-term and long-term effects when a particular policy is implemented, so analyzing the exit testing policy's effectiveness from a long-term perspective is warranted.

Methods

Data

This study uses data from three sources from the National Center for Education Statistics (NCES): (1) the National Education Longitudinal Study of 1988 (NELS:88), (2) the Education Longitudinal Study of 2002 (ELS:2002), and (3) the High School Longitudinal Study of 2009 (HSLS:09). These survey data are nationally representative of American high school students, collected by NCES, and provide rich and elaborate information on students' background, test scores, and high school transcripts for three cohorts between 1988 and 2009. The NELS:88 is based on an initial representative sample of 24,000 eighth graders, with follow-ups in 1990, 1992, 1994, and 2000 when postsecondary transcripts were also collected. The ELS:02 includes a nationally representative sample of over 15,000 10th graders, with follow-ups in 2004 and 2006. The most recent survey data HSLS:09 is based on more than 23,000 ninth-graders

surveyed in 2009 across the United States, with follow-ups in 2012 and 2014.

Above all, the data for these three cohorts have significant advantages in having comparable data structures. To optimize the comparability between these data, NCES suggests that the analytic sample should be limited under several conditions (Dalton et al., 2007). We adopted their recommendations, and the conditions are as follows. First, this study analyzed only students who were in the on-time 12th grade cohort. Next, the analysis included only students who completed at least one English class and graduated from high school. To compare the difficulties of the completed math coursework across the cohorts, we included only students with complete coursework during high school. Finally, only public-school students who are compulsorily exposed to this policy were included in the analysis. Private school students were excluded due to no obligation to pass the state-driven test to graduate.

The NCES provides weighting variables to account for the probabilities of participation in the base-year and follow-up surveys, as well as the nonresponse rates. The analyses used the appropriate transcript sample weights for each dataset to ensure that the estimates can be generalized to the 12th grade high school graduates in 1992, 2004, and 2013. We used *F3TRSCWT* for NELS:88, *F1TRSCWT* for ELS:02, and *W3HSTRANS* for HSLS:09. The sample size (*N*) for NELS:88 was 8,419, ELS:02 was 8,423, and HSLS:09 was 13,276 students.

Measure

This study's dependent variables (DVs) are the highest level of mathematics coursework completed by a student at the end of high school. We created two indicators—completing Algebra II or above and Precalculus or above. Researchers have long been interested in equity in overall degree attainments and STEM degree attainments (Kao & Thompson, 2003; Riegle-Crumb & King, 2010). Prior research indicates that Algebra II or above is a required course for admittance into most four-year colleges and universities and, thus, acquiring a bachelor's degree (Adelman 1999; Adelman et al., 2003; Attewell & Domina, 2008), while Precalculus or above is a required course for degree attainment in STEM fields (Adelman, 1998; Burkam & Lee, 2003; Maltese & Tai, 2011; Tyson & Roksa, 2016). For a comprehensive analysis of state exit exam policies' impact, we focus on these two specific mathematics courses that students have completed at the end of high school. The difficulty in classifying NELS:88 and ELS:02 was adjusted to match HLS:09 by referring to the NCES manual to make the difficulty level of mathematics subjects in each data comparable.

Next, the treatment variable in this study is the state's mathematics exit exam policy. A state mathematics exam policy refers to mandatory tests that students must pass to receive a high school diploma. We collected information from the Center on Education Policy (CEP) report of 2009 to identify states implementing high school exit exam policies in mathematics and states without the policies (Center on Education Policy, 2009). The report provides comprehensive information on whether the policy was implemented in 2002 and 2009, based on state enforcement laws related to high school exit examinations. According to the CEP report (Center on Education Policy, 2012), in 2002, high school exit exam policies in mathematics were implemented in 8 states: Alabama, Georgia, Indiana, Louisiana, New Jersey, New York, North Carolina, and

Texas. In 2009, they were additionally implemented in 15 states—Alaska, Arizona, California, Florida, Idaho, Massachusetts, Maryland, Minnesota, Mississippi, Nevada, Ohio, South Carolina, Tennessee, Virginia, and Washington. The students in states with the high school exit exam accounted for 39.0% in the ELS:02 cohort, and 66.2% in the HSLS:09 cohort.

Additionally, we included student and school background variables that have been found to associate with the outcomes. Following the detailed guidelines of the NCES, variables were selected only for data with sufficient comparability in the three datasets. The individual variables include race/ethnicity, a composite score of socioeconomic status (SES), gender, and standardized ninth-grade math achievement score. We also controlled for high school urbanicity (rural, urban, suburban) in our analysis. The descriptive statistics of control variables are illustrated in Table 1.

Table 1. Descriptive statistics of covariates for each cohort

	Cohorts		
	NELS:88	ELS:02	HSLS:09
Race (reference = White)			
Black	0.11 (0.01)	0.12 (0.01)	0.12 (0.01)
Hispanic	0.08 (0.01)	0.15 (0.01)	0.20 (0.01)
Asian	0.04 (0.00)	0.04 (0.00)	0.04 (0.00)
Native American	0.01 (0.00)	0.05 (0.00)	0.09 (0.00)
Gender (reference = male)	0.52 (0.01)	0.52 (0.01)	0.51 (0.01)
Math test standardized score at ninth grade	54.21 (0.36)	51.45 (0.20)	51.50 (0.24)
Socio-economic status index	0.08 (0.02)	0.05 (0.02)	0.02 (0.02)
School urbanicity (reference = urban)			
Suburban	0.41 (0.02)	0.51 (0.02)	0.34 (0.02)
Rural	0.33 (0.02)	0.2 (0.02)	0.24 (0.02)

Note. Standard errors are reported in parentheses. All estimates are adjusted by weighting.

Analytic approach

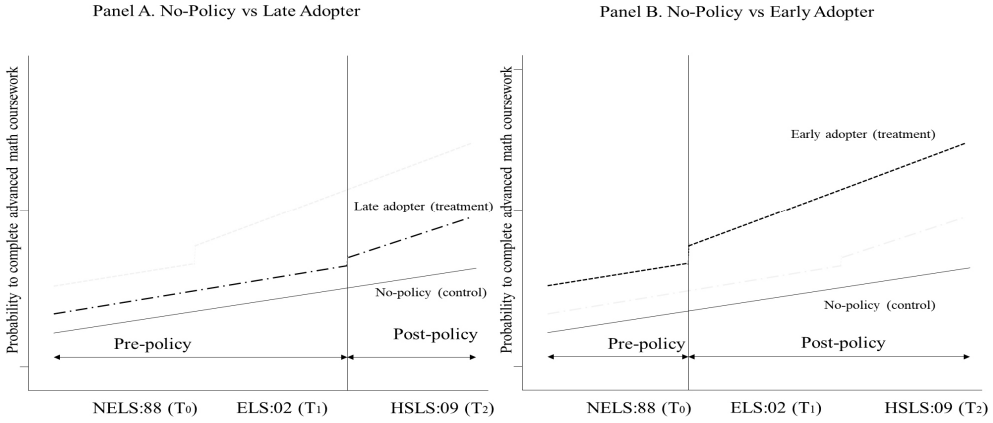
This study uses a combined difference in difference (DD) framework to estimate changes from the 1988 cohort to 2009 cohort in outcomes among three state groups: (1) states that never performed high school exit exam, (2) states that have conducted exit exams in 2002—referred to as an *early adopter*, and (3) those that implemented exit exams in 2009—referred to as a *late adopter*. The DD framework helps estimate treatment effects by comparing the pre- and post-treatment differences in the outcomes between control and treatment groups. In our study, the outcomes are the sets of the highest level of completed math coursework. Error terms of the estimated are clustered at the cohort and school levels because each cohort has a hierarchical data structure with students nested in school (Clair & Cook, 2015). The DD model can be specified as:

$$\text{(Eq. 1)}\ Y_i = \beta_0 + \beta_1 T_i + \beta_2 P_i + \beta_{3DD} T_i P_i + \beta_4 C_i$$

Where Y_i represents the outcomes for the student *i*. As the dependent variables are whether a student has completed a certain level of mathematics, the DD model becomes a non-linear model. Therefore, Y_i indicates the conditional expectation of the binary potential outcomes. T_i, captures the secular trend that would have occurred in enacting a high school exit exam policy. P_i, a state-level indicator, represents state-level differences in the implementation of the high school exit exam policy. C_i is a vector of additional control variables. One problem is that systematic variations in the distribution of C_i for each of the three time points may result in bias in the estimation. However, each dataset was collected based on the student and school population for each year. The ratio of demographic distributions, such as the ratio of race/ethnicity, gender, and school urbanity, has been not dramatically changed during the periods (Domina & Saldana, 2012). In the preliminary analysis, we also confirmed that other control variables, such as SES and mathematics achievement scores in the ninth grade, show commonly acceptable normal distributions for each cohort data. The most important indicator of this study is the interaction term, T_iP_i. It indicates the average change of the highest-level mathematics coursework measured by comparing pre-and post-policy periods in the states with and without high school exit exam requirements. This DD function assumes that the states would have had identical outcomes if the high school exit exam policy had not been implemented, estimated as the interaction is 0. Thus, the treatment effects are estimated based on the coefficients of the interaction term for the time and group dummies.

Since the dependent variables in this study are dichotomous, the DD model is a non-linear model that transforms the outcomes using a logit-normal transformation. In a non-linear model, it is difficult to capture the meaning of the DD coefficient because the outcome variables are the conditional probability that varies with other explanatory variables. To interpret the value of DD intuitively from the interaction term in the non-linear model, Puhani (2012) suggested that the magnitude of DD should be held constant. Following his approach, this study presents the differences of the marginal effects between when $T_iP_i = 1$, assuming the interaction turns on, and when $T_iP_i = 0$, assuming the interaction turns off, to verify the effect of the treatment on the treated. From this point of view, the estimated difference between the marginal effects shows the results of how much difference there would have been if DD had been present.

States were divided into three groups according to when they implemented the exit exam policy: (1) no policy, (2) early adopters, and (3) late adopters. We analyzed the effect of exit exam policies by dividing the analytic samples according to the timing of the policy implementation and then split them into two cases, as shown in Figure 1. They are the comparisons between no-policy states and states with the different timing of policy implementation groups (i.e., early adopters and late adopters), which are graphically displayed in Panel A and Panel B, respectively. Each comparison is performed separately according to the treatment timing of the treatment group. In comparisons between the early adopter and no-policy groups, the treatment timing is T1, data from 2002. For late adopters, the treatment timing is T2, or 2009. Here, each intercept and slope in this figure is not based on actual or predicted value but is composed in conceptualized framework to explain the process of DD analysis. Therefore, it is necessary to understand consciously that the values of each slope and intercept do not reflect the actual tendency.



Note. Since each slope and intercept value is expressed as a conceptual framework, they do not reflect the actual trend.

Figure 1. The analytical conceptual framework for two compositions of difference-in-difference estimation from the three groups—no-policy, early adopter, and late adopter

Sensitivity analysis

As the pre or post-treatment period combines with the two-time cohort in the previous DD model, it cannot consider two cases in which estimation can be biased. First, the previous model is limited, considering that the policy effects could be biased from varying time points. Comparing the non-policy and late adopter states, the previous model does not consider whether the two groups show a similar trend across T_0 and T1. If the state that enacted the exit exam policy in T_2 has a greater tendency to increase T_0 and T_1 than their counterparts, the DD results could be biased. Additionally, for comparisons between non-policy adopter and early adopter states, the previous model does not adjust unobservable factors related to the degree of policy effect over two time periods (T_1 and T_2). It does not consider whether the exit exam policy effect is constant over time. For example, if the effect of early treatment is decreased over time, the estimates of the effect can be biased.

Second, the previous DD model does not consider the unobservable cohort, state factors that can be simultaneously related to the outcome variables, and implementation of the high school exit exam. For example, if a state changes high school graduation requirements, such as the required mathematics credits and a standardized curriculum, the estimation of the high school exit exam effect can be biased because it may be simultaneously associated with changes in math outcomes and high school exit exam policy.

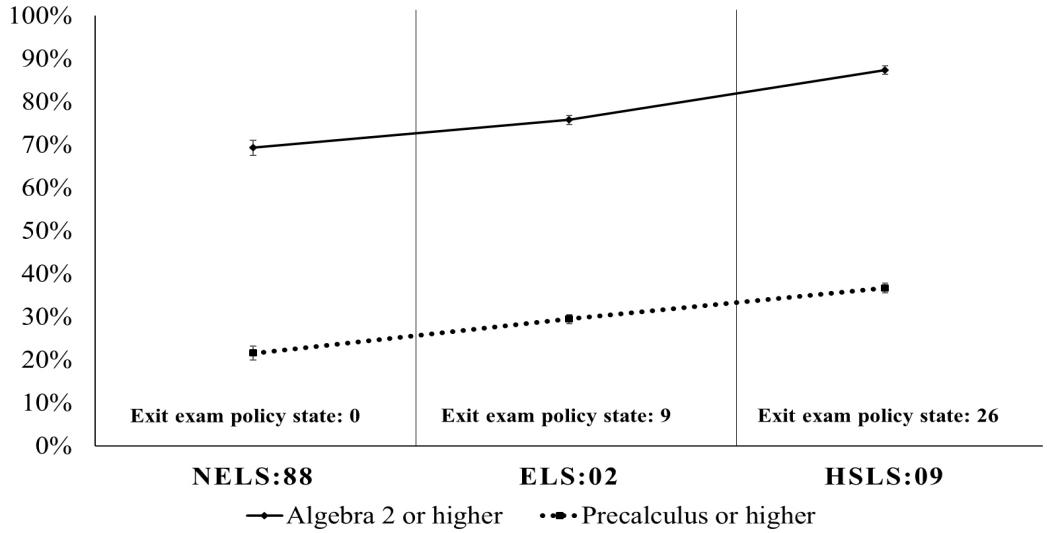
To check the sensitivity of the previous model, we tried an alternative model that reflects the time zone more granularly and combines with a two-way fixed-effect model. First, we used the 2002 cohort as a reference group when analyzing the differences between states with and without exit exam policies. The exit testing policy effect for late-adopter states is presumptive by the change between the 2002 and 2009 cohorts on

DVs compared to the 1998 and 2009 cohorts. The exit exam policies' effects in early adopter states are inferred from the changes between the 1998 pre-policy and the 2002 post-policy cohorts and between the 2002 and the 2009 cohorts. Second, we combined a two-way fixed-effect model, which inputs a complete set of states and cohort dummies into equation 1. This approach limits estimating the marginal effects of changes between pre- and post-treatment by adding a set of dummy variables that partially correlate with when and whether treatment is enacted. However, it has the advantage of isolating the treatment effect by taking into account unobservable state and cohort factors correlated to the mathematics attainment outcomes that were coincident with the high school exit examinations.

Results

We first document the changes in students' completed highest mathematics coursework during the state exit exam policy implementation with mathematics curricular intensification. Figure 2 shows the proportion of students who completed Algebra II or higher and Precalculus or higher as their highest-level mathematics coursework by cohorts. As previously discussed, there was no high school exit exam in the early cohort period, and the more recent cohort, the more states implemented this policy. The proportion of students who completed Algebra II or higher and those who have completed Precalculus or higher has increased during this policy spreading. Before implementing an exit exam policy, approximately 70% of students in the NELS:88 cohort completed Algebra II or above. The rate increased to approximately 90% among HSLS:09 cohorts when the exit exam policy was expanded. Approximately 20% of students in the NELS:88 cohort completed Precalculus or above; this proportion increased to around 29% in ELS:02 and 37% in HSLS:09. The trends show growth rates at both completing relatively intermediate-level mathematics coursework and higher-level mathematics coursework following an expansion of the high school exit exam policy.

In contrast, the DD model analysis, which shows a counterfactual treatment effect of the high school exit exam policy, provides conflicting results about the high school exit examinations' effect on the highest level of mathematics coursework compared to those found in descriptive trends. It raises doubts about whether this policy positively affects the proportion of students completing the higher level of mathematics coursework.



Note. The error bars indicate the 95% confidence interval.

Figure 2. The proportion of students who completed Algebra II or higher and Precalculus or higher as their highest-level mathematics coursework by cohorts

Table 2 shows the results of the DD model, which estimates the comparisons between no-policy states and states with different timings of the policy implementation (i.e., the early adopter and late adopter). Overall, there was no evidence that the high school exit exam policy influenced the students' likelihood of completing Algebra II or above and Precalculus. Between the pre-policy period (1988) and post-policy period (2002 and 2009), in the no-policy states and the early adopter states, the probability of students completing Algebra II or above increased by 14.1 percentage points and 11.4 percentage points in the 95% confidence interval (CI), respectively. The difference in the amount of increase between each group was -2.7 percentage points, which was insignificant in the 95% CI. The likelihood of completing Algebra II or above increased by 16.6 and 17.1 percentage points, in no-policy states and late adopter states, respectively, between the pre-policy (1992 and 2002) and post-policy (2008) periods. However, the difference between the groups in increments was only 0.5 percentage points, which was not significant in the 95% CI.

Table 2. Difference-in-difference estimate of the effect of high school exit exam

			△ = post-policy−pre-policy							
					95% C.I.[a]				95% C.I.	
			△	S.E[b]	LL[c]	UL[d]	DD[e]	S.E	LL	UL
Algebra 2 or above	No-policy vs Early adopter[f]	No-policy	.141	.020	.102	.181	-.027	.036	-.097	.043
		Early adopter	.114	.030	.055	.173				
	No-policy vs Late adopter[g]	No-policy	.166	.015	.135	.196	.005	.022	-.039	.049
		Late adopter	.171	.016	.140	.202				
Precalculus or above	No-policy vs Early adopter	No-policy	.143	.017	.111	.176	.056	.029	-.001	.113
		Early adopter	.199	.023	.155	.244				
	No-policy vs Late adopter	No-policy	.115	.018	.079	.151	-.026	.025	-.075	.023
		Late adopter	.089	.016	.056	.121				

Note. The number of observations is 30,118.
[a]Confidence Interval. [b]Standard error. [c]Lower level. [d]Upper level. [e]Difference in Difference. [f]The states that has implemented high school exit exam since 2002. [g]The states that has conducted high school exit exam since 2009.

The probability of students completing Precalculus or above increased by 14.3 percentage points in no-policy states, and 19.9 percentage points in the early adopter states, between the pre-policy (1992) and the post-policy (2002 and 2009) periods, in the 95% CI, respectively. We found a 5.6 percentage points difference in the increment in the two groups, which was insignificant in the 95% CI. Similarly, while the likelihood of completing Precalculus or above increased by 11.5 percentage points in non-policy sates, and 8.9 percentage points between the pre-policy (1988 and 2002) and post-policy (2009) periods, there was no significant difference in the growth rate in the two groups in the 95% CI.

Finally, table 3 shows the results of an alternative model predicting the degree of change in the odds for dependent variables between non-policy states and policy implementation states as a reference group in the cohort of 2002. The results are consistent with the descriptive statistics shown: a clear trend of increasing the odds of completing Algebra II or above and Precalculus or above in more recent cohorts. However, no evidence was found for a difference in the extent of change in completing the highest level of mathematics coursework between states with and without the high school exit exam requirements. Both between 1998 and 2002 and between 2002 and 2009, there was no significant difference between non-exam policy states and states that implemented an exit exam policy regarding changes in the odds of completing Algebra 2 or above and Precalculus or above. These results were consistent, regardless of whether the high school exit exam policies were adopted early or late. Taken together, in the states in which the high school exit exam policy was implemented, the probability of students completing more rigorous mathematics coursework did not increase in comparison to other states. These results suggest that the high school exit exam policy's impact on students' increasingly rigorous mathematics coursework is unclear.

Table 3. Results of difference-in-difference with fixed effect model predicting the highest math coursework during high school

Variables	Model 1 Algebra 2 or above	Model 2 Precalculus or above
Exit exam (reference = no-policy)		
Late adopter[a]	-0.30	0.80
	(0.73)	(0.46)
Early adopter[b]	-0.67	0.41
	(0.82)	(0.55)
Cohort (reference = 2002 cohort)		
1988 cohort	-0.48***	-0.68**
	(0.12)	(0.16)
2009 cohort	1.14***	0.35**
	(0.14)	(0.13)
Exit exam*Cohort		
Late adopter#1988 cohort	-0.08	-0.09
	(0.17)	(0.21)
Late adopter#2009 cohort	-0.16	-0.18
	(0.19)	(0.16)
Early adopter#1988 cohort	0.09	-0.19
	(0.24)	(0.25)
Early adopter#2009 cohort	-0.32	0.24
	(0.26)	(0.17)
Demographic, and school backgrounds	controlled	controlled
State fixed	yes	yes

Note. Demographic and school background factors include gender, race/ethnicity, ninth grade match achievement score, socio-economic status index, and school urbanicity. The number of observations is 30,118. *p < .05. **p < .01. ***p < .001. Standard errors are reported in parentheses.

[a]The states that have conducted high school exit exams since 2009. [b]The states that have implemented high school exit exam since 2002.

Discussion

The results of this study make us question whether the high school exit exam policy had the intended positive effect on students' advanced-level course-taking in mathematics. High school exit exam requirements expanded widely in the United States during the last two decades. The descriptive statistics show that the probability of students completing rigorous coursework in mathematics has increased gradually. We estimated the effect of high school exit exam requirements based on data from three cohorts between 1988 and 2009. However, we find no evidence that the probability of students completing Algebra II or above and Precalculus or above increased in states with high school exit exam policies compared to states without such policies. These results were consistent, regardless of the timing of the high school exit exam policy implementation. The number of students taking rigorous mathematics coursework in high school increased during the policy period. This occurrence increased the student population affected by high school exit exam policies, raising doubts about whether the change resulted from the high school exit exam policy.

This study offers a broader and longer-term understanding based on three national-level data sets, considering the limitation of prior research in addressing the exit testing policy's effect at the state level from a short-term perspective. Our results are inconsistent with some previous large-scale studies demonstrating high school exit exam policies' positive impact on completing rigorous mathematics coursework. In this regard, one potential explanation for the inconsistency is that as the analysis makes the positive findings in the prior studies of state-level data, it may not be appropriate to compare the difference between pre- and post-effects of the exit testing policy to determine the overall impact of the policy.

The results in this article directly contribute to the understanding of the effect of the high school exit exam policies from a more comprehensive point of view. However, the significance of this study does not reside in its finding that there is no evidence of positive impacts of high school exit exam requirements on students' advanced-level course-taking. Instead, its significance lies in clarifying a need for the more careful examination and amelioration of the current high school exit exam policies regarding school accountability. As noted earlier, a more rigorous form of the current high school exit exam requirements was introduced, focusing on academic improvement (Center on Education Policy, 2012). Regarding students' rigorous coursework, this study shows that the increase of students completing advanced-level course-taking in mathematics is observed across the United States, irrespective of implementing the exit testing policy. Taken together, the effect of the current high school exit exam policies is unclear.

Given that a vast majority of minority students in public schools are affected by high school exit exam requirements (Center on Education Policy, 2012), questions remain. First, does the current exit testing policy improve historically marginalized students' high-level coursework in mathematics? Second, if they do, to what extent? Several studies have emphasized that minority underrepresentation in mathematics and science is an educational inequality issue that can reproduce social hierarchies (Martin, 2019; McGee, 2016; Mensah & Jackson, 2018). As Domina and Saldana (2012) indicate, however, racial and class-based inequality of course-taking in mathematics still persists, whereas the gap of mathematics credit earning is reduced. The past 3 decades show an intensification of high school students' course-taking across the United States (Planty et al., 2007). If current high school exit exam policies did not contribute to an increase in rigorous coursework among minority students, then researchers and policymakers must reconsider the limitations of the current approach and refocus on historically marginalized students and their difficulties.

Conclusion

This study considered the effect of the high school exit exam policy on students' rigorous mathematics coursework through examination of three cohorts of a nationally representative dataset. Given that literature on exit testing policies has predominantly analyzed single-state datasets, this work offers a more complete and comprehensive understanding of the impact of high school exit exam requirements. Findings show that, despite the overall increase in rigorous mathematics coursework, there is no evidence that such results are caused by implementing high school exit exam policies. This

finding suggests that the question of the effect of exit testing policies on students' mathematics attainments remains unsolved, and thus that further research is needed to understand better the influence of exit testing policies in terms of school accountability.

In this regard, it is important to clarify limitations in the current project for the applicability of these findings to the broader and deeper discussion. First, this study is only dedicated to understanding the effect of high school exit exam policies on advanced-level mathematics course-taking. We focused on students' mathematics coursework because most states selected mathematics in their high school exit exam requirements. As a result, this work does not cover the impacts of other subjects in high school exit exam requirements and has a weakness in grasping the whole picture of the effect of exit testing policies. Therefore, further research is needed to analyze the significance of other subjects in high school exit exam requirements.

Furthermore, since we paid specific attention to the issue of rigorous coursework in mathematics, this article does not address other potential educational outcomes. The importance of the high-level mathematics course-taking as a gatekeeper of selective college admissions and success in college is persistently increasing. Considering that the purpose of the high school exit exam is to make students academically prepared, it is valid to investigate the effect of the high school exit exam policy on taking rigorous mathematics coursework. However, there are still other potential educational outcomes to look at carefully. For example, future research can examine the effect of exit testing policies on students' educational attainments by delving into other factors such as test scores and grade point average, high school graduation rates, or low-performing students' dropout rates.

In addition, the limitations of these data should also be noted. As this study used a 3-time points dataset, this study could not fully consider the varying effects depending upon the implementation timing of the high school exit-exam policy. If the policy effect according to the starting point of the high exit exam policy is significantly different among the policy enacted groups, a bias may occur in estimating the policy effect. Nevertheless, as this study determined that no effect of the timing of policy implementation, it is expected that the bias of the estimate from not considering the timing of policy introduction would not be substantial. Future research should address this issue in more depth based on data surveyed over more periods, such as panel data.

Another limitation is that the target population of this study is somewhat out-of-date. The youngest in this work was a 10th grader in 2009 in the United States. Even though this study used the most recent nationally-representative data of high school students in the United States, scholars and policymakers must use caution to generalize the results of this study to its recent younger cohort. Therefore, a further study using more frequently updated datasets, such as stat-representative data, is required to understand the current realities of high school graduation exams in the United States.

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