Algebra for All: California's Eighth-Grade Algebra Initiative as Constrained Curricula

THURSTON DOMINA

University of California, Irvine

ANDREW M. PENNER

University of California, Irvine

EMILY K. PENNER

University of California, Irvine

ANNEMARIE CONLEY

University of California, Irvine

Background/Context: *Across the United States, secondary school curricula are intensifying as a growing proportion of students enroll in high-level academic math courses. In many districts, this intensification process occurs as early as eighth grade, where schools are effectively constraining their mathematics curricula by restricting course offerings and placing more students into Algebra I. This paper provides a quantitative single-case research study of policy-driven curricular intensification in one California school district.*

Research Questions: *(1a) What effect did 8th eighth grade curricular intensification have on mathematics course enrollment patterns in Towering Pines Unified schools? (2b) How did the distribution of prior achievement in Towering Pines math classrooms change as the district constrained the curriculum by universalizing 8th eighth grade Algebra? (3c) Did 8th eighth grade curricular intensification improve students' mathematics achievement?*

Setting: *Towering Pines is an immigrant enclave in the inner-ring suburbs of a major metropolitan area. The district's 10 middle schools together enroll approximately 4,000 eighth graders each year. The districts' students are ethnically diverse and largely economically disadvantaged. The study draws upon administrative data describing 8th eighth graders in the district in the 2004–20-05 through 2007–20-08 school years.*

Intervention/Program/Practice: *During the study period, Towering Pines dramatically intensified middle school students' math curricula: In the 2004–20-05 school year 32% of the district's 8th eighth graders enrolled in Algebra or a higher- level mathematics course; by the 2007–20-08 school year that proportion had increased to 84%.*

Research Design: *We use an interrupted time-series design, comparing students' 8th eighth*

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grade math course enrollments, 10th grade math course enrollments, and 10th grade math test scores across the four cohorts, controlling for demographics and prior achievement.

Findings/Results: *We find that students' odds of taking higher level mathematics courses increased as this district implemented the state's Algebra mandate. However, even as the district implemented a constrained curriculum strategy, mathematics achievement growth between 6th sixth and 10th grade slowed and the achievement advantages associated with 8th eighth grade Algebra declined.*

Conclusions/Recommendations: *Our analyses suggest that curricular intensification increased the inclusiveness and decreased the selectivity of the mathematics tracking regime in Towering Pines middle schools. However, the findings suggest that this constrained curriculum strategy may have may have unintended negative consequences for student achievement.*

Over the last two decades, many American secondary schools have eliminated low-level and nonacademic courses and enrolled increasing proportions of students in college-preparatory courses (Domina & Saldana, 2012). The result has been the largest curricular restructuring of American secondary schools since the "unremarked revolution" of the 1960s and 1970s, when American high schools and middle schools abandoned overarching tracks in favor of tracked courses (Lucas, 1999). While American secondary school curricula remain hierarchically organized, recent changes in secondary school structure have broadened access to high-status courses and rendered tracking systems far more inclusive.

The scholarly consensus holds that tracking fails to improve student achievement, even as it exacerbates educational inequality (Gamoran, 1992; Gamoran, Nystrand, Berends, & LePore, 1995; Hallinan 1994; Lucas, 1999; Oakes, 2005). Based on this literature, one might expect curricular intensification to narrow achievement gaps. However, racial- and class-based inequalities in American schools persist. Furthermore, experimental research and studies examining the effects of curricular change on student achievement raise important questions about the effects of detracking on the distribution of student achievement (Allensworth, Nomi, Montgomery, & Lee, 2009; Burris, Heubert, & Levin, 2006; Burris, Wiley, Welner, & Murphy, 2008; Clotfelter, Ladd, & Vigdor, 2012; Slavin, 1990).

This paper provides a quantitative single-case research study of policy-driven curricular intensification in one California school district. During the study period, Towering Pines dramatically intensified middle school students' math curricula: In the 2004–2005 school year 32% of the district's eighth graders enrolled in Algebra or a higher level mathematics course; by the 2007–2008 school year that proportion had increased to 84%. This rapid shift provides a powerful opportunity for understanding the relationship between tracking and student exposure to advanced mathematics courses and student mathematics achievement.

CURRICULAR INTENSIFICATION AND TRACKING

Sørenson (1970) distinguishes between four dimensions of within-school academic tracking: (a) *inclusiveness*, or the extent to which high-level coursework is available to students; (b) *selectivity*, or the extent to which tracking systems sort students based on their prior achievement to produce homogeneous learning environments; (c) *electivity*, or the extent to which students can choose their own classroom placements; and (d) *scope*, or the extent to which classroom placements in one academic subject are associated with classroom placements in other academic subjects (see also Gamoran, 1996; Kelly, 2007). The detracking efforts of the 1960s and 1970s primarily changed the scope of tracking in American secondary schools, making it possible for students to simultaneously take high-track coursework in one subject and low-track coursework in another. Recent shifts in American middle and high schools, meanwhile, have reduced track electivity in order to increase track inclusiveness. Consistent with Lee's (1993; Lee, Croninger, & Smith 1997; Lee & Smith 1995) notion of constrained curriculum, contemporary American middle and high schools limit students' ability to choose nonacademic courses in order to broaden access to high-status and academically rigorous courses. In the process, American schools may also reduce track selectivity by opening high-level courses to relatively low-achieving students.

The curricular intensification movement in U.S. schools springs from a confluence of two very different political perspectives. The 1983 *A Nation at Risk* report provided a major impetus for these curricular changes (National Commission on Excellence in Education, 1983) from the political right. Warning of a "rising tide of mediocrity that threatens our very future," the commission argued that all American students should be exposed to a more rigorous "New Basics" course curriculum. At approximately the same time, a loose coalition of scholars, educators, and activists on the political left began arguing that improving access to advanced courses for poor and minority students was central to narrowing educational inequality (cf. Moses & Cobb, 2001; Oakes, 2005). Succinctly summarizing this perspective, activist and educator Robert Moses organized communities and developed curricula around the claim that "Algebra is a civil right."

Both of these movements focused particularly on mathematics, where U.S. achievement has long trailed in international comparisons. Together, these movements have reshaped U.S. educational policy, particularly by raising educational standards and high school graduation requirements (Center on Education Policy, 2009; Clune & White, 1992; Darling-Hammond & Berry, 1988; Wilson & Rossman, 1993). While the policies implemented in the wake of *A Nation at Risk* clearly changed course enrollment patterns in American high schools, their effects on the distribution of student achievement are less clear (Hoffer, 1997; Schiller & Muller, 2003).

Over the last 25 years, California has emerged as a national leader in the effort to intensify mathematics curricula. In 1987, California's State Superintendent of Public Instruction argued that detracking middle schools was a central step toward raising academic standards in high schools. In 1992, the state department of education called for "heterogeneous grouping and detracking as a goal" and the 1997 revision of the state's content standards called on middle schools to enroll all eighth graders in Algebra I. In 1999, the California State Senate passed the Public School Accountability Act (PSAA), which created accountability penalties for enrolling eighth graders in courses other than Algebra. In the decade following the PSAA's implementation, eighth grade Algebra enrollment rates increased from 16% to 51% (Rosin, Barondess, & Leichty, 2009).

In 2008 the state's Board of Education voted to make the Algebra California Standards Test (CST) the "sole test of record" for the state's eighth graders (Rosin et al., 2009). This requirement intensifies the incentives for California schools to enroll eighth graders in Algebra, because it recognizes only students who pass end-of-course Algebra tests as proficient under No Child Left Behind as well as California state accountability policy. Under this policy, even students who excel in less rigorous end-of-course tests do not count as proficient in eighth grade mathematics. While California's adoption of the Common Core Standards will likely slow this move toward enrolling all eighth graders in Algebra, several of the state's most prominent educational policy makers argue that universal eighth grade Algebra should remain a central educational priority (Wurman & Evers, 2010).

California's policy history provides unique opportunities for understanding curricular intensification. This paper investigates one large California public school district's experience with the constrained curriculum strategy. This district, which we pseudonymously refer to as Towering Pines, was an early mover in the state's push to enroll more eighth graders in Algebra. The district began to upgrade its seventh grade math curricula in 2004. By 2007–2008, Towering Pines enrolled more than 80% of eighth graders in Algebra I or Geometry (the next course in the mathematics course sequence).

CONSTRAINED CURRICULUM AND THE EFFECTS OF CURRICULAR INTENSIFICATION

Lee's notion of "constrained curriculum" (e.g., Lee, 1993) provides a useful lens for understanding the curricular change that occurred in Towering Pines during the study period. Prior to the Algebra-for-all push, eighth graders in Towering Pines had the option of enrolling in one of three tiered mathematics courses: General Mathematics, Algebra, and Geometry.[1] Because secondary math courses are nearly universally sequenced in American secondary schools, eighth grade course enrollments largely determine students' chances of enrolling in more advanced courses throughout high school. In particular, students must take Algebra in eighth grade in order to take Calculus before they graduate from high school. In implementing California's eighth grade Algebra-for-all policy, Towering Pines dramatically reduced enrollment in the bottom rung of the tiered eighth grade mathematics course hierarchy, General Mathematics. This move limited curricular electivity in order to boost curricular inclusiveness.

Lee's constrained curriculum hypothesis suggests that such policies will tend to have positive effects on achievement, particularly for low-achieving students (Lee, Croninger, & Smith 1997; Lee & Smith, 1995;). In Lee, Croninger, and Smith's words (1997, p. 102) the constrained curriculum hypothesis holds that: "a commonality in students' course-taking behaviors and in schools' offerings, centered around a narrow set of academic courses, has positive benefits for students along the dimensions of excellence and equity defined by performance on tests." This hypothesis springs directly from the literature on the effects of curricular tracking. This literature is methodologically diverse, drawing upon nationally representative data (Argys, Rees, & Brewer, 1996; Gamoran, 1992; Gamoran & Mare, 1989) as well as case studies of particular school districts using administrative, survey, and qualitative data (Gamoran, Nystrand, Berends, & LePore, 1995; Oakes, 2005). With a few notable exceptions (Betts & Shkolnick, 2000; Figlio & Page, 2002), most relevant studies indicate that placement in low-track courses lowers student achievement while placement in higher track courses raises student achievement. Furthermore, several studies indicate that challenging course placements have positive average effects on student learning and educational attainment (Attewell & Domina, 2008; Chaney, Burgdorf, & Atash, 1997; Gamoran & Hannigan, 2000).

However, two empirical challenges make it difficult to rigorously evaluate the constrained curriculum hypothesis. The first of these challenges is selection bias. Much of the literature in this tradition uses a regression framework to attempt to control for the complex mechanisms that determine which students are exposed to constrained curricula. Lee and Smith (1995), for example, compare educational outcomes across schools that enroll all students in college preparatory courses and schools with more varied course offerings, controlling for students' academic and family background. Consistent with the constrained curriculum hypothesis, they find educational advantages for students at schools with universal college prep. However, interpretation of these findings hinges on the assumption the controls exhaust the important differences between schools with more or less constrained curricula. This assumption is restrictive and difficult to empirically assess.

Second, the implementation of a constrained curriculum strategy necessarily changes the student composition in affected classrooms. By moving students from low-tracked classes to higher tracked classes, curricular intensification tends to increase the amount of heterogeneity in achievement among students enrolled in high-tracked classes (Nomi & Allensworth, 2012). If teachers adjust the content of their instruction in response to the changing composition of their classrooms, some students may learn less in detracked educational environments than in tracked classrooms (Loveless, 1999; Rosenbaum, 1999). Furthermore, peer achievement may exert an independent influence on student learning (Hanushek, Kain, Markman, & Rivkin, 2003). These peer effects are difficult to detect in observational studies that compare outcome for students enrolled in high-track courses with their peers in low-track courses (see Gamoran & Hannigan, 2000, for an attempt using nationally representative data).

Evidence From Curricular Reforms

Longitudinal evaluations of school systems that have implemented middle and high school curricular reforms provide an opportunity to surmount these challenges and empirically assess the constrained curriculum hypothesis. By measuring student course enrollments and outcomes before and after course placement policies change, these evaluations minimize the risks of selection bias and make it possible to observe the ways curricular reforms change classroom compositions as well as achievement.

Existing evaluations of efforts to reform curricula in order to universalize Algebra enrollment return strikingly mixed results (Stein, Kaufman, Sherman, & Hillen, 2011). Burris, Heubert, and Levin (2006) and Burris, Wiley, Welner, and Murphy (2008) describe a large-scale detracking effort that occurred in one suburban school district in Long Island, New York, in the late 1990s. In an effort to prepare more students to enroll in high-level high school mathematics courses and remedy racial gaps in mathematics course enrollments, this district completely eliminated ability grouping for sixth through eighth grade mathematics classes. The district enrolled all students in an accelerated curriculum designed to prepare them to take Algebra courses in the eighth grade. In addition, it created optional "mathematics workshop" courses, in which an average of eight students met every other day with their regular mathematics teacher for supplementary help with the accelerated curriculum. Using a series of interrupted time-series analyses, Burris et al. (2006) and Burris et al. (2008) find these reforms increased students' odds of completing high-level high school mathematics courses, as well as their odds of earning high-status Regents and International Baccalaureate diplomas. However, these analyses provide limited information regarding the effects of curricular reform on student achievement. Although Burris et al. (2006) and Burris et al. (2008) find that AP Calculus scores improved under the detracking policy, they present no achievement data for students outside of this select group.

Evaluations of similar curricular reforms efforts in the Chicago Public Schools (CPS) and the Charlotte-Mecklenberg public schools yield less encouraging results (Allensworth, Nomi, Montgomery, & Lee, 2009; Clotfelter, Ladd, & Vigdor, 2012; Nomi, 2012). While these policies were larger in scale than the Long Island district detracking effort, they were considerably more modest in scope. In 1997, CPS required all ninth graders to enroll in Algebra I and college prep English and implemented an intensive "double-dose" Algebra curriculum that enrolled low-achieving students in a supplementary Algebra "support" course as well as a mainstream Algebra I course (Nomi & Allensworth, 2012). Policy evaluations reveal no evidence to suggest that the Chicago policy improved average achievement test scores (Allensworth et al., 2009) and some evidence to suggest that it had unintended negative effects for high-achieving students (Nomi, 2012). Subsequent analyses indicate that policy's most desirable effects occurred in schools that maintained a differentiated mathematics, clustering students into skills-homogenous Algebra classrooms (Nomi & Allensworth, 2012).

Similarly, the Charlotte-Mecklenberg schools launched an effort in 2002–2003 to accelerate Algebra enrollment without substantially changing middle school curricula or teaching preparation. Using this effort to execute an instrumental variables analysis strategy, Clotfelter, Ladd, and Vigdor (2012) find that early Algebra has net negative effects on student mathematics test scores.

THE CURRENT STUDY

Against this backdrop, we investigate middle school mathematics course enrollments in one California public school district to better understand constrained curriculum strategies and their consequences. The push to increase Algebra enrollment in Towering Pines is an intermediate case between the highly planned and comprehensive detracking effort that occurred in Long Island and the more ad hoc curricular reforms that occurred in Chicago and Charlotte. Like the Long Island district, Towering Pines took care to adapt its elementary school curricula to better prepare all students for middle school Algebra, and sixth grade mathematics test scores improved markedly across the study period in Towering Pines. Like the Chicago and Charlotte efforts, however, the Towering Pine effort was top down. The district did not invest heavily in professional development for middle school mathematics, and teachers received little explicit training regarding teaching Algebra to a more heterogeneous population of students. Furthermore, the district did not substantially change the instruction materials or other aspects of the official curriculum for eighth grade Algebra during the study period. Unlike the Long Island, Chicago, and Charlotte cases, Towering Pines maintained a stratified course sequence even as it constrained curricular options for middle school students. In this regard, Towering Pines is typical of U.S. schools more generally. The changes we observe in Towering Pines therefore provide insights into constrained curriculum efforts as they are commonly practiced in contemporary American schools that are unavailable in earlier case studies (Stein et al., 2011).

Between the 2004–2005 and 2007–2008 school years, the Towering Pines school district undertook a concerted effort to intensify eighth grade mathematics curricula. In this period, the proportion of eighth graders enrolled in Algebra or higher increased by 2.5 times, from 32% to 84%, with the proportion of eighth graders enrolled in Algebra I increasing from 32% to 71% and the proportion of eighth graders enrolled in Geometry increasing from 4% to 13%. The curricular intensification that occurred between 2005 and 2008 in Towering Pines was far more pronounced than elsewhere in California. Statewide, Algebra enrollments grew from 47% to 51% over the study period (Rosin et al., 2009) and Geometry enrollments grew from 2.7% to 3.6%. Nonetheless, the changes in course enrollment patterns that have occurred in this district roughly parallel the shifts in secondary school course enrollments that have occurred recently in California and across the United States (Domina & Saldana, 2012).

In this paper, we draw upon administrative data on every eighth grader in Towering Pines in the 2004–2005 through 2007–2008 school years to address three research questions:

1. What effect did eighth grade curricular intensification have on mathematics course enrollment patterns in Towering Pines Unified schools?
2. How did the achievement distribution in Towering Pines math classrooms change as the district universalized eighth grade Algebra?
3. Did eighth grade curricular intensification improve students' mathematics achievement?

Towering Pines is an immigrant enclave in the inner-ring suburbs of a major metropolitan area. The district's 10 middle schools together enroll approximately 4,000 eighth graders each year. The districts' students are ethnically diverse and largely economically disadvantaged. More than 50% of Towering Pines students are Latino, approximately 25% are Vietnamese, and approximately 15% are White. Most of the remaining students are Asian and 1% of the students in the district are African American. Over 60% of the students in the district were English Language Learners (ELLs) when they enrolled in school, and while a large proportion of these students had been reclassified as English-proficient by the time they were eighth graders, more than a third of the sample remained classified as ELLs in their eighth grade year. This sample is clearly not representative of eighth graders nationwide or statewide, and it is difficult to know whether the Towering Pines experience generalizes. However, the district's ethnic, economic, and linguistic diversity makes it a rich research site, especially because students of color and English Language Learners are frequently excluded from high-level courses.

Table 1 indicates that these changes in eighth grade mathematics course enrollment patterns were the result of an exogenous policy shift, rather than a change in the student body composition. Students in the five cohorts are similar on each of the demographic comparisons, with no statistically significant differences in terms of gender composition and only moderate changes in ethnic composition. Similarly, the proportion of students who were native English speakers remained unchanged across the study period, although in later cohorts the district did reclassify a relatively large proportion of nonnative speakers as English proficient by the eighth grade.

That said, we note that eighth grade curricular intensification is not the only change that occurred in the district over the study period. In particular, student achievement, as measured by student scores on CSTs in mathematics and English Language Arts administered to all students prior to eighth grade, improved significantly over the study period. It seems unlikely that changes in eighth grade mathematics placements could drive improvements in sixth and seventh graders' test scores. Furthermore, these trends are roughly consistent with statewide trends in sixth and seventh grade student achievement over the study period. We thus control for students' prior mathematics and English scores to estimate the effects of cross-cohort curricular intensification in Towering Pines.

Table 1. Descriptive Statistics by Cohort

	2004–2005	2005–2006	2006–2007	2007–2008
Gen Math in eighth grade (*n*)	2,414	1,867	988	612
(%)	64	50.79	25.48	15.65
Algebra in eighth grade (*n*)	1,216	1,501	2,438	2,773
(%)	32.24	40.83	62.87	70.9
Geometry in eighth grade (*n*)	142	308	452	526
(%)	3.76	8.38	11.66	13.45
ELL in eighth grade (*n*)	1,469	1,301	1,289	1,325
(%)	38.93	35.39	33.1	33.84
RFEP in eighth grade (*n*)	884	988	1,155	1,205
(%)	23.43	26.88	29.66	30.78
Eng only/FEP in eighth grade (n)	1,420	1,387	1,450	1,385
(%)	37.64	37.73	37.24	35.38
Hispanic (*n*)	1,939	1,852	2,075	2,111
(%)	51.39	50.38	53.29	53.92
Vietnamese (*n*)	834	867	921	963
(%)	22.1	23.59	23.65	24.6
White (*n*)	692	624	584	514
(%)	18.34	16.97	15	13.13
Other (*n*)	308	333	314	327
(%)	8.16	9.06	8.06	8.35
Sixth grade math score (mean)	–0.135	0.002	0.057	0.070
(*SD*)	(0.952)	(0.959)	(1.042)	(1.027)
Seventh grade ELA score (mean)	–0.146	–0.021	0.053	0.104
(*SD*)	(0.976)	(0.969)	(1.016)	(1.018)

Note: Sixth grade math and ELA scores are standardized across cohorts.

METHODS

Q1: What effect did eighth grade curricular intensification have on mathematics course enrollment patterns in Towering Pines Unified schools?

We estimate a series of multinomial logistic regression models to assess the ways mathematics course enrollment patterns changed for Towering Pines students during the study period (Williams, 2006). This model investigates eighth graders' odds of enrolling in Algebra or Geometry:

$$\mathbf{P(Y_i > j) = Logit(\beta_0 + \Sigma\, \beta_1 Year\ 8th + \Sigma\, \beta_2 Controls), j = 1, 2,}$$

where $\mathbf{Y_i}$ indexes whether or not an eighth grader was enrolled in Algebra or Geometry; **Year 8th** is a matrix of dummy variables capturing the year in which the student enrolled in eighth grade (the 2004–2005 cohort is the reference); and **Controls** include student gender, ethnicity, language status, and prior mathematics and English Language Arts (ELA) test scores. Our measures of prior achievement are students' sixth grade math CSTs and their seventh grade ELA CSTs. We use math CST scores from the sixth grade rather than the seventh grade because roughly 15% of Towering Pines seventh graders take the Algebra CST rather than the grade-level CST. However, because all students take the same ELA CST in the seventh grade, the seventh grade CST provides a measure of student language skills prior to eighth grade. β_1 in this model thus represents changes in eighth grade mathematics course enrollments over the study period net of other changes in the district.

Even if Towering Pines' curricular reforms succeeded in channeling eighth graders into more advanced courses, they would have little lasting effect if they failed to prepare students to continue taking advanced courses in high school. We thus estimate the effects of Towering Pines' curricular reform on student mathematics course enrollments in 10th grade. Using multinomial logistic regression models that parallel the eighth grade mathematics course enrollment models summarized above, we estimate cross-cohort changes in 10th grade mathematics course enrollment. As in the eighth grade course enrollment models, we use students' course-specific CST mathematics test to measure their 10th grade course enrollment. The categories for 10th grade course enrollment are: Algebra I, Geometry, Algebra II, and Summative Mathematics (which is the CST designed for students enrolled in Trigonometry, pre-Calculus, Calculus, or a more advanced mathematics course).

Q2: How did the achievement distribution in Towering Pines math classrooms change as the district universalized eighth grade Algebra?

Second, we examine changing achievement distributions for eighth grade math courses in Towering Pines. Using our district-wide census data, we investigate the achievement distribution of students in eighth grade General Mathematics, Algebra, and Geometry courses by plotting kernel density graphs of the *z*-scored sixth grade mathematics test scores for students in these courses. These distributions provide a measure of the extent to which the district sorts students into eighth grade mathematics classes based on prior mathematics achievement. Comparing these distributions across cohorts sheds light on the ways these sorting practices changed during a period of curricular intensification.

Q3: Did eighth grade curricular intensification improve students' mathematics achievement?

Finally, we investigate changes in students' mathematics achievement, as measured by the mathematics portion of California's high-stakes high school exit exam (CAHSEE), during the period in which the district expanded eighth grade Algebra enrollment. This exam—which consists of roughly 90 multiple-choice questions covering Algebra, measurement and geometry, statistics, data analysis and probability, number sense, and mathematical reasoning—is designed under contract by ETS to align with California seventh and eighth grade instructional standards and is subject to annual independent validation (HumRRO, 2012). It is administered to all students in the spring of their 10th grade year. However, because the exam provides limited coverage of advanced mathematical reasoning and does not cover content beyond Algebra, it may fail to capture the effect of curricular intensification on students' achievement in relatively advanced mathematics topics.

We first estimate cross-cohort changes in student achievement using ordinary least squares (OLS) regression models that take the same general form as the multinomial logistic regression models described above. The Year coefficients in these models capture the mean differences in mathematics achievement across cohorts, controlling for changes in student composition and sixth and seventh grade test scores. These cross-cohort changes provide a measure of the average effects of roll-out of the constrained curriculum strategy in Towering Pines.

In addition, we estimate a model that adds Course main effects and Year × Course interaction effects to measure the extent to which curricular intensification changed the payoff associated with taking Algebra or Geometry over time. Course in this model is a set of dummy variables identifying students who took the Algebra or Geometry end-of-year test (with students who took the eighth grade General Math end-of-year test as the reference categories); the Year × Course interaction allows the relationship between these course enrollments and student achievement to vary across cohorts. The Year × Course interaction terms estimate the ways the effects of eighth grade Algebra and Geometry enrollment change as Towering Pines constrained curricula in middle school mathematics. We then add controls for heterogeneity and mean achievement levels in eighth grade mathematics classrooms to determine the extent to which peer effects and the challenges associated with teaching heterogeneous classrooms mediate the effects of curricular intensification on student achievement.

Because we lack achievement scores and course enrollment data for students who are not enrolled in Towering Pines schools, students who transferred into Towering Pines for eighth grade are excluded from all multivariate analyses. Similarly, approximately 17% of the students for whom we have eighth grade data provide no data on 10th grade course taking or achievement. Many of these students likely dropped out of school before taking the exit exam. Low-achieving students and Hispanic students were disproportionately likely to leave the sample between eighth and 10th grade. To account for the fact that our students are nested in schools and classrooms, all multivariate analyses utilize robust standard errors.

RESULTS

Q1: What effect did eighth grade curricular intensification have on mathematics course enrollment patterns in Towering Pines Unified schools?

Figure 1 reports eighth grade course enrollment trends in Towering Pines between 2004–2005 and 2007–2008, first descriptively and second with controls for changing student demographics and prior test scores. Appendix Table A1 reports the results of the full regressions upon which Figure 1 is based. As Figure 1a illustrates, General Math was the modal course for Towering Pines eighth graders in 2004–2005. But as the district began placing more students in eighth grade Algebra, the proportion of eighth graders enrolled in General Math fell dramatically. In 2007–2008, Algebra was the modal eighth grade math course, accounting for 70% of students, and nearly as many eighth graders were enrolled in Geometry as General Math. A particularly notable sharp uptick in eighth grade Algebra taking occurred in the 2006–2007 school year. These cohort-to-cohort increases in eighth grade Algebra and Geometry enrollment are each statistically significant.

Figure 1b demonstrates that this curricular intensification is not an artifact of demographic change in the district or a downstream effect of improvements in elementary mathematics education. This figure, which is based on the second model reported in Appendix Table A1, represents the predicted probability of General Math, Algebra, and Geometry for a hypothetical "average" Towering Pines eighth grader for whom all demographic and prior achievement variables are set to the cross-cohort district mean. In 2004–2005, this hypothetical student had a 57% chance of enrolling in eighth grade General Math; 43% chance of enrolling in eighth grade Algebra; and a less than 1% chance of enrolling in eighth grade

Geometry. By 2007–2008, this hypothetical student's odds of enrolling in eighth grade Algebra had increased to 94%. Again, Appendix Table A1 indicates that each of these cross-cohort increases is statistically significant. Indeed, a comparison of Figures 1a and 1b indicates that the expansion of advanced mathematics course enrollment is even more pronounced after controlling for student demographics and prior test scores.

Figure 1a. Towering Pines eighth grade math course enrollment 2004/2005 to 2007/2008

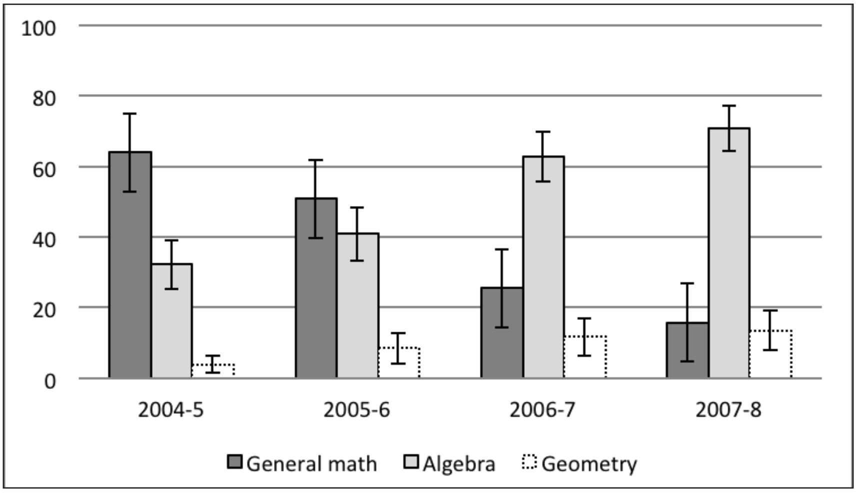
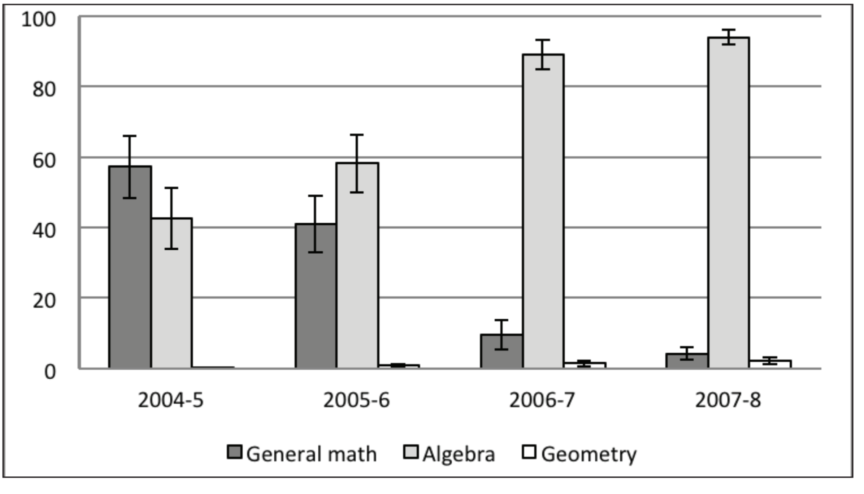


Figure 1b. Towering Pines eighth grade math course enrollment 2004/2005 to 2007/2008, controlling for student demographics, language status, and prior math and ELA scores



The results reported in Figure 2a indicate that eighth grade curricular intensification continues to influence students' mathematics course patterns two years later, when students are in 10th grade. Appendix Table A2 reports the results of the full regressions upon which Figure 2 is based. In the 2004–2005 school year, math course enrollments for Towering Pines 10th graders were split fairly evenly among Algebra, Geometry, and Algebra II, with approximately 30% of 10th graders enrolled in each of these courses. By 2007–2008, the proportion of 10th graders enrolled in Algebra had fallen to less than 10% and more advanced math course enrollments increased accordingly. Figure 2b indicates that these cross-cohort shifts in 10th grade enrollment are even more pronounced after controlling for cross-cohort changes in student language status, demographics, and prior test scores. These cross-cohort changes in mathematics course enrollments are statistically significant, even after controlling for changes in student demographics and prior achievement.

However, the expansion of advanced 10th grade mathematics course enrollments revealed in Figure 2 is somewhat less pronounced than the expansion of eighth grade mathematics course enrollments reported in Figure 1, indicating that not all students who enroll in more advanced eighth grade courses continue to take advanced mathematics courses in 10th grade. Students who complete eighth grade Algebra should be on track to enroll in Algebra II in 10th grade. However, although the hypothetical "average" Towering Pines eighth grader in the 2007–2008 cohort had a 94% chance of taking eighth grade Algebra, this analysis indicates that that students' chances of completing Algebra II by 10th grade was just 39%. Supplementary analyses indicate that this falloff between eighth and 10th grade occurs in large part because an increasing proportion of Towering Pines students had to repeat math courses in their eighth and ninth grade years as the district implemented the constrained curriculum strategy. In the 2004–2005 school year, approximately one third of students who took eighth grade Algebra repeated Algebra in their ninth grade year; by 2007–2008, that proportion increased to nearly 50%. Nonetheless, taken together, the analyses presented in Figures 1 and 2 clearly indicate that eighth grade mathematics curricular intensification has net positive consequences for inclusiveness in advanced mathematics courses, both in eighth grade and later in their high school careers.

Figure 2a. Towering Pines 10th grade math course enrollment 2004/2005 to 2007/2008

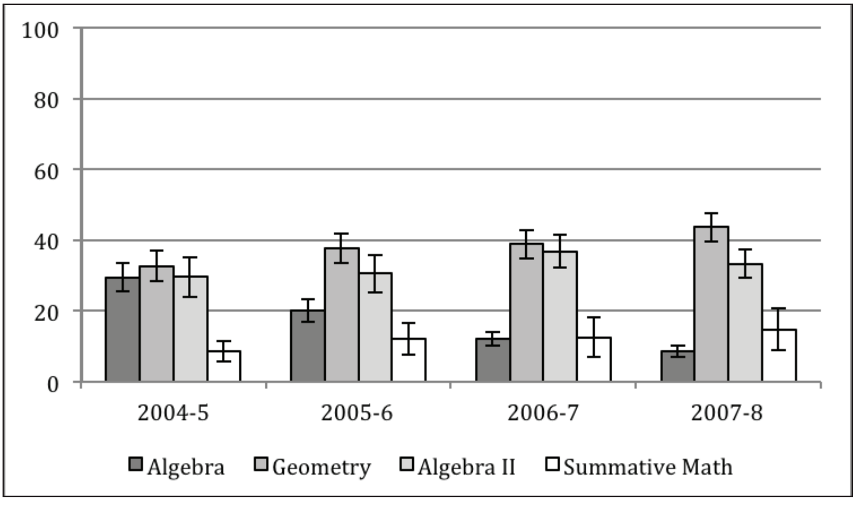
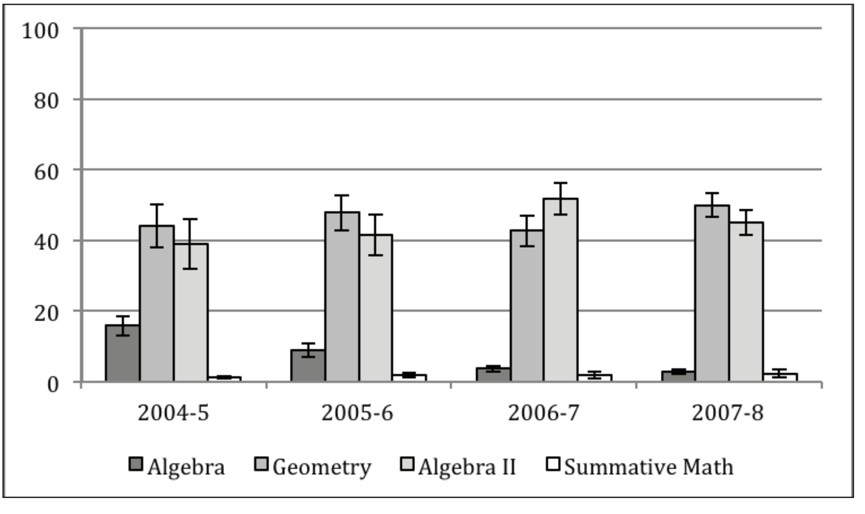


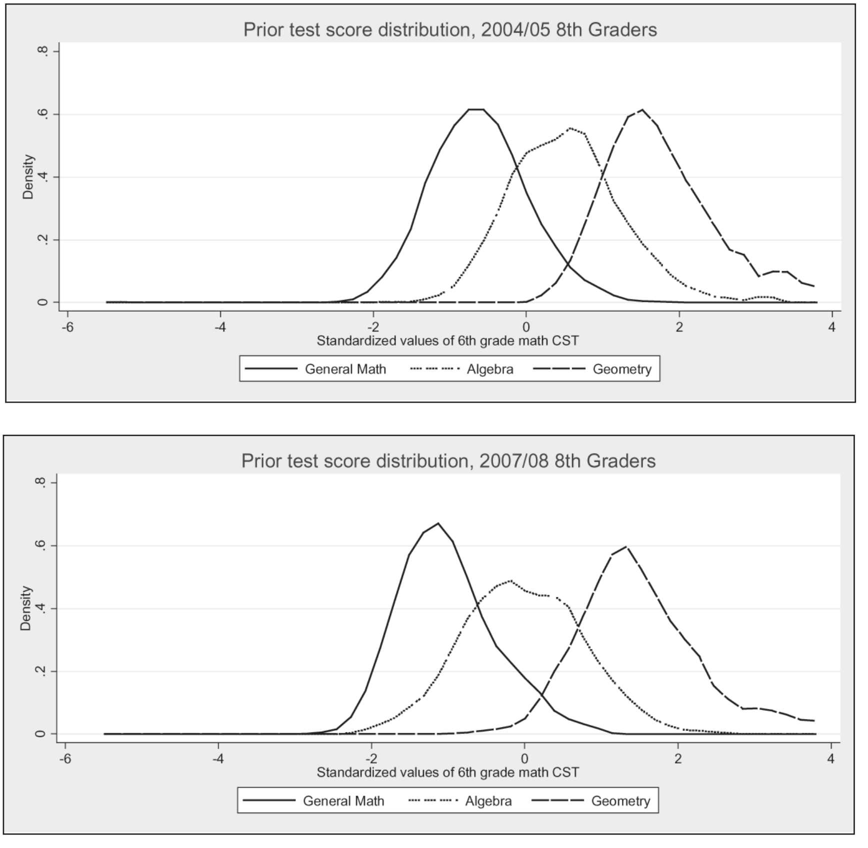
Figure 2b. Towering Pines 10th grade math course enrollment 2004/2005 to 2007/2008, controlling for student demographics, language status and prior math and ELA scores



Q2: How did the achievement distribution in Towering Pines math classrooms change as the district universalized eighth grade Algebra?

Figure 3 reports the sixth grade test score distribution for eighth graders enrolled in Towering Pines General Math, Algebra, and Geometry classes in the 2004–2005 and 2007–2008 school years. Both of these kernel density graphs clearly suggest that eighth grade math course placement is stratified based on students' prior achievement. In 2004–2005, the median eighth grade General Math student had prior math scores that were more than a standard deviation lower than those of the median eighth grade Algebra student. Similarly, the median eighth grade Algebra student's prior math scores were more than a standard deviation below those of the median eighth grade Geometry student. Despite these differences, however, there is some overlap between these distributions. In the 2004–2005 cohort, the median eighth grade General Math student had higher sixth grade math test scores than approximately 10% of the eighth graders enrolled in Algebra. A similar overlap exists between eighth grade Algebra and Geometry students.

Figure 3. Prior test score distributions 2004–2005 versus 2007–2008 by eighth grade math class



At first glance, the prior math test score distribution for 2007–2008 eighth graders seems to parallel the 2004–2005 distribution. Upon closer inspection, however, two important differences emerge between these two cohorts.

First, the distribution of prior test scores in all three eighth grade math courses shifted to the left in Towering Pines between 2004–2005 and 2007–2008. Among eighth grade Algebra students the standardized median prior math test score declined by half a standard deviation during this time period. Among eighth grade General Math students, the median declined by 0.4 standard deviations; and among eighth grade Geometry students, the median declined by 0.2 standard deviations. As Table 1 makes clear, this decline prior test scores among eighth grade Algebra and Geometry students is not driven by an overall test score decline within the district—in fact, test scores increased during the study period. Rather, the rightward shift in the distribution of prior test scores with eighth grade math course levels occurs because the district's constrained curricula effort extended access to high-status Algebra and Geometry courses to students who would have been excluded from these advanced math courses at the beginning of the study period. In short, therefore, the shift in the Algebra and Geometry course prior test score distribution is indicative of increasing course inclusiveness in Towering Pines.

Second, the distribution of prior test scores widened in eighth grade Algebra classes during this time period, even as that distribution narrowed in eighth grade General Math classes. The interquartile range of prior math test scores for eighth grade Algebra students in 2004–2005 was 0.9 points, but by the 2007–2008 cohort the interquartile range had widened to 1.15 points. This shift suggests that eighth grade Algebra courses became more heterogeneous in terms of prior achievement as the district intensified middle school mathematics curricula. At the same time, eighth grade General Math courses became more homogeneous as students who might have once been at the top of the achievement distribution in these classes were enrolled in more challenging eighth grade math courses.

Q3: Did eighth grade curricular intensification improve students' mathematics achievement?

These findings suggest that Towering Pines pursued a strategy consistent with Lee's (1993) theory of constrained curriculum as it placed more students into rigorous eighth grade math courses. But did this strategy succeed in boosting math achievement in the district? Table 2 summarizes the results of several OLS regression models investigating student achievement trends in Towering Pines during the period in which the district implemented the constrained curriculum strategy.

Table 2. OLS Regression Coefficients, 10th Grade Math Test Scores

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
2004–2005	–	–	–	–	–	–
	–	–	–	–	–	–
2005–2006	0.086	–0.041	–0.090**	–0.090**	-0.079**	–0.076**
	(0.073)	(0.024)	(0.030)	(0.029)	(0.027)	(0.027)
2006–2007	–0.01	–0.147***	–0.144***	–0.128***	-0.087**	–0.062
	(0.071)	(0.022)	(0.031)	(0.030)	(0.030)	(0.033)
2007–2008	0.013	–0.158***	–0.227***	–0.211***	-0.126**	–0.098*
	(0.073)	(0.021)	(0.043)	(0.040)	(0.039)	(0.043)
Hispanic		–0.165***	–0.163***	–0.162***	-0.122***	–0.153***
		(0.022)	(0.020)	(0.021)	(0.020)	(0.020)
Vietnamese		0.224***	0.216***	0.217***	0.214***	0.216***
		(0.026)	(0.023)	(0.023)	(0.022)	(0.023)
Other		0.119***	0.107***	0.107***	0.106***	0.109***
		(0.025)	(0.024)	(0.024)	(0.024)	(0.024)
ELL		0.041*	0.042*	0.043*	0.046*	0.039*
		(0.020)	(0.019)	(0.018)	(0.018)	(0.018)
Reclassified English		0.109***	0.088***	0.085***	0.088***	0.082***
		(0.016)	(0.015)	(0.015)	(0.015)	(0.015)
Sixth grade Math (std)		0.518***	0.480***	0.476***	0.420***	0.446***
		(0.015)	(0.016)	(0.015)	(0.015)	(0.015)
Seventh grade ELA (std)		0.264***	0.230***	0.229***	0.202***	0.204***
		(0.011)	(0.011)	(0.010)	(0.010)	(0.010)
Eighth grade Algebra			0.400***	0.394***	0.167***	0.362***
			(0.033)	(0.032)	(0.034)	(0.029)
Eighth grade Geometry			0.105	0.180**	-0.424***	0.128*
			(0.057)	(0.058)	(0.072)	(0.053)
Algebra * 2006			0.012	0.018	0.029	–0.009
			(0.042)	(0.042)	(0.039)	(0.039)
Algebra * 2007			–0.184***	–0.217***	-0.153***	–0.257***
			(0.041)	(0.041)	(0.039)	(0.041)

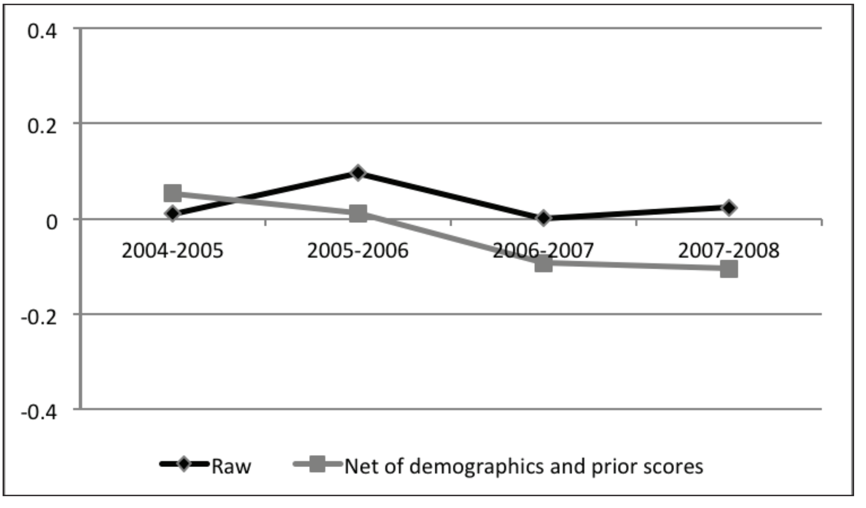
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Algebra * 2008			–0.128**	–0.158**	-0.125**	–0.257***
			(0.049)	(0.048)	(0.046)	(0.048)
Geometry * 2006			0.142*	0.125*	0.182*	0.126*
			(0.059)	(0.058)	(0.076)	(0.056)
Geometry * 2007			0.109	0.089	0.092	0.018
			(0.062)	(0.062)	(0.068)	(0.061)
Geometry * 2008			0.194**	0.161*	0.161*	0.055
			(0.065)	(0.065)	(0.068)	(0.064)
Math course skill heterogeneity (IQR)				0.004***		
				(0.001)		
Math course peer quality (mean)					0.319***	
					(0.025)	
% math course peers below basic						–0.755***
						(0.051)
Constant	0.011	0.053*	–0.101***	–0.102***	0.006	–0.029
	(0.056)	(0.025)	(0.026)	(0.025)	(0.024)	(0.025)
N	11941	10384	10384	10384	10384	10384

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

Model 1 reveals that Towering Pines students who were eighth graders in 2005–2006, 2006–2007, and 2007–2008 did not score significantly differently on their 10th grade math test than their peers who were eighth graders in 2004–2005. Figure 4 provides a graphical representation of this analysis, reporting trends in scores on the math component of the California High School Exit Exam (CAHSEE), a high-stakes exam that all California public school students take in the spring of their 10th grade year. The black line on this graph represents mean CAHSEE scores for eighth graders in the 2004–2005, 2005–2006, 2006–2007, and 2007–2008 cohorts. This line is flat; mean CAHSEE scores do not significantly differ across these four cohorts. Contrary to the theory of constrained curriculum, this finding lends little credence to the hypothesis that enrolling more students in advanced eighth grade math courses boosted student achievement in the district.

Supplemental analyses, available by request, suggest that odds of reaching the ceiling on the 10th grade math test increased during the study period, particularly for students who enrolled in eighth grade Geometry. To ensure that this did not impact our analyses, we estimated censored regression models; as results were substantively identical, we do not report them separately here. We also conduct analyses separately for CAHSEE subscores measuring Algebra I, Algebra and Functions, and Measurement and Geometry. As there are no noteworthy differences, we do not report them here. Nonetheless, this finding suggests that our findings may overlook limited positive effects of curricular intensification on student achievement in more advanced mathematical areas, which are not tested in the CAHSEE.

Figure 4. Cross-cohort changes in spring 10th grade CAHSEE math test scores, raw and regression corrected*



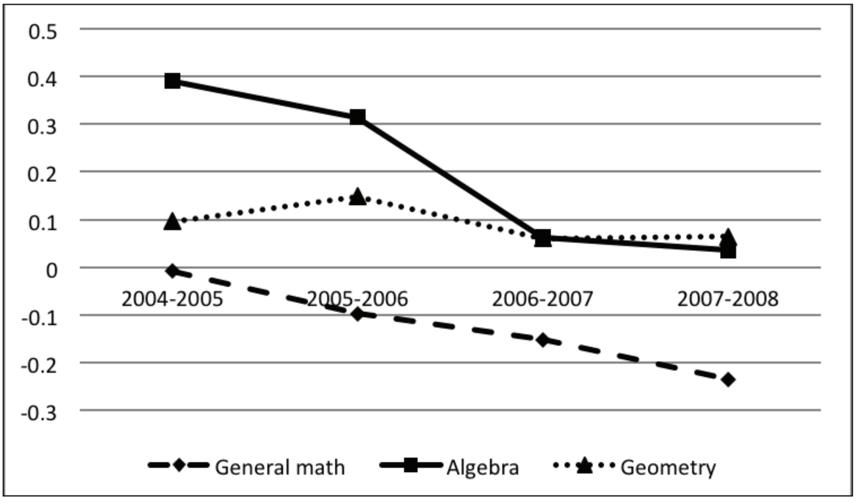
*Includes controls for gender, race/ethnicity, language status, and prior ELA and math test scores. Prior test scores fixed at mean for all students in course level across the four cohorts.

Recall, however, that Towering Pines enjoyed significant improvements in sixth grade math test scores over this period. The gray line in Figure 4 controls for these cross-cohort changes, as well as changes in student demographics, presenting results from Model 2 in Table 2. This suggests that 10th grade student test scores actually fell in Towering Pines during the constrained curriculum implementation period. Net of demographics and prior test scores, students in the 2006–2007 and 2007–2008 eighth grade cohorts scored approximately 0.15 standard deviations lower on the 10th grade math test than their peers in the 2004–2005 cohorts. These differences, which are statistically significant at the 0.001 level, are striking given the intensification of eighth and 10th grade math course enrollments reported in Figures 1 and 2. While it is impossible to make strong causal statements about the effects of curricular intensification based on our observational data, the significant decline in 10th grade test scores suggests that Towering Pines' eighth grade Algebra push may have impeded student mathematics learning.

Why might a policy that increases the rigor of eighth graders' mathematics course placements have negative long-term effects on their mathematics learning? This study is unable to conclusively answer this question. But Figure 5 provides an interesting hint. This figure, which is based on the results of the third model reported in Table 2, reports predicted CAHSEE test scores for Towering Pines eighth graders in the 2004–2005, 2005–2006, 2006–2007, and 2007–2008 cohorts enrolled in eighth grade General Math, Algebra, and Geometry, holding student demographics and prior achievement constant at the sample mean. This graph indicates that enrolling in eighth grade Algebra and Geometry had a positive effect on student CAHSEE scores for students in each of the survey years, as all of the predicted scores are greater than zero. In the 2004–2005 school year, students enrolled in eighth grade Algebra scored 0.40 standard deviations higher on the CAHSEE than they might have had they enrolled in eighth grade General Math. This difference is statistically significant at the .001 level. However, consistent with Figure 3, this figure shows that conditional student mathematics achievement declined in Towering Pines as the district implemented the constrained curriculum strategy. Furthermore, Figure 5 indicates that these achievement declines were especially pronounced in the eighth grade Algebra track. In other words, this figure indicates that the achievement returns to eighth grade Algebra declined significantly as the Towering Pines broadened student access to that course. As a result of secular achievement declines in Towering Pines combined with shrinking returns to Algebra, there is no difference between the predicted 10th grade mathematics achievement for students enrolling in 2007–2008 eighth grade Algebra and students enrolled in 2004–2005 eighth grade General Mathematics.

While the positive effect associated with eighth grade Geometry enrollment is smaller than the positive effect of eighth grade Algebra in most of the study years, the results reported in Figure 5 indicate that the achievement effects of eighth grade Geometry enrollment remained constant across the four cohorts. This finding is striking, because the Geometry enrollment rate increased even more rapidly than the Algebra enrollment

Figure 5. Regression-corrected* cross-cohort changes in spring 10th grade CAHSEE math test scores, by eighth grade math course



*Includes controls for gender, race/ethnicity, language status, and prior ELA and math test scores.

rate during the study period. However, Geometry is distinctive among eighth grade math courses in Towering Pines in that the distribution of students' prior math achievement remained relatively stable across the study period. The classroom distribution of student achievement is likely to influence the behavior of students and teachers alike. The effects of curricular intensification on classroom distributions of prior achievement may help to explain unexpectedly disappointing test score trends in Towering Pines.

The remaining models in Table 2 test potential explanations for this unexpected negative effect. Model 4 considers the possibility that curricular intensification hurts student learning in eighth grade Algebra classrooms because it increases the degree of student achievement heterogeneity in these classrooms, forcing teachers to attempt to simultaneously meet the needs of an increasingly diverse pool of learners (Rosenbaum, 1999). Surprisingly, however, the measure of classroom heterogeneity used in this model—the interquartile range of students' sixth grade mathematics test score—emerges as *positive* predictor of student learning, all else equal. Furthermore, controlling for heterogeneity does very little to moderate the differential returns associated with higher level mathematics course enrollment in eighth grade. This analysis, therefore, provides little support for the idea that the heterogeneity undermines the effectiveness of curricular reforms that detrack by intensifying curricula.

Another possible explanation revolves around changes to average peer achievement in eighth grade mathematics courses. Model 5 of Table 2 tests this possibility by controlling for peer achievement in eighth grade mathematics classrooms via a standardized measure of the mean sixth grade mathematics test score for eighth graders' mathematics class peers. Comparing the cohort coefficients in Model 5 with the cohort coefficients in Model 3 reveals that peer quality explains over a third of the decline in student achievement in eighth grade General Mathematics classrooms that occurred in Towering Pines during the study period. Comparing the Model 3 and Model 5 Algebra coefficients suggests that peer effects explain approximately two thirds of the advantage associated with enrolling in Algebra in the baseline year. Likewise, comparing the Model 3 and Model 5 Geometry coefficients suggests that, if not for positive peer effects, students in the baseline cohort would have been better off enrolling in a lower level mathematics course. While average peer achievement explains some of the apparent decline in the relative value of Algebra course enrollments that occurred over the study period, the reverse is true for Geometry, where the gap in learning increases relative to eighth grade General Math after controlling for peer achievement. Thus, this model suggests that much of the learning decline in General Mathematics classes can be attributed to peer effects, as can much of the base effect of Algebra and some of the changes in the returns to Algebra and Geometry over time.

We also introduce peer effects into the model by controlling for the percent of students in each mathematics course who scored below basic on their sixth grade mathematics test.[2] This approach suggests that the effects of peers operate not through the average level of preparation in a classroom but rather through the proportion of students who are not well prepared. The results for General Mathematics in Model 6 show that that this conceptualization of peer effects is slightly better at explaining the decline we observe than the average classroom achievement (Model 5). Similarly, controlling for below basic peers mediates the relationship between Geometry enrollment and student success in the study's later years, suggesting that one of the reasons that enrolling in Geometry improves student achievement is that it insulates students from below basic peers. The pattern for Algebra is somewhat different. Controlling for the proportion of peers scoring below basic explains very little of the baseline Algebra effect and does not explain the declining returns to Algebra enrollment that we observe over the study period.

These analyses suggest that peer effects partially explain the disappointing student achievement trends that occurred in Towering Pines during the period of curricular intensification. While both measures of peer effects return complementary findings, it is interesting to note that the concentration of peers who scored below basic in sixth grade math is a somewhat stronger predictor of 10th grade math achievement than the classroom average of sixth grade student achievement. Furthermore, we find that the concentration of below basic peers is a particularly salient mediator of the negative relationship between low-level math course placement and achievement in the district.

DISCUSSION

California is at the forefront of a national movement to intensify mathematics curriculum, and Towering Pines is an early adopter in California's movement to do so. Over the past few years, driven by the statewide push to enroll all California eighth graders in Algebra courses, Towering Pines has dramatically intensified eighth grade mathematics curricula. By constraining middle and high school curricula, Towering Pines attempted to broaden access to rigorous coursework and thus raise student achievement. Between 2004–2005 and 2007–2008, the proportion of the district's eighth graders who enrolled in Algebra more than doubled and the proportion of eighth graders who enrolled in Geometry increased nearly fourfold. Although remarkable in magnitude and speed, these shifts are consistent with a broader effort to reduce electivity in middle and high school course placements in order to increase the inclusiveness and decrease the selectivity of rigorous high track courses. In this paper, we use Towering Pines' experience with curricular reform in middle school mathematics to understand the implications of constrained curriculum approaches more broadly.

We find that the push to place eighth graders into Algebra raised the odds that Towering Pines students enrolled in advanced math courses in eighth grade and, to a lesser extent, 10th grade. Further, it increased the odds that previously low-achieving and high-achieving students enrolled in eighth grade math classes together. Thus, our analyses suggest that curricular intensification increased the inclusiveness and decreased the selectivity of the mathematics tracking regime in Towering Pines middle schools. These are important first-order consequences of the curricular intensification effort.

While earlier work on tracking, as well as Lee's constrained curriculum theory, suggests that curricular intensification should improve student learning, our analyses of 10th grade mathematics achievement yield discouraging findings. During the period in which Towering Pines intensified eighth grade mathematics curricula, student mathematics achievement growth slowed. We are cautious about making sweeping statements based on this finding, because we cannot completely rule out alternative explanations for the decline and do not know how representative the Towering Pines experience is. Nonetheless, curricular intensification seems to have depressed student achievement in Towering Pines and undermined the advantages associated with enrolling in eighth grade Algebra, and it thus serves as an important cautionary tale about the potential for improving student achievement via constrained curricula.

By design, constrained curriculum efforts changes the composition of students' prior achievement in targeted classrooms, increasing the chances that previously low-achieving students sit in the same classroom as previously high-achieving students. These changes may be socially desirable, providing low-achieving students access to the higher expectations and enriched educational opportunities associated with high-level courses and creating new opportunities for student interaction across class and race divides.

However, they may also come at a cost. If teachers adjust the content of their instruction to meet the perceived ability of their students, curricular intensification like that undertaken in Towering Pines may undermine the rigor of high-level math courses, so that students are no better off than if they had been in lower level classes in a differentiated system (cf. Figure 5). Further, teachers may adjust their instructional strategies (in either effective or ineffective ways) to address the needs of learners with heterogeneous prior achievement. Classroom composition may also influence students in unexpected ways. The detracking literature has typically assumed that detracking will reduce stigma for disadvantaged students placed into low-track classes. But the sharp declines in student achievement that occurred during the study period of Towering Pines students in General Math courses suggest that incomplete detracking may actually intensify stigma for low-track students, as the only students left in the low-level tracks are increasingly anomalous. Gamoran (1992) considered this possibility, but it has not been explored elsewhere in the literature. Furthermore, classroom peer composition may have independent effects on student achievement, independent of instruction.

Our findings suggest that constrained curriculum efforts may have unintended consequences. While this study cannot ultimately adjudicate between different explanations for these consequences, instructional challenges and peer effects may be partially to blame. Given the impending adoption of the Common Core State Standards throughout the United States, we suggest that research examining the pedagogical challenges and changes in peer effects associated with curricular intensification is needed to understand the myriad changes associated with curricular intensification policies and ensure that attempts to provide all students with the opportunity to learn advanced math are not abandoned due to potentially avoidable iatrogenic effects.

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Notes

1. The district's schools offered a number of different grade level General Mathematics courses during the study period including remedial/developmental mathematics, basic math, Pre-Algebra, and the first year of a two-year course sequence that integrates pre-Algebra and Algebra course content. Since these course offerings vary idiosyncratically between schools and over time and all students in these courses take the state's General Mathematics end-of-course test, we consider these courses as functionally equivalent here and define courses based on the end-of-year test that students take.

2. California uses five performance levels to report student achievement on the CSTs: advanced, proficient, basic, below basic, and far below basic. The distinction between basic and below basic is particularly consequential for school accountability purposes, because the state considers students who score basic on the CSTs at grade level.

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APPENDIX

Table A1. Eighth Grade Math Course Enrollment Odds, Multinomial Logistic Regression (Standard Errors in Parentheses)

	Model 1		Model 2	
	>=Algebra	**Geometry**	**>=Algebra**	**Geometry**
(2004–2005)				
2005–2006	1.772**	1.772**	2.150***	2.150***
	(0.333)	(0.333)	(0.396)	(0.396)
2006–2007	5.283***	2.817***	13.809***	3.468***
	(1.148)	(0.854)	(3.824)	(1.173)
2007–2008	9.691***	3.312***	34.038***	4.409***
	(2.152)	(1.031)	(9.390)	(1.564)
Hispanic			1.264	1.264
			(0.177)	(0.177)
Vietnamese			2.257***	2.257***
			(0.351)	(0.351)
Other			1.793***	2.564***
			(0.271)	(0.386)
ELL			1.414***	0.719
			(0.142)	(0.171)
Reclassified English			1.615***	1.615***
			(0.118)	(0.118)
Constant	0.556***	0.047***	0.354***	0.003***
	(0.085)	(0.012)	(0.074)	(0.001)
N	15227		12395	

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

APPENDIX

Table A2. 10th Grade Math Course Enrollment Odds, Multinomial Logistic Regression (Standard Errors in Parentheses)

	Model 1:			Model 2:		
	Geometry	**Alg. II**	**Summ.**	**Geometry**	**Alg. II**	**Summ.**
2004–2005	–	–	–	–	–	–
	–	–	–	–	–	–
2005–2006	1.664***	1.196	1.433	1.962***	1.234	1.457
	(0.226)	(0.204)	(0.373)	(0.225)	(0.204)	(0.362)
2006–2007	3.035***	1.578**	1.515	4.443***	1.883***	1.363
	(0.400)	(0.264)	(0.454)	(0.523)	(0.295)	(0.411)
2007–2008	4.461***	1.499*	1.832*	6.292***	1.445*	1.763*
	(0.659)	(0.251)	(0.526)	(0.777)	(0.229)	(0.510)
Hispanic				0.983	0.983	0.983
				(0.085)	(0.085)	(0.085)
Vietnamese				3.162***	3.162***	3.162***
				(0.318)	(0.318)	(0.318)
Other				1.567**	2.354***	3.167***
				(0.214)	(0.269)	(0.458)
ELL				1.277***	1.277***	1.277***
				(0.092)	(0.092)	(0.092)
Reclassified English				1.246*	1.603***	1.819***
				(0.119)	(0.125)	(0.195)
Sixth grade Math (std)				3.120***	4.565***	7.037***
				(0.227)	(0.268)	(0.668)
Seventh grade ELA (std)				2.080***	2.460***	2.218***
				(0.136)	(0.124)	(0.190)
Constant	2.413***	0.615***	0.094***	2.644***	0.254***	0.006***
	(0.242)	(0.086)	(0.018)	(0.281)	(0.039)	(0.001)
N	11918			10142		

THURSTON DOMINA is Associate Professor of education and sociology at the University of California, Irvine. He studies the relationship between education and social inequality. In addition to his work on middle school mathematics, he is currently involved in projects researching admissions, instruction, and persistence in U.S. post-secondary education.

ANDREW M. PENNER is Assistant Professor of sociology at UC Irvine. His research focuses on gender and race inequality in the labor market and educational system. He is currently involved in projects examining gender inequality in transition economies, racial fluidity in the United States, and international gender differences in education.

EMILY K. PENNER is a PhD student in the School of Education at UC Irvine. Her research focuses on educational inequality and policy, and considers the ways that districts, schools, teachers, peers, and parents can contribute to or ameliorate educational inequality. She is currently involved in projects examining the impact of alternative teacher preparation programs, how curriculum placement policies affect student learning, and the quality of measures of teacher effectiveness.

ANNEMARIE CONLEY is Assistant Professor of education at UC Irvine. Her research asks how students' motivation to learn develops and how this development can be supported by teachers, classrooms, and schools.