Does Detracking Work?
Evidence from a Mathematics Curricular Reform

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Abstract:

Across the United States, secondary school curricula are intensifying as a growing proportion of school students enroll in high-level academic math courses. Using data from a diverse California school district, we examine the role of a multi-year effort to raise the inclusiveness of high-level middle school mathematics courses by placing nearly every 8th grader in Algebra I courses. We find that curricular intensification increased students' odds of taking higher level mathematics courses and created more skill-heterogeneous 8th grade math classrooms. However, we find the rate of 7th-10th grade mathematics score growth slowed as the district intensified math curricula, particularly for low-achieving students. Peer effects are partly to blame for the disappointing effects of curricular intensification on student achievement.

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Over the last two decades, standards-based school reforms, rising student expectations, and the increasing skills demands of the American labor force led American secondary schools to eliminate low-level and non-academic courses and enroll increasing proportions of students in college-preparatory courses (Author 2010, 2011a). 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, reducing the scope of the tracking system in American schools (Lucas 1999). While American secondary schools remain hierarchically tracked, recent trends toward curricular intensification have broadened access to high-status courses and rendered their 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 1985, 2005; Oakes 1994; Powell, Farrar, & Cohen 1985). This would seem to suggest that moves away from rigid curricular tracking – including the sort of curricular intensification that has occurred in American secondary schools over the past several decades – should narrow achievement gaps. However, racial and class-based inequalities in American schools persist despite recent curricular changes. Furthermore, earlier experimental research suggests that tracking may have no effect on either educational efficiency or equity (Slavin 1990); and contemporary studies examining the effects of curricular change on the distribution of student achievement yield mixed results (Allensworth, Nomi, Montgomery, & Lee 2009; Burris, Heubert, & Levin 2006; Burris, Wiley, Welner, & Murphy 2008). In this paper, we investigate the consequences of curricular intensification by examining changes in the social organization of schooling and student achievement in one California school district. Our analyses focus on 8th grade student data collected from a large, ethnically-diverse Southern California school district during a four year period in which state policy provided strong incentives for schools to enroll a greater proportion of 8th graders in Algebra I courses. In the 2004-05 school year 32% of the district's 8th graders enrolled in Algebra or a higher-level mathematics course; by the 2007-08 school year that proportion had increased to 84%. This rapid curricular intensification provides a powerful opportunity for understanding the relationship between tracking and the distribution of educational achievement.

Curricular intensification and tracking

Sørenson (1970) distinguishes between four dimensions of within-school academic tracking: (1) *inclusiveness*, or the extent to which high-level coursework is available to students; (2) *selectivity*, or the extent to which tracking produces homogeneous learning environments; (3) *electivity*, or the extent to which students can choose their own classroom placements; and (4) *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 unremarked revolution 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. The recent movement toward curricular intensification, on the other hand, has primarily influenced track *inclusiveness*, by making higher-level course available to more students. Curricular intensification may also influence the *selectivity* of secondary school tracks by making the group of students enrolled in these courses less homogeneous.

Commissioned by the Reagan administration, the National Commission on Excellence in Education's 1983 *A Nation at Risk* report provided a major impetus for curricular intensification in American secondary education (National Commission on Excellence in Education 1983).

Warning of a “rising tide of mediocrity that threatens our very future” the commission argued that all high school students should be required to complete a “New Basics” curriculum including 4 years of English, 3 years of mathematics, 3 years of science, and 3 years of social studies. Published at a moment in which technological change was boosting the demand for highly skilled workers (Goldin & Katz 2008), the report hit a nerve. In the years immediately following its publication, states enacted an estimated 700 new pieces of educational policy, many of which raised standards for grade promotion and high school completion (Darling-Hammond & Berry 1988; Timar & Kirp 1989; Wilson & Rossman 1993). By 2008, 25 states required students to satisfy the “New Basics” academic courses in order to earn a high school diploma (Education Commission of the States 2010)[1] and 24 states had implemented high school exit exams in order to certify that graduates have mastered basic academic skills (Center on Education Policy 2009).

In the decades that followed, secondary schools across the U.S. took large steps toward implementing the commission’s vision. Between 1982 and 2004, the number of academic course credits earned by the average U.S. high school graduate increased by more than 30 percent, from 15 to 19. As American high school students complete a greater number of academic courses, they also reach higher levels of coursework. This trend is most discernible in mathematics, where nearly all high schools send students through a sequence of academic mathematics courses that begins with Algebra I. In 1982, more than 20 percent of high school graduates earned their diploma without completing a single academic mathematics course and an additional 20 percent of high school graduates finished no mathematics beyond Algebra I. In contrast, just 7 percent of

[1] The curricular requirements for this count exclude the half year of computer science included in the “New Basics” curricula, since data on state computer science requirements are not widely available. http://mb2.ecs.org/reports/Report.aspx?id=735

graduates in the class of 2004 nationwide finished high school without completing an academic mathematics course and less than 7 percent of 2004 high school graduates finished no mathematics beyond Algebra I. At the same time, the proportion of high school graduates who earned credit in pre-Calculus or Calculus increased from 10 percent to nearly 35 percent (Authors 2011).

California's Algebra-for-all movement

These shifts are particularly pronounced in California. 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 issued curricular standards in mathematics calling 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 8th graders in Algebra I. The adoption of these standards spurred rapid intensification in middle school mathematics curricula in California. Between 1999 and 2008, the proportion of California 8th graders enrolled in algebra more than tripled, from 16 percent to 51 percent (Rosin, Barondess, Leichty 2009). In 2008 the California State Board of Education voted to make the Algebra California Standards Test (CST) the "sole test of record" for the state's 8th graders. This requirement creates strong incentives for California schools to enroll all 8th graders in Algebra in order to meet the expectations of *No Child Left Behind* as well as California state accountability policy (Rosin, Barondess, Leichty 2009). However, the future of California's algebra-for-all push is currently uncertain as the state adopts the national Common Core Standards.

In this paper, we evaluate the consequences of curricular intensification in a large California public school district. This district, which we pseudonymously refer to as "Towering Pines" was an early mover in the state's push to enroll more 8th graders in Algebra. In the 2004-

2005 school year, the district offered four main mathematics course options for 8th graders: Pre-Algebra, Algebra Ia (the first year of a two-year Algebra course sequence), Algebra Ip (a one-year Algebra course), and Geometry. Just 32 percent of 2004-2005 8th graders enrolled in the full Algebra I course, and less than 2 percent enrolled in Geometry. In the years that followed, the district phased out the Pre-Algebra course offering, and gradually began placing more and more 8th graders in the 1 year Algebra and Geometry courses, putting more students on track to take Calculus by graduation. By the 2007-08 school year, more than 70% of the district's 8th graders were enrolled in the one-year Algebra course and an additional 13 percent were enrolled in Geometry.

The intensification of 8th grade mathematics enrollment that occurred between 2004-05 and 2007-08 in Towering Pines was a largely exogenous shift and did not correspond with noticeable changes in the district's student composition. While Towering Pines is demographically distinctive, the increase in academic mathematics course enrollments that occurred in the district epitomize the curricular changes that have been occurring in American middle and high schools over the last two decades. By examining changes in course enrollment patterns, classroom composition, and student achievement between 2004-05 and 2007-08 in Towering Pines, we seek to shed light on the effects of curricular intensification on: (1) the social organization of schools, (2) student exposure to advanced mathematics courses, and (3) the distribution of student achievement. In doing so we address changes in two key elements of the tracking system identified by Sorenson (1970): *inclusiveness*, the extent to which high-level coursework is available to students, and *selectivity*, the extent to which tracking produces homogeneous learning environments.

Constrained curriculum and the effects of curricular intensification

Lee's notion of "constrained curriculum" (e.g. Lee 1993:140) provides a useful lens for understanding curricular intensification, both in Towering Pines middle schools, and throughout American secondary education. Like students in middle and junior high schools throughout the United States, 8th graders in most California middle schools have the option of enrolling in one of several tiered mathematics courses, including remedial and applied mathematics, general mathematics, pre-Algebra, Algebra, and, for a handful of particularly advanced students, Geometry or higher level mathematics. California's Algebra-for-all 8th graders policy aims to replace this differentiated mathematics curriculum with a more constrained curriculum, in which 8th graders can only enroll in Algebra or a more advanced mathematics course. In Towering Pines, this movement took the form of eliminating the bottom rung of the tiered 8th grade mathematics course hierarchy. Lee and her colleagues hypothesize that this move toward a more constrained mathematics curriculum will simultaneously raise student achievement and reduce educational inequalities (Lee and Smith, 1995; Lee, Smith, and Croninger 1997).

Lee's constrained curriculum 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 1987; Gamoran 1992) as well as case studies of particular school districts using administrative, survey, and qualitative data (Gamoran, Nystrand, Berends, & LePore 1995; Hallinan, Oakes 2005; Rosenbaum 1976). Despite their methodological differences, studies regarding the effects of tracking almost universally indicate that placement in low-track courses lowers student achievement while placement in higher-track courses raises student achievement. As a result, a strong scholarly consensus holds that the practice of tracking in American secondary education produces inequality without substantially improving educational efficiency. Furthermore several studies indicate that challenging course placements have positive average effects on student learning and educational attainment (Authors 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. In their tests of the constrained curriculum hypothesis, Lee and colleagues compare student outcomes between schools that enroll all students in college preparatory courses and schools that do not, controlling for student academic and family background. While potentially informative, this approach assumes that there are no unmeasured differences between these two categories of schools and the students who choose to enroll in them. This assumption is restrictive and ultimately impossible to empirically assess. In an attempt to address the issue of selection bias, Authors (2008) use propensity score matching to compare students who enroll in academically rigorous courses with a balanced sample of students who take less rigorous courses. Their findings suggest that academic course enrollments have positive effects net of selection.

However, Authors (2008) are unable to address a second challenge: since policy efforts to enroll all students in college preparatory courses also likely increase student skill heterogeneity within these courses, a test of the constrained curriculum must separate the effects of rigorous curriculum from the effects of sharing a classroom with peers at different achievement levels (Zimmer 2003). This ambiguity has important consequences for the constrained curriculum hypothesis. If peer achievement exerts an independent influence on student learning, policies that increase classroom heterogeneity by pushing more students into advanced academic courses may not be as effective as earlier findings suggest. As most of the students in nationally representative samples enroll in ability-grouped courses, it is impossible to distinguish between the consequences of rigorous course curricula with the effects of high-achieving peers without looking at district level case studies.

Evidence from curricular reforms

Longitudinal evaluations of districts 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 districts change their course placement policies, 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 return strikingly mixed results. Gamoran (1996) evaluates the consequences of a policy effort to standardize of secondary school curricula in Scotland in the 1980s. Prior to this reform, Scottish students were required to enroll in selective O-Grade courses in order to take qualifying examinations for post-secondary education. Beginning in 1986, Scotland replaced these selective O-Grade courses with universally-accessible S-Grade courses. Gamoran demonstrates that course attainment levels and average test scores improved in Scotland after the implementation of the S-Grade curriculum, even as socio-economic educational inequalities declined.

Similarly, Burris and colleagues describe a wide-ranging detracking effort that occurred in one suburban school district in Long Island, New York in the late 1990s (Burris, Heubert, & Levin 2006; Burris, Wiley, Welner, & Murphy 2008). In an effort to prepare more students to enroll in high-level high school mathematics courses, and in particular to remedy racial gaps in mathematics course enrollments, this district completely eliminated ability grouping for 6th through 8th grade mathematics classes. In addition to enrolling all students in an accelerated curriculum designed to prepare them to take Algebra courses in the 8th grade, the district also created optional “mathematics workshop” courses, in which an average of 8 students met every other day with their regular mathematics teacher for supplementary help with the accelerated curriculum. Burris and colleagues find, in a series of interrupted time-series analyses, that 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. This district’s experience suggests that curricular reforms can have positive effects on student course completion, particularly when they are part of a broader effort to improve educational offerings for disadvantaged students. However, these analyses are limited in that they provide no information regarding the effects of curricular reform on student achievement for their full sample, although they do find that AP Calculus scores improved among students taking AP Calculus exams. Thus, while they show that the reforms are helpful in ameliorating differences in course-taking, they are unable to examine how this ultimately affects student learning.

Evaluations of the Chicago Public Schools’ (CPS) 1997 move to eliminate remedial mathematics coursework and require all students to enroll in college preparatory coursework yield less encouraging results (Allensworth, Nomi, Montgomery, & Lee 2009). The CPS policy was larger in scale than the Long Island district detracking effort, encompassing all high schools in the US’s third largest public school district. However, it was considerably more modest in scope. CPS required all 9th 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 2010). However, CPS did not conceive of this policy as a broad-based detracking. In particular, the district did not intensify its middle school curricula or invest in substantial teacher professional development to prepare students for the 9th grade change. As such, the CPS effort is arguably a purer test of the constrained curriculum hypothesis. Not surprisingly, as in New York the CPS policy boosted the odds that low-achieving students enrolled in college preparatory courses. However, many of the CPS students who enrolled in more rigorous courses under the policy failed. Further, Allensworth et al. find no evidence to suggest that the policy improved average achievement test scores, narrowed test score inequalities, or influenced student high school graduation or college enrollment rates.

Understanding failed reforms

Why might some curricular intensification reforms fail to improve student outcomes and narrow inequalities? One possibility is that curricular reforms fail to fundamentally change the social organization of the school. Lucas's (1999) theory of effectively maintained inequality suggests that racial and class-based inequalities in access to rigorous courses will persist even after districts move to eliminate lower-track courses and constrain the curricular choices available to students. Rather than undermining ability grouping, Lucas's theory suggests that curricular reforms cause course credit inflation. Such policies may succeed in moving students out of remedial courses and into mainstream academic courses. However, if high-status parents demand new curricular opportunities to distinguish their children's educational achievements, class, race, and skills-based inequalities in access to advanced courses may persist. A large body of qualitative and case-study educational research conducted in schools, districts and states in the process of undertaking broad curricular reforms supports this hypothesis, documenting the array of structural and ideological factors that allow high-status parents to "work the system" (Wells & Oakes 1996, p. 137; Yonezawa, Wells & Sarna 2002) and reproduce their social advantages. Furthermore, implementation studies from schools, districts, and states that have undertaken broad curricular reforms suggests that patterns of social stratification in high school course-taking patterns are remarkably robust (Gamoran & Weinstein 1998; Wilson & Rossman 1993). Oakes and colleagues argue that since tracking practices resonate with educators' theories of student intelligence; teachers and administrators are often reluctant to adopt heterogeneous classroom organizational schemes (Oakes & Guiton 1995; Oakes, Wells, Datnow, & Jones 1997; see also Sandholtz, Ogawa, & Scribner 2004). If this explanation is correct, curricular reforms may not serve to actually constrain the curriculum.

However, this explanation does not seem to apply to CPS curricular reform, where the policies substantially changed the student composition in college preparatory courses (Allensworth et al. 2009). Rather, Allensworth et al. suggest that the policy's failure was due to the pedagogical challenges associated with teaching heterogeneous courses. This explanation suggests that the constrained curriculum hypothesis is mistaken, and ability-grouping has positive effects for high-achieving and low-achieving students alike. Qualitative evidence from other detracked schools lends some support to this explanation (Loveless 1999; Rosenbaum 1999). For example, based on interviews with teachers in a high school that had undertaken a major curricular reform, Rosenbaum (1999) argues that teachers in heterogeneous classrooms struggle to simultaneously engage students of divergent skill levels. Rosenbaum writes (1999, p. 2) that: "Increased variation among students made extra attention to the various groups a necessity, but when teachers offered this help to one group, students in the other groups tended to become restless and disengaged. Teachers tried to steer a middle ground by teaching to the middle of the class; but as they did, they were acutely aware of losing students at both extremes."

Alternatively, iatrogenic peer effects may explain disappointing results associated with efforts to intensify curricula and detrack schools. There is strong evidence to suggest that peers exert a positive effect on student achievement (Hanushek, Kain, Markman, & Rivkin 2003; Hoxby 2000). By design, detracking policies change the peer composition of classrooms. The CPS algebra-for-all policy, for example, improved peer quality for the low-achieving students it moved from Pre-Algebra or general mathematics courses to Algebra I. At the same time, however, the policy lowered mean achievement in Algebra classrooms by moving low-performing students from general math courses to Algebra courses. Assuming peer quality has a similar effect on low- and high-achieving students, the changes in peer quality that low- and high-achieving students experience likely cancel one another out and the net peer effect associated with the CPS Algebra-for-all policy or a similar policy is likely zero. However, Zimmer (2003) argues that peer quality exerts a greater effect on learning for high-achieving students than low-achieving students. If this is the case, peer effects may indeed undermine detracking policies like the CPS Algebra-for-all policy.

The shape of peer effects may be more complicated in schools that undertake curricular intensification while maintaining a stratified course sequence. Towering Pines, for example, increased the proportion of students in upper-level courses and reduced the proportion of students in lower-level courses, but did not completely eliminate these courses. While less dramatic than the New York and CPS detracking efforts, this sort of curricular intensification is more typical of the changes that have occurred in American secondary schools at large over the last two decades. In this case, curricular intensification may raise peer quality for students who have been moved to a higher-level course. At the same time, it likely lowers peer quality for low-achieving students who remain in low-level courses even as it lowers peer quality for higher-achieving students who remain in more advanced courses. In this case, the peer effects associated with detracking may be negligible across an entire population, but noticeable and negative within course levels.[2]

The current study

Like earlier analyses of detracking efforts in New York and Chicago, our analyses take advantage of a policy-driven change in school social organization to estimate the effects of tracking net of confounding selection effects. Unlike the broad de-tracking efforts that occurred in New York and Chicago analyses, however, we focus on a curricular intervention that maintained a stratified course sequence. As the prior discussion of peer effects makes clear, this aspect of Towering Pines' curricular intensification introduces substantial conceptual challenges. However, Towering Pines is not alone in intensifying curricula even while maintaining course stratification. Indeed, although curricular intensification in Towering Pines has been uniquely fast-paced; the increase in the proportion of students who take high-level courses and the decline in the proportion of students who take low-level courses in Towering Pines parallel the shifts in secondary school course enrollments that have occurred recently across the U.S. We thus argue that the changes we observe in Towering Pines provide important insights into the effects of curricular intensification. In this paper, we draw upon administrative data on every 8th grader in

[2]A thought experiment helps to illustrate the complex relationship between curricular intensification within a stratified course sequence and classroom peer composition. Consider a school with 100 students that undertakes a pattern of intensification similar to that undertaken in Towering Pines over the study period. Prior to curricular intensification, 75 of the students in this hypothetical school took General Math; 20 took Algebra I; and 5 took Geometry. After curricular intensification, 25 took General Math; 60 took Algebra I; and 15 took Geometry. Assuming curricular intensification redirects stronger students to higher course levels, the 25 students who took General Math after curricular intensification in this hypothetical case would have considerably lower quality peers than they would have without the curricular change. If the school's course sorting mechanism is meritocratic, the 50 students who were redirected from General Math to Algebra I would have higher quality peers than they would have in General Math, but likely only slightly so, curricular intensification has redirected all but the 10 lowest-scoring Algebra I students to a higher course. Curricular intensification lowers peer quality for the 10 students left in Algebra I; raises peer quality for the 10 students redirected from Algebra I to Geometry; and lowers peer quality for the 5 students who remain in Geometry.

Towering Pines in the 2004-2005 through 2007-2008 school years to address three research questions:

1) What effect did 8th grade curricular intensification have on mathematics course-taking patterns in Towering Pines Unified schools?

2) What effect did 8th grade curricular intensification have on classroom-level ethnic, language-based, and skills-based segregation in the district?

3) What long-term effects did 8th grade curricular intensification have on students' mathematics course taking and mathematics achievement?

Towering Pines is an immigrant enclave in the inner-ring suburbs of a major metropolitan area. The district's student population is ethnically diverse and largely economically disadvantaged. More than fifty percent of the students in our sample are Latino, approximately 25 percent are Vietnamese, and approximately 15 percent are white. Most of the remaining students are Asian and 1 percent of the students in the district are African American. Over 60 percent of the students in the district were English-language learners when they enrolled in school, and while a large proportion of these students had been reclassified as English-proficient by the time they were 8th graders, more than a third of the sample remained classified as English Language Learners (ELLs) in their 8th grade year. This sample is clearly not representative of 8th graders nationwide or statewide. However, the district's demographic profile provides a unique opportunity for understanding the consequences of curricular change on a population that is often excluded from rigorous coursework.

To measure students' 8th grade mathematics course enrollment, we use information about the California Standards Test (CST) that students took in mathematics in the spring of their 8th

grade year.[3] As Table 1 reveals, Towering Pines 8th graders in each of the study years take either the General Mathematics (Pre-algebra), Algebra I, or Geometry CSTs. However, the proportion of students taking each of these course-based exams changed dramatically as the district intensified 8th mathematics curricula over the study period. The proportion of 8th graders enrolled in Algebra I more than doubled between the 2004-2005 and 2007-2008 school years, from 32 percent to 71 percent. In the same period, the proportion of 8th graders enrolled in Geometry increased from less than 4 percent to 13 percent. 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 percent to 51 percent over the study period (Rosin, Barondess, Leichty 2009) and Geometry enrollments grew from 2.7 percent to 3.6 percent

[Insert Table 1 about here]

The remainder of Table 1 indicates that these changes in 8th 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 remarkably similar on each of the demographic comparisons, with no statistically significant differences in terms of gender composition and only moderate changes in ethnic composition. In addition to comparing student demographics across cohorts, this table compares the language status of students in the four 8th grade cohorts. For the purposes of this paper, students are sorted into three language status categories: ELLs are students who entered the district with limited English language skills and

[3] While we also have access to 8th grade course titles, these change over the study period, are not entirely consistent from school to school, and are often not representative of course content. We choose to instead use the CST that students took, as this better indicates the content covered in the course. Thus, for example, despite the difference in course titles, students enrolled in "Pre-Algebra" and "Algebra Ia" classes in 8th grade both finish Algebra I in 9th grade, putting them on a track that will not take calculus before graduation. However, both take the General Math (Pre-Algebra) CST, rather than the Algebra I CST, which more accurately captures the fact that they will not have covered the material in Algebra I by the end of 8th grade.

have not demonstrated English-language proficiency by their 8th grade year; Reclassified Fluent English Proficient describes students who had limited English skills when they entered the district but who demonstrated proficiency before 8th grade; all other students, including native English speakers and students who were bilingual in English and another language upon district entry, are in the third category. The language status composition of the district remains relatively stable across the study period.[4] Given this degree of between-cohort balance, we regard the district's effort to intensify 8th grade mathematics curricula as a powerful case study for understanding the implications of curricular intensification.

That said, we note that 8th grade curricular intensification is not the only change that occurred in the district over the study period. In particular, we find that student achievement as measured by student scores on CSTs in mathematics and English-language arts administered to all students in the spring of their 7th grade year improved significantly over the study period.[5] It seems unlikely that changes in 8th grade mathematics placements could drive improvements in 7th graders' test scores. Furthermore, these trends are roughly consistent with statewide trends in 7th grade student achievement over the study period. We thus view 7th grade test scores as endogenous and our multivariate analyses control for students' prior mathematics and English scores.

Methods

Q1: Estimating changes in course enrollments

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[4] It is worth noting that although the level of initially fluent students remains constant, there are some changes in the proportion of those reclassified as proficient. There is some evidence that this is due to the fact that detracking the math classes raised English scores and led some students to be reclassified because it changed the English classes in these which students were enrolled.

[5] While the mathematics CSTs administered to 8th-12th graders are course-specific; all 7th graders take the same grade-specific mathematics CST.

We begin by examining the effects of curricular intensification on 8th grade course enrollment patterns in Towering Pines. To address this we estimate a series of generalized ordered logistic regression models on 8th graders' odds of enrolling in Algebra or Geometry (Williams 2006). These models can be simplified as:

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

where **Yi** is an 8th grader's course enrollment odds of enrolling in a course higher than General Mathematics (j=1) or Algebra (j=2); **Year 8th** is a matrix of dummy variables the school year in which the student enrolled in 8th grade (the 2004-2005 cohort is the reference); and **Controls** include student gender, ethnicity, language status, and 7th grade mathematics and English Language Arts (ELA) test scores. $\boldsymbol{\beta_1}$ in this model, therefore, represents the extent to which 8th grade mathematics course enrollments changed over the study period, net of other changes in the district. In an additional model, we add a series of interactions between the **Year** dummies and the 7th grade score variables, in order to estimate the extent to which curricular intensification changed the relationships between prior achievement and 8th grade mathematics course placement.

Even if Towering Pines' curricular reforms succeeded in channeling students into more advanced courses, their consequences would have been short lived if they did not prepare students to succeed in these courses and continue to enroll in advanced courses as they progressed through school. We thus estimate the effects of Towering Pines' curricular intensification on student mathematics course enrollments in 10th grade.[6] Using generalized

[6] We also estimate models examining whether the odds of failing algebra and geometry increased across cohorts, as Nomi and Allensworth (2010) show that curricular intensification increased the odds of failure in Chicago. Our findings, which we do not report here but are available by request, similarly indicate that suggest that curricular intensification Towering Pines increased student odds of failing a math course between 8th and 10th grade, particularly for students who took Algebra in the 8th grade.

ordered logistic regression models, we estimate cross-cohort changes in 10th grade mathematics course enrollment net of 7th grade test scores and demographics. These models follow the same general form as the 8th grade mathematics course enrollment generalized ordered logistic models summarized above. As in the 8th 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: Estimating changes in classroom composition

Second, we examine trends in classroom-level gender, ethnic, language-based, and skills-based segregation in the district. This analysis provides a far more detailed picture of the social sorting that occurs in middle schools than is available elsewhere in the literature. Since we have data on the specific class that the students were in (e.g. 4th period algebra with Ms. Smith), we can examine not only 8th graders' rates of enrollment in Algebra and Geometry, but also the extent to which 8th graders are sorted into different classrooms based on ascriptive characteristics, language skills, and past academic performance.

We calculate Duncan and Duncan's (1955) index of dissimilarity (D) to measure the degree to which students are segregated into different 8th grade mathematics classrooms based on their gender, ethnicity, English language ability, and measured 7th grade skills. The index of dissimilarity ranges from 0 to 1, and measures the proportion of members of a given group that would have to move to a different classroom to achieve an even distribution across all classrooms. For example, the index of dissimilarity between ELLs and native English speakers calculated for all of the classrooms in the Towering Pines district represents the proportion of

ELLs who would have to relocate to another classroom in order to spread all ELLs equally across the district. More formally, this measure is defined as:

$$\mathbf{D_{xy} = .5 * \Sigma \mid (x_i/X) - (y_i/Y) \mid}$$

where, for example, x_i is the number of ELLs in classroom *i* and X is the number of ELLs district-wide; y_i is the number of native English speakers in the classroom and Y is the number of native English speakers district-wide. By comparing dissimilarity measures across the years in which Towering Pines intensified 8^{th} grade mathematics curricula, we capture the consequences of this curricular reform class-room-level segregation.

In addition to examining measures of segregation, we also address changes in classroom composition by examining how mean classroom skill level and within-classroom skill heterogeneity students are exposed to changes across cohorts. We calculate mean classroom skill level by averaging 7^{th} grade mathematics achievement scores (measured as a percentile score of all students across cohorts) for all students in each 8^{th} grade mathematics classroom in the district. We calculate within-classroom skill heterogeneity by taking the interquartile range of 7^{th} grade mathematics achievement (also measured as a percentile score) for each 8^{th} grade mathematics classroom in the district. We report the mean classroom skill level and interquartile range separately for students in General Mathematics, Algebra I, and Geometry courses in each cohort.

Q3: Estimating changes in the distribution of student test scores

Finally, we estimate the effects of curricular intensification in Towering Pines on students' mathematics skills as measured by the mathematics portion of California's high-stakes high school exit exam (CAHSEE). This exam, which is designed to test student mastery of basic mathematics skills, is administered to all students in the spring of their 10^{th} grade year. This test provides a better metric for measuring the consequences of curricular intensification on student achievement than the mathematics CSTs administered to California high school students, since all students take the test in the same form, regardless of their mathematics course enrollment. However, since the most advanced concepts tested on the exit exam are covered in Algebra I courses, analyses of student scores on the exit exam may understate the effects of curricular intensification.[7] This is particularly true at the top of the skill distribution, where test ceiling effects make it difficult to assess the extent to which curricular changes influence student achievement.

We first estimate the average effect of curricular intensification on average student achievement using OLS regression models that take the same general form as the ordered logistic regression models described above. The **Year** coefficients in these models capture the mean changes in student mathematics achievement across cohorts, controlling for changes in student composition and 7th grade skills. In addition, we estimate **Year*Course** interaction effects to measure the extent to which curricular intensification changed the payoff associated with taking Algebra or Geometry over time. Finally, we add controls for skill heterogeneity and mean skill level in 8th grade mathematics classrooms to determine the extent to which the challenges associated with teaching heterogeneous classrooms and peer effects mediate the effects of curricular intensification on student achievement.

We also estimate quantile regression models, which allow us to compare the achievement distributions of the cohorts at a variety of points in the distribution. For example, while the OLS results provide us with information about how the mean of two cohorts differ, quantile regression

[7]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.

models can provide us with information about how the 10th, 90th or any other percentile differs between two cohorts. As laid out in Koenker and Bassett (1978), the standard model

$$y_i = X_{ki}\beta_k + \varepsilon_i$$

where y_i is the mathematics score for student i, and the X_k are the independent variables, can be estimated at the θ^{th} quantile by minimizing:

$$\min_{\beta}\left[\sum_{\{i|y_i \geq X_i\beta\}} \theta|y_i - X_i\beta| + \sum_{\{i|y_i < X_i\beta\}} (1-\theta)|y_i - X_i\beta|\right] \qquad (2)$$

Intuitively, this estimates β_k at different quantiles by changing the weights (θ and 1-θ) on the positive and negative residuals. For example, at the median (θ = .5) positive and negative residuals are given equal weight so that the sum of absolute deviations is minimized, while at the 90th percentile (θ = .9) negative residuals are multiplied by .9 and positive residuals are multiplied by .1, so that the negative residuals have more weight.[8]

Results

Our first research question asks about the extent to which curricular intensification influenced mathematics course placements in Towering Pines. Table 2 uses general ordered logistic regression to model changes in the 8th grade mathematics course placement regime in Towering Pines between the 2004-2005 and 2007-2008 school years. These analyses make it possible to examine differences in course taking by cohort while controlling for demographic characteristics and 7th grade test scores. Consistent with the descriptive enrollment statistics

[8] For an excellent nontechnical introduction to quantile regression, see Koenker and Hallock (2001).

reported in Table 1, we find that 8th graders' odds of enrolling in Algebra and Geometry rise dramatically over the study period. For example, the odds that 2007-2008 8th graders enroll in Algebra or higher (as opposed to General Mathematics) are 9 times higher than the odds of 2004-2005 8th graders enrolling in Algebra or higher. Similarly, the odds that 2007-2008 8th graders enroll in Geometry (as opposed to Algebra or General Mathematics) are 3 times higher than the odds for 2004-2005 8th graders.

[Insert Table 2 about here]

This curricular intensification is not an artifact of demographic change in the district or a downstream effect of improvements in elementary mathematics education. Indeed, Model 2 of Table 2 reveals that the expansion of student advanced mathematics course-taking odds is even more pronounced after controlling for student demographic and 7th grade mathematics test scores than it is in the baseline Model 1.

In addition to boosting student access to advanced mathematics courses, Towering Pines' curricular intensification push may have influenced the degree to which prior achievement affects course placement. We see in Model 3 that the role of 7th grade scores in predicting 8th grade mathematics course lessens over the course of the study period. This is noteworthy given the importance of cumulative advantage processes in education (Diprete and Eirich 2006, Farkas 2003), as it suggests that curricular intensification in Towering Pines weakened one mechanism through which skills inequalities widen over students' educational careers. That is, to the degree that a deficit in 7th grade achievement precludes students from taking higher level mathematics achievement in 8th grade, these initial deficits are likely to be reinforced and become difficult to overcome. Thus, finding that 7th grade scores are less predictive of 8th grade course placement indicates that curricular intensification weakens the link between earlier achievement and later course taking. The findings present in Table 2 thus show not only that curricular intensification has increased the accessibility of Algebra and Geometry in Towering Pines, but it has also changed more fundamentally the way course placements are made in the district.

The results reported in Table 3 indicate that 8th grade curricular intensification continues to influence students' mathematics course patterns two years later, when students are in 10th grade. 10th graders in the later cohorts are significantly more likely to be enrolled in advanced mathematics courses than students in the first cohort. The odds that students who were in the 8th grade in 2007-2008 enroll in Geometry or a higher mathematics course by their 10th grade year is four times higher than the odds for students in the 2004-2005 8th grade cohort. Students in this cohort were also significantly more likely to enroll in Algebra II or a higher-level mathematics course in their 10th grade year than their peers in the 2003-2004 8th grade cohort. As in Table 2, these cohort effects remain significant after controlling for cross-cohort changes in student language status and demographics and 7th grade mathematics and ELA test scores in Model 2. The expansion of advanced 10th grade mathematics course enrollments revealed in Table 3 is somewhat less pronounced than the expansion of 8th grade mathematics course enrollments reported in Table 2, indicating that not all students who enroll in more advanced 8th grade courses continue to take advanced mathematics courses in 10th grade. Overall, however, the Table 3 suggests that 8th grade mathematics curricular intensification has lasting positive consequences for student access to advanced mathematics courses, particularly for students with low 7th grade mathematics achievement.

[Insert Table 3 about here]

Table 4 considers the effects of these shifts on gender, ethnic, language-based, and skills-based segregation in the districts' 8th grade mathematics classrooms. These findings provide a look at the extent of classroom-level tracking that is generally unavailable elsewhere in the literature, since few studies have access to census data and classroom indicators. We find only modest change in the extent of gender, ethnic, or language-based segregation in the district's 8th grade mathematics classrooms. However, this table indicates that the district underwent some skills-based desegregation after it implemented its 8th grade curricular intensification policy. In 2004-2005, 68 percent of students who scored in the bottom half on the state's 7th grade mathematics test would have had to move to another classroom to establish an even distribution of high- and low-skill students in the district. In 2007-2008, by contrast, 52 percent of such students would have had to move to a new classroom. We find similar evidence of skills-based desegregation when we consider the extent to which students that scored in bottom quartile on California's 7th grade mathematics test, which roughly corresponds to the students who are categorized as below basic proficiency in 7th grade mathematics, shared 8th grade mathematics classrooms with students who scored in the top quartile of the 7th grade test. Furthermore, although the changes are less pronounced, we also find evidence to suggest that mathematics class segregation based on 7th grade ELA test scores also declined in the district over the study period.

[Insert Table 4 about here]

Table 5 provides another look at the way curricular intensification changed the composition of 8th grade mathematics classrooms in Towering Pines. The first panel in this table reports changes in the mean classroom 7th grade percentile scores by 8th grade mathematics course (General Mathematics, Algebra, and Geometry) across the study period. Even as 7th grade test scores improved for Towering Pines students over the study period, the mean student achievement level within 8th grade mathematics class levels declined since the district's curricular intensification redirected relatively low-achieving students into higher-level mathematics courses. In 2004-2005, the average General Mathematics 8^{th} grade student came into the course with a score at the 32^{nd} percentile on the 7^{th} grade mathematics assessment of mathematics achievement. As General Mathematics enrollments declined, so did the incoming scores of General Mathematics students. By 2007-08, the mean 7^{th} grade mathematics test score for 8^{th} grade students in General Mathematics was at the 20^{th} percentile. The trend for 8^{th} graders enrolled in Algebra and Geometry is similar. Consistent with the ordered logistic regressions reported in Table 2, these findings indicate that curricular intensification led students with lower skills levels to be placed in higher-level courses.

[Insert Table 5 about here]

The second panel in Table 5 considers changes in the concentration of low-performing students in Towering Pines math classrooms, measured as the proportion of students who scored below basic on the 7^{th} grade math California Standards Test. Throughout the study period, a large proportion the district's students entered 8^{th} grade with below basic math scores. While this proportion fell somewhat as average 7^{th} grade math scores rose, in 2007-08, 21 percent of the district's 8^{th} graders had low incoming math scores. Not surprisingly, these low-performing students were largely concentrated in General Math courses. As the district undertook curricular intensification and General Math enrollments shrunk, the concentration of low-performing students in General Math increased, from 42 percent to 67 percent. However, many low-performing students also took part in the curricular intensification, and the proportion of Algebra students with below basic 7^{th} grade math skills increased from 1 percent in 2004-2005 to 15 percent in 2007-2008.

The third panel of Table 5 reports changes in within-8th grade classroom interquartile ranges on 7th grade test scores over the study period. These interquartile ranges, which are defined as the difference between the 7th grade test score of a student at the 75th percentile in a given classroom and the 7th grade test score of a student at the 25th percentile, provide a measure of the extent of skill heterogeneity in the students' 8th grade mathematics classrooms.[9] We find that the amount of skill heterogeneity that occurs among peers in General Mathematics classrooms declined modestly over the study period. On the other hand, as Algebra and Geometry enrollments expanded, the skill heterogeneity that students in these high-level classrooms encountered grew dramatically. This change was particularly pronounced in Geometry classrooms. The average 7th grade mathematics test interquartile range for 8th graders in Geometry classes increased by more than three times between the 2004-2005 and 2007-2008 school years. This finding, which is consistent with the finding that curricular intensification loosened the association between 7th grade mathematics scores and 8th grade mathematics course placements, suggests that 8th graders in Geometry classes were exposed to a far wider range of peers in the later cohorts than in the earlier cohorts. Taken together, therefore, the analyses presented in Tables 2, 3, 4, and 5 indicate that the Towering Pines' push to intensify 8th grade curricula had lasting effects on students' math course attainment and the social organization of 8th grade mathematics classrooms.

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[9] The size of the interquartile range for students at a given course level is a function of the proportion of students enrolled in a given course, as well as the extent to which students are sorted. A couple of hypothetical examples help to interpret these values. Take a case where 7th grade skill levels do not vary across cohort, students are sorted into courses so that there are one-third each in General Mathematics, Algebra, and Geometry, and students are randomly assigned to classrooms within courses. If course level assignments were entirely random, the interquartile range for skills in General Mathematics, Algebra, and Geometry would equal 50; the interquartile range for the population at large. By contrast, if students were perfectly sorted based on 7th grade score, the IQR would equal approximately 16.7 (33.3/2). If instead we had 50 percent of students in General Mathematics, and 25 percent each in Algebra and Geometry, then perfect sorting would give us IQR's of 25 for General Mathematics and 12.5 for Algebra and Geometry, while random sorting would still give IQR's of 50.

In Table 6 we explore the effects of curricular intensification on mathematics achievement tests scores by examining student scores on the California High School Exit Exam administered in the spring of students' 10th grade year. Model 1 reveals that Towering Pines students who were 8th graders in 2005-2006, 2006-2007, and 2007-2008 did not score significantly differently on the 10th grade test than their peers who were 8th graders in 2004-2005.

[Insert Table 6 about here]

However, we find in Model 2 that students in the 2005-2006, 2006-2007 and 2007-2008 8th grade cohorts scored significantly worse on the high school exit exam than students with similar 7th grade test scores in the 2004-2005 8th grade cohort. This finding suggests that exit exam gains experienced by Towering Pines students in the later cohorts were the result of improvements that occurred prior to their 8th grade year, where the curricular reform was targeted. Despite significantly improving students' odds of enrolling in advanced 8th and 10th grade mathematics courses, curricular intensification failed to boost student mathematics learning. Indeed, the cohort effects in Model 2 of Table 6 indicates that this policy shift may have impeded student learning in mathematics.

Why might a policy that increases the rigor of 8th graders' mathematics course placements have negative long-term effects on their mathematics learning? The remaining models in Table 6 test likely explanations for this unexpected negative effect. Model 3, which includes a set of mathematics course by cohort interactions, investigates the possibility that curricular intensification in Towering Pines could have diluted the effectiveness of Algebra and Geometry courses. The results of this model suggest that the score gains associated with taking different courses changed as curricular intensification came into effect. We see some evidence to suggest that the difference between General Mathematics and Algebra takers shrank somewhat over the study period. In the baseline cohort, Algebra takers scored roughly a third of a standard deviation above the General Mathematics students. In the 2006-2007 cohort, however, Algebra takers scored less than a fifth of a standard deviation better than students in General Mathematics. While the interactions for the 2005-2006 and 2007-2008 cohorts are not significant, they are both negative. By contrast, the benefits associated with Geometry grew over the study period. For 8^{th} graders in the 2004-2005 cohort, enrolling in Geometry had no effect on student 10^{th} grade mathematics achievement net of incoming scores. But by 2007-2008, Geometry course-taking raised student scores by more than half a standard deviation. These findings suggest that while the educational benefits available to Towering Pines students who enrolled in Algebra courses diminished, the educational benefits available to students who enrolled in Geometry increased.

One way that curricular intensification could hurt student learning in 8^{th} grade Algebra classrooms is by increasing the degree of student skill heterogeneity in these classrooms, forcing teachers to attempt to simultaneously meet the needs of an increasingly diverse pool of learners (Rosenbaum 1999). Model 4 of Table 6 considers this possibility by adding a control for skill heterogeneity in 8^{th} grade mathematics classrooms, measured as the inter-quartile range of students' 7^{th} grade mathematics test score. Surprisingly, this analysis indicates that that skill heterogeneity *improves* student learning, all else equal. Furthermore, controlling for skill heterogeneity does very little to moderate the differential returns associated with higher-level mathematics course enrollment in 8^{th} grade. This analysis, therefore, provides little support for the idea that the skill heterogeneity undermines the effectiveness of curricular reforms that detrack by intensifying curricula.

Another possible explanation revolves around changes to peer quality in 8th grade mathematics courses. Model 5 of Table 6 tests this possibility by controlling for peer quality in 8th grade mathematics classrooms via a standardized measure of the mean 7th grade mathematics test score for 8th graders mathematics class peers. Comparing the cohort coefficients in Model 5 with the cohort coefficients in Model 3 reveals that peer quality explains approximately a third of the decline in student achievement in 8th 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 peer quality explains some of the apparent decline in the value of Algebra course enrollments that occurred over the study period, the reverse is true for Geometry, where cross-cohort increases in the returns to enrollment are even stronger after controlling for peer quality. Thus, much of the decline among students in General Mathematics 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 7th grade mathematics test. This approach allows us to examine a different aspect of peer effects—instead of conceptualizing the effects of peers as operating through the average level of preparation in a classroom, it suggests that the effects of peers operates through the proportion of students who are not well prepared. The results for General Mathematics in Model 6 show that the percentage of the class that is below basic in 7th grade mathematics score accounts for much of the decline in learning that we observe in Model 3, and that this conceptualization of peer effects is slightly better at explaining this decline than the average classroom achievement (Model 5). Similarly, controlling for low-performing 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 protects students from low-performing peers. The pattern for Algebra is somewhat different. Controlling for low-performing peers explains approximately one-third of the baseline Algebra effect. However, the growing proportion of low-achieving students enrolled in Algebra courses does not explain the declining returns to Algebra enrollment that we observe over the study period.

These analyses suggest that iatrogenic 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 classroom concentration of low-performing peers is a somewhat stronger predictor of student achievement than classroom average student achievement levels. Furthermore, we find that the classroom concentration of low-performing peers is a particularly salient mediator of the negative relationship between low-level math course placement and achievement in the district.

Finally, given that many proponents of tracking argue that detracking harms high achieving students, we examine the distributional consequences of curricular intensification in Towering Pines. While Table 6 provides an indication of how successive cohorts differed on average from the baseline cohort, Figure 1 examines how the 10th through 90th percentile mathematics scores varied across cohorts. Figure 1 reports the results from quantile regression models estimating Model 2 of Table 6 at different points across the distribution; the y-axis reports the estimate of beta, while the x-axis reports the percentile that we are examining. We see that for all the 2005-2006 and 2007-2008 cohorts the top of the distribution is close zero, while at the middle and bottom of the distribution the difference is slightly negative. This indicates that in these cohorts scores at the top of the distribution are not lowered by detracking, while at the bottom of the distribution scores are not improved, and are in fact lowered. For the 2006-2007 cohort, however, we find a slightly different pattern: scores are lower than the 2004-2005 cohort throughout the distribution, but particularly so at the top end of the distribution. As this is the year with the largest shift in course enrollments, this suggests that there is a temporary disadvantage experienced at the top of the distribution but that this effect is not lasting. Thus, we find no evidence to suggest that detracking 8th grade mathematics courses in Towering Pines has deleterious long term effects on high-achieving students' learning. Unfortunately, however, we also find little evidence to suggest that detracking leads to learning gains for low-achieving students.

[Insert Figure 1 about here]

Discussion

Driven by a statewide push to enroll all California 8th graders in Algebra courses, Towering Pines has dramatically intensified 8th grade mathematics curricula. Between the 2004-2005 and 2007-2008 school years, the proportion of the district's 8th graders who enrolled in Algebra more than doubled and the proportion of 8th graders who enrolled in Geometry increased more than eightfold. Although remarkable in magnitude and speed, the shifts in 8th grade course enrollments that occurred in Towering Pines over this time period are consistent with a broader nationwide trend toward curricular intensification in secondary education. In this paper, we use

Towering Pines' experience with curricular intensification in middle school mathematics as a case study to understand the implications of curricular intensification more broadly.

Specifically, we address three questions: 1) Did the 8th grade Algebra for all policy succeed in placing more students into higher level mathematics courses; 2) How did the reforms affect the social organization of schools; and 3) What effects did the policy have on students' mathematics achievement?

We find that the push to place 8th graders into Algebra had lasting impacts on students' course-taking trajectories, raising the odds that Towering Pine students enrolled in academic math courses in both 8th and 10th grades. Thus, we conclude that the policy was successful in its stated goal. Further, the policy diluted the effect of previous achievement on course placement, so that 7th grade mathematics achievement is less predictive of 8th and 10th grade course-taking in later cohorts.

Decoupling prior achievement from course placement resulted in a substantial decline in classroom level mathematics skill based segregation. We also find that skill heterogeneity increased in the district's Algebra and Geometry classrooms. Together with the declines that we observe in the average skill level of peers at all three course levels, this suggests that curricular intensification made Algebra and Geometry classes grow less select and thus more variable. Thus, in answer to our second question, we conclude that curricular intensification partially detracked mathematics education in the district.

Finally, we examine the impact of curricular intensification on mathematics achievement. We find that students at the top of the distribution do not appear to experience long term declines in scores, though it is possible that large changes in course enrollments might have led to a one time drop in scores at the top of the distribution. Thus, detractors' claims that detracking will harm those at the top of the distribution appear unfounded. Unfortunately, however, we find that students at the bottom of the distribution were negatively affected by the curricular intensification. Given that high achieving students are performing no better, and low achieving students are performing somewhat worse, on average curricular intensification negatively affects students' learning. We examine two explanations for this decline--the pedagogical challenges associated with teaching a heterogeneous classroom and the effects of being in a classroom with lower achieving peers. We find little evidence that classroom heterogeneity accounts for the changes that we observe, but peer effects appear to account for a substantial portion of these changes. As Algebra courses became modal in the district, the average level of peer achievement in Algebra courses declined. This decline explains a large portion of the fall-off in learning that occurred in Towering Pines Algebra classrooms over the study period. At the same time, the movement of relatively high-achieving students into Algebra classes increased the concentration of low-achieving peers in General Math classes. This concentration explains a large proportion of the decline in learning that occurred in the district's General Math courses.

Similar iatrogenic peer effects may help to explain why the effects of curricular intensification efforts in Towering Pines and the Chicago Public Schools differ so dramatically from the predicted consequences of a constrained curriculum and the measured effects of detracking efforts in Scotland and Long Island. Curricular intensification lowered average student achievement levels in courses across the Towering Pines even as it maintained the concentration of students with below-basic skills in General Math courses. Similarly, Chicago's Algebra-for-all effort integrated 9th grade mathematics classrooms even as it instituted the double-dose Algebra classes that concentrated low-performing students for part of the day. These policies were designed to detrack mathematics instruction, and for much of the student population they did. However, these policies also unintentionally reinforced the academic isolation of a relatively small number of low-achieving students.

It is possible, therefore, that policies that more fully eliminate instructional tracks, such as the Long Island policy, may be more efficient and more equitable than policies that attempt to make access to high-level courses within stratified course sequences more inclusive. However, our analysis suggests that the wholesale detracking strategy pursued in Long Island may also pose risks. While curricular intensification in Towering Pines did not have a negative effect on achievement for students at the top of the skills distribution, this is largely due to the fact that the district maintained a fairly selective 8^{th} grade Geometry classes for high-achieving students. While average incoming test scores for 8^{th} graders in Geometry declined over the study period as Geometry enrollments increased, very few students who had scored below basic in 7^{th} grade math enrolled in Geometry. This exclusionary policy seems to have boosted the returns to Geometry coursework in the district, and a more broad-based detracking policy might reverse those gains.

Another approach that Towering Pines and other districts that undertake curricular intensification might pursue in order to avoid the negative peer effects that we observed is to focus on improving incoming students' skill readiness, particularly at the bottom of the skill distribution. While Towering Pines raised the 7^{th} grade achievement scores of successive cohorts of students in preparation for taking more advanced 8^{th} grade mathematics courses, the proportion of students who scored below basic in 7^{th} grade remained relatively constant. These students' early deficits likely constrained their ability to take advantage of the opportunity to enroll in more advanced coursework. Furthermore, our analyses suggest that the concentration of low-achieving students in math classrooms hurt their classroom peers' performance. By thinking about the readiness of the whole classroom and improving skills at the bottom of the distribution, Towering Pines might have avoided these negative peer effects and raised the overall effectiveness of its 8th grade algebra-for-all effort.

However, peer effects do not fully account for the changes in test scores that we observe. It is therefore worth considering other factors that may explain the disappointing consequences of curricular intensification for student achievement in Towering Pines. One potential candidate is students' academic motivation. Our analyses of supplemental motivational data from two cohorts of Towering Pines 8th graders indicate that curricular intensification lowers student academic motivation and efficacy when it causes students to be placed in courses that are above their skill level (Authors 2011b). Another potential candidate is teacher quality. Just as curricular intensification requires students to take more rigorous courses than they might otherwise have, it also requires teachers to teach more rigorous courses than they might otherwise have. If this process creates a mismatch between teacher preference or ability and their course assignment, it may undermine teacher effectiveness.

In sum, our findings suggest that enrolling students in more rigorous courses is not, in itself, enough to raise student achievement. Rather, our analyses suggest that successful curricular reforms must prepare students across the skill distribution and carefully attend to classroom peer dynamics.

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Table 1: Descriptive statistics by cohort

	2004-2005	2005-2006	2006-2007	2007-2008
Gen Math in 8th grade (n)	2,433	1,931	1,022	648
(%)	64.18	51.36	25.58	16.1
Algebra in 8th grade (n)	1,216	1,520	2,512	2,848
(%)	32.08	40.43	62.86	70.76
Geometry in 8th grade (n)	142	309	462	529
(%)	3.75	8.22	11.56	13.14
ELL in 8th grade (n)	1,482	1,344	1,336	1,378
(%)	39.08	35.74	33.3	34.2
RFEP in 8th grade (n)	884	993	1,181	1,226
(%)	23.31	26.41	29.44	30.43
Eng only/FEP in 8th grade (n)	1,426	1,423	1,495	1,425
(%)	37.61	37.85	37.26	35.37
Hispanic (n)	1,955	1,905	2,144	2,178
(%)	51.56	50.66	53.44	54.06
Vietnamese (n)	835	875	948	978
(%)	22.02	23.27	23.63	24.27
White (n)	693	642	599	532
(%)	18.28	17.07	14.93	13.2
Other (n)	309	338	321	341
(%)	8.15	8.99	8	8.46
7th grade math score	-0.098	0.030	0.064	-0.01
7th grade ELA score	-0.146	-0.021	0.053	0.103

Note: 7th grade math and ELA scores are standardized across cohorts.

Table 2: 8th grade math course enrollment odds, generalized ordered logistic regression. (Standard errors in parentheses)

	Model 1		Model 2		Model 3	
	>=Algebra	Geometry	>=Algebra	Geometry	>=Algebra	Geometry
(2004-2005)						
2005-2006	1.772**	1.772**	2.098***	2.098***	2.232***	2.232***
	(0.333)	(0.333)	(0.366)	(0.366)	(0.452)	(0.452)
2006-2007	5.283***	2.817***	15.184***	3.458***	12.679***	12.679***
	(1.148)	(0.854)	(4.202)	(1.116)	(2.757)	(2.757)
2007-2008	9.671***	3.306***	43.305***	4.657***	22.384***	22.384***
	(2.146)	(1.029)	(12.172)	(1.538)	(4.708)	(4.708)
Hispanic			1.261	1.261	1.272	1.272
			(0.191)	(0.191)	(0.190)	(0.190)
Vietnamese			1.599*	3.108***	1.556*	3.135***
			(0.324)	(0.577)	(0.314)	(0.581)
Other			1.506*	2.736***	1.494*	2.846***
			(0.249)	(0.398)	(0.250)	(0.421)
ELL			1.239*	0.465***	1.259*	0.439***
			(0.117)	(0.103)	(0.118)	(0.099)
Reclassified English			1.451***	1.451***	1.436***	1.436***
			(0.098)	(0.098)	(0.095)	(0.095)
7th grade Math (std)			8.547***	2.611***	11.746***	4.779***
			(0.734)	(0.293)	(1.857)	(1.011)
7th grade ELA (std)			1.589***	3.679***	1.965***	4.537***
			(0.095)	(0.338)	(0.184)	(0.580)
7th Gr Math * 2006					1.366	1.366
					(0.316)	(0.316)
7th Gr ELA * 2006					0.813	0.813
					(0.110)	(0.110)
7th Gr Math * 2007					0.625*	0.625*
					(0.136)	(0.136)
7th Gr ELA * 2007					0.626***	0.626***
					(0.084)	(0.084)
7th Gr Math * 2008					0.311***	0.311***
					(0.059)	(0.059)
7th Gr ELA * 2008					0.907	0.907
					(0.119)	(0.119)
Constant	0.556***	0.047***	0.367***	0.005***	0.356***	0.001***
	(0.085)	(0.012)	(0.078	(0.001	(0.083)	(0.000)
N	15,233		13,734		13,734	
* p<0.05	** p<0.01	***p<0.001				

Table 3: 10th grade math course enrollment odds, generalized ordered logistic regression. (Standard errors in parentheses)

	Model 1: Geometry	Alg II	Summ.	Model 2: Geometry	Alg II	Summ.	Model 3: Geometry	Alg II	Summ.
2004-2005	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--
2005-2006	1.664***	1.196	1.433	2.063***	1.179	1.423	1.711***	1.152	1.019
	(0.226)	(0.204)	(0.373)	(0.238)	(0.185)	(0.353)	(0.212	(0.198)	(0.275)
2006-2007	3.035***	1.578**	1.515	4.686***	2.017***	1.485	3.744***	2.206***	1.469
	(0.4)	(0.264)	(0.454)	(0.539)	(0.306)	(0.450)	(0.497	(0.352)	(0.463)
2007-2008	4.464***	1.497*	1.831*	7.066***	1.750***	2.054*	6.602***	1.890***	2.484**
	(0.66)	(0.251)	(0.525)	(0.852)	(0.272)	(0.590)	(1.054	(0.314)	(0.776)
Hispanic				1.048	1.048	1.048	1.03	1.03	1.03
				(0.090)	(0.090)	(0.090)	(0.088	(0.088)	(0.088)
Vietnamese				3.208***	3.208***	3.208***	3.141***	3.141***	3.141***
				(0.334)	(0.334)	(0.334)	(0.326	(0.326)	(0.326)
Other				1.577***	2.247***	2.952***	1.571**	2.211***	2.980***
				(0.215)	(0.267)	(0.371)	(0.218	(0.266)	(0.383)
ELL				1.112	1.112	1.112	1.113	1.113	1.113
				(0.076)	(0.076)	(0.076)	(0.076	(0.076)	(0.076)
Reclassified English				1.121	1.428***	1.664***	1.114	1.439***	1.628***
				(0.106)	(0.109)	(0.155)	(0.105	(0.109)	(0.150)
7th grade Math (std)				4.835***	7.422***	3.108***	5.771***	11.322***	5.947***
				(0.344)	(0.537)	(0.304)	(0.613	(1.405)	(0.872)
7th grade ELA (std)				1.449***	1.843***	3.279***	1.659***	1.659***	1.659***
				(0.09)	(0.107)	(0.276)	(0.126	(0.126)	(0.126)
7th Gr Math * 2006							0.911	0.911	0.911
							(0.116	(0.116)	(0.116)
7th Gr ELA * 2006							0.694**	0.978	1.640*
							(0.091	(0.119)	(0.327)
7th Gr Math * 2007							0.630***	0.630***	0.630***
							(0.084	(0.084)	(0.084)
7th Gr ELA * 2007							1.027	0.889	1.769***
							(0.153	(0.098)	(0.291)
7th Gr Math * 2008							0.806	0.403***	0.294***
							(0.168	(0.064)	(0.048)
7th Gr ELA * 2008							0.958	1.486**	2.779***
							(0.143	(0.190)	(0.377)
Constant	2.413***	0.615***	0.094***	2.801***	0.231***	0.009***	3.184***	0.218***	0.008***
	(0.242)	(0.086)	(0.018)	(0.276)	(0.035)	(0.001)	(0.323)	(0.035)	(0.001)
N	11,920			11005			11005		

* p<0.05 ** p<0.01 ***p<0.001

Table 4: Segregation in 8th grade mathematics classrooms, 2004-2005 to 2007-2008 (index of dissimilarity)

	2004-2005	2005-2006	2006-2007	2007-2008
Gender				
Male/Female	0.25	0.21	0.23	0.24
Ethnicity				
Hispanic/Vietnamese	0.58	0.57	0.55	0.58
Hispanic/non-Hispanic	0.48	0.48	0.48	0.51
Language Status				
ELL/Fluent English	0.46	0.45	0.48	0.45
7th Grade Mathematics Test Score				
Top 25%/Bottom 25%	0.92	0.93	0.81	0.79
Top 50%/Bottom 50%	0.68	0.71	0.59	0.52
7th Grade ELA Test Score				
Top 25%/Bottom 25%	0.81	0.78	0.74	0.77
Top 50%/Bottom 50%	0.57	0.55	0.51	0.52
N(Classrooms)	256	204	213	241

Table 5: Peer quality and skill heterogeneity 8th grade math classrooms

	2004-2005	2005-2006	2006-2007	2007-2008
Peer quality (Classroom mean, 7th grade math percentile)				
General Math	32.14	30.29	23.84	19.66
Algebra	72.20	69.35	57.31	51.87
Geometry	93.09	88.52	87.76	77.76
All courses	46.90	50.63	52.18	50.58
Low-performing peers (% of classroom below basic on 7th grade math)				
General Math	42.11	45.35	55.48	67.38
Algebra	0.87	1.55	11.34	15.28
Geometry	0.00	0.00	0.00	1.15
All courses	26.39	22.39	20.27	20.67
Skill heterogeneity (Classroom IQR, 7th grade math percentile)				
General Math	22.68	23.76	18.20	18.68
Algebra	23.45	24.01	31.02	29.54
Geometry	7.15	14.12	13.26	25.5
All courses	22.36	23.05	25.79	27.37

Table 6: OLS regression coefficients, 10th grade math test scores

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
2004-2005						
2005-2006	0.084	-0.044*	-0.073*	-0.077**	-0.063*	-0.056*
	(0.073)	(0.019)	(0.028)	(0.027)	(0.025)	(0.025)
2006-2007	-0.012	-0.128***	-0.143***	-0.126***	-0.096**	-0.085*
	(0.071)	(0.019)	(0.033)	(0.032)	(0.031)	(0.034)
2007-2008	0.01	-0.084***	-0.227***	-0.212***	-0.153***	-0.117**
	(0.073)	(0.02)	(0.041)	(0.039)	(0.037)	(0.038)
Hispanic		-0.139***	-0.144***	-0.149***	-0.115***	-0.125***
		(0.021)	(0.019)	(0.019)	(0.019)	(0.019)
Vietnamese		0.236***	0.211***	0.207***	0.212***	0.212***
		(0.024)	(0.022)	(0.023)	(0.022)	(0.022)
Other		0.096***	0.073**	0.071**	0.072**	0.081***
		(0.023)	(0.023)	(0.023)	(0.023)	(0.023)
ELL		-0.011	-0.013	-0.012	-0.006	-0.006
		(0.017)	(0.016)	(0.016)	(0.016)	(0.016
Reclassified English		0.063***	0.045**	0.042**	0.047***	0.042**
		(0.015)	(0.014)	(0.015)	(0.014)	(0.014)
7th grade Math (std)		0.589***	0.537***	0.534***	0.480***	0.494***
		(0.016)	(0.017)	(0.017)	(0.017)	(0.017)
7th grade ELA (std)		0.191***	0.156***	0.152***	0.139***	0.136***
		(0.012)	(0.011)	(0.011)	(0.011)	(0.011)
8th grade Algebra			0.326***	0.331***	0.118***	0.214***
			(0.032)	(0.032)	(0.033)	(0.027)
8th grade Geometry			0.080	0.159**	-0.315***	0.028
			(0.054)	(0.054)	(0.065)	(0.049)
Algebra * 2006			-0.015	-0.014	-0.008	-0.042
			(0.038)	(0.038)	(0.035)	(0.035)
Algebra * 2007			-0.149***	-0.200***	-0.117**	-0.192***
			(0.039)	(0.041)	(0.037)	(0.039)
Algebra * 2008			-0.067	-0.111*	-0.041	-0.154***
			(0.046)	(0.045)	(0.042)	(0.042)
Geometry * 2006			0.179**	0.154**	0.212**	0.163**
			(0.054)	(0.055)	(0.069)	(0.051)
Geometry * 2007			0.238***	0.195**	0.258***	0.160**
			(0.062)	(0.062)	(0.071)	(0.060)
Geometry * 2008			0.532***	0.439***	0.605***	0.388***
			(0.061)	(0.06)	(0.067)	(0.057)
Math course skill heterogeneity (IQR)				0.004***		
				(0.001)		
Math course peer quality (mean)					0.242***	
					(0.021)	
% math course peers below basic						-0.514***
						(0.048)
Constant	0.012	0.011	-0.099***	-0.091***	-0.022	0.057*
	-0.056	-0.023	-0.024	-0.024	(0.022)	(0.026)
N	11,961	11,278	11,278	11,278	11,278	11,278
* p<0.05	** p<0.01	***p<0.001				

Figure 1: Quantile regression estimates of the effects of curricular intensification across the 10th grade math test score distribution