Title: Does Detracking Work? Evidence from a Mathematics Curricular Reform

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Background/Context

Across the United States, secondary school curricula are intensifying as a growing proportion of school students enroll in high-level academic math courses. 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. These shifts are particularly pronounced in California, where a decades-long effort to reduce curricular tracking in middle and high schools culminated with a 2008 State Board of Education vote 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).

This policy movement provides a unique opportunity for understanding the relationship between educational policy, the social organization of schools, and the distribution of student achievement. 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; Powell, Farrar, & Cohen 1985). This would seem to suggest that California's move away from rigid curricular tracking should narrow achievement gaps. However, 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.

Research Questions

Our analyses consider the following 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?

Setting/Population/Participants/Subjects

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. This district, which we pseudonymously refer to as "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.

Program/Intervention

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 three main mathematics course options for 8th graders: Pre-Algebra, Algebra I, and Geometry. Just 32 percent of 2004-2005 8th graders enrolled in Algebra I, 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 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 Algebra and an additional 13 percent were enrolled in Geometry.

While Towering Pines is demographically distinctive, the increases 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.

Research Design

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. As Table 1 indicates, students in the five cohorts are remarkably demographically similar, with no statistically significant differences in terms of gender composition and only moderate changes in ethnic composition. 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.[1] 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.

Data Collection and Analysis

Q1: Estimating changes in course enrollments

We begin by examining the effects of curricular intensification on 8th and 10th grade course enrollment patterns in Towering Pines. We first estimate a series of generalized ordered logistic regression models on 8th graders' odds of enrolling in Algebra or Geometry. 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 $\mathbf{Y_i}$ 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

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

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. The analyses of 10th grade course enrollments take a similar form. 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 measure changes in classroom composition, first, by calculating 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. In addition, we examine the way mean classroom skill level and within-classroom skill heterogeneity changed in 8th grade classrooms across cohorts.

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 10th grade year.

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.

Findings/Results

Our first research question asks about the extent to which curricular intensification influenced mathematics course placements in Towering Pines. Table 2 examines differences in course taking by cohort while controlling for demographic characteristics and 7th grade test scores. 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. In addition, we find that the role of 7th grade scores in predicting 8th grade mathematics course lessens over the course of the study period. These findings show that curricular intensification not only 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. Although not reported here, our analyses of 10th grade course enrollment return similar results.

Table 3 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 changes 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. Table 4 provides another look at the way curricular intensification changed the composition of 8th grade mathematics classrooms in Towering Pines. It demonstrates that district's curricular intensification redirected relatively low-achieving students into higher-level mathematics courses, lowering mean student achievement level within 8th grade mathematics class even as 7th grade test scores improved. In the process, the amount of skill heterogeneity in 8th grade Algebra and Geometry classrooms increased.

In Table 5, 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. However, 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. The remaining models in Table 3 test likely explanations for this unexpected negative effect. We find some evidence (in Model 5) to suggest that that iatrogenic peer effects partially explain the disappointing student achievement trends that occurred in Towering Pines during the period of curricular intensification.

Conclusions

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.

Appendices

Appendix A. References:

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Appendix B. Tables

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)
th 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: 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 4: 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 5: 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

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