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What Do the California Standards Test Results Reveal About the Movement Toward Eighth-Grade Algebra for All?

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In California, an increasing number of 8th graders have taken algebra courses since 2003. This study examines students' California Standards Test (CST) results in grades 7 through 11, aiming to reveal who took the CST for Algebra I in 8th grade and whether the increase has led to a rise in students' taking higher-level mathematics CSTs and an improved performance in following years. Results show that the pipeline of 8th-grade algebra and following years' higher-level mathematics CSTs has a significant leak in it. Furthermore, the longitudinal analysis reveals that 9th-grade students have a 69% greater chance of succeeding in algebra if they passed the CST for General Mathematics in 8th grade compared to those who failed the CST for Algebra I.

Keywords: *mathematics education, middle school, high school, education policy*

California's educational standards and assessments as well as its accountability policies related to mathematics achievement are designed to advance the expectation that all 8th graders will take algebra and then, like all California students in grades 2 through 11, be assessed through state testing as part of school- and district-wide accountability requirements (California Department of Education, 2008b). As a result of this policy, the percentage of 8th graders taking algebra has steadily risen, from 32% in 2003 to 59% in 2011 (California Department of Education, 2003, 2011). With the increased number of 8th-grade students taking algebra, there is now a need to investigate some of the claims and impacts of this effort by examining student achievement as shown by student performance scores on the California Standards Tests (CSTs) for mathematics in following years.

The purpose of this article is to examine the degree to which students who take the algebra CST in eighth grade succeed in future mathematics CSTs in high schools. By analyzing these links, we believe our analysis can inform and raise questions about the stance of educators and policymakers on promoting algebra for all in the eighth grade. The analysis also raises questions about whether other mathematics focuses might, instead, provide students with greater future success in mathematics.

Both educators and policymakers view algebra as the gatekeeper for advancement to higher mathematics and science courses, which themselves are gateways for later success during the college years. It is argued that algebra courses and learning the knowledge and skills of algebra are necessary for college entrance and success (Adelman, 1999; Horn & Nuñez, 2000). For example, the California State University and the University of California require incoming freshman candidates to complete the Requirement C in mathematics as part of their A–G requirements for high school graduates to be admitted to campuses of both systems. Both the California State University and the University of California require 3 and recommend 4 years of mathematics beginning with Algebra I (University of California, 2007).

In addition, many states including California (California Algebra Instruction Act 2000) require students to complete algebra for high school graduation (Achieve, Inc., 2006). However, this requirement does not specify the grade level at which algebra should be taken (California Department of Education, 2006). Nevertheless, "algebra for everyone" has become a driving force in educational reform policies (Allensworth & Nomi, 2009), during the beginning decades of the 21st century. For example, the College Board's initiative, called Equity 2000, encourages all students entering high school to take algebra at the ninth grade (College Board, 2000). In addition, American Institutes for Research and Microsoft, reflecting the voices of segments of the education and business communities, have urged eighth-grade students to succeed in algebra (Evan, Gray, & Olchefske, 2006). These policy changes and initiatives have resulted in an unprecedented increase in the number of eighth and ninth graders who are enrolled in algebra (National Center for Education Statistics, 2005).

The National Mathematics Advisory Panel's 2008 report, *Foundations for Success*, while proposing a focus on algebra and recommending that such a focus happen earlier than later in students' educational program (p. xviii), has also cautioned that with this and other related recommendations regarding algebra, the research supporting these recommendations is less than solid and certainly not causal:

> In view of the sequential nature of mathematics, the Critical Foundations of Algebra described in the preceding section require judicious placement in the grades leading up to Algebra. To encourage the development of students in Grades PreK–8 at an effective pace, the Panel suggests the Benchmarks for the Critical Foundations in Table 2 as guideposts for state frameworks and school districts. There is no empirical research on the placement of these benchmarks, but they find justification in a comparison of national and international curricula. (p. 19)

Other research studies also provide evidence for and against the practice and the policies in support of algebra course taking and a focus on designated algebra knowledge and skills at particular points in a student's educational program. Gamoran and Hannigan (2000) found that all students, regardless of prior mathematics skills, benefit from taking algebra, although low-achieving students gain less in their subsequent math course taking and test scores. Smith (1996) concluded that "early access to algebra has a sustained positive effect on students, leading to more exposure to advanced mathematics curriculum and, in turn, higher mathematics performance by the end of high school" (p. 148). Spielhagen (2006) found that "students who completed algebra in eighth grade stayed in the mathematics pipeline longer and attended college at greater rates than those who did not" (p. 35).

Despite these positive findings, evidence from student performance data, such as CST reports and research on CST results from several schools and districts in southern California (Kriegler & Lee, 2006), suggests that a policy requiring all eighth graders to enroll in algebra needs further investigation. A recent comprehensive study on middle-grade mathematics performance by Williams, Haertel, Kirst, Rosin, and Perry (2011b) concludes that "placing all 8th graders into Algebra I, regardless of their preparation, sets up many students to fail" (p. 3). In addition, Loveless (2008) found many students nationwide were misplaced in eighth-grade algebra classrooms. Allensworth and Nomi (2009) found placing all ninth graders in algebra had few benefits. They concluded, "Although more students completed ninth grade with credits in algebra . . . , failure rates increased, grades slightly declined, test scores did not improve, and students were no more likely to enter college" (p. 367).

Education groups in California have also raised questions about the July of 2008 vote of the California State Board of Education that required all California eighth graders to be assessed in algebra within three years (2008). The Association of California School Administrators and the California School Boards Association challenged this decision in a Sacramento superior court on the grounds that, should such a decision be implemented, California lacked the infrastructure to help all students succeed in algebra. The California Teachers Association and Superintendent of Public Instruction Jack O'Connell later joined the plaintiffs in the suit. In December of that year, a judge issued a preliminary injunction against the State Board of Education regarding its decision to mandate algebra for all eighth-grade students (Association of California School Administrators, 2008). A focal argument in this effort is that by building students' algebra readiness, all students can succeed in algebra (O'Connell, 2008).

Quoting from the National Mathematics Advisory Panel's (2008) *Foundations for Success*,

> There are many gaps in the current understanding of how students learn algebra and the preparation that is needed before they enter Algebra. What is known indicates that too many students in middle or high school algebra classes are woefully unprepared for learning even the basics of algebra. (p. 32)

Clearly, much more has to be known to understand the necessary progression of the mathematical experiences students should have to succeed in mathematics in high school and beyond. To make that contribution, this study examines students' CST results to provide greater insights into the issues surrounding the movement for algebra for all eighth-grade students. Specifically, we are interested in finding out whether the increased number of students taking algebra in eighth grade comes along with their success for moving on and taking higher level mathematics CSTs in following years, as reflected in these students' taking CSTs and scoring proficient or above on their CSTs. (California set five performance levels for its statewide assessments: advanced, proficient, basic, below basic, and far below basic. The state's target is for all students to score at the proficient or advanced level.) We are also interested in comparing ninth-grade students' performance on various CSTs, particularly the CST for Algebra I, with a subgroup of the students who took the CST for General Mathematics, which assesses California standards in grades six and seven, and a subgroup of the students who took the CST for Algebra I in eighth grade. Furthermore, we are interested in finding out the factors that affect students' choice of which CST they take in eighth grade between the CST for General Mathematics and Algebra I. In analyzing the CST data, we explore answers to the following questions:

1. During a 4-year period from grades 8 through 11, how many students took the CST for Algebra I in 8th grade? In subsequent years, how many of these students continued taking higher level math CSTs? How did students perform on each of the CSTs for each of the subsequent years?
2. For those eighth graders who took the CST for Algebra I and scored below proficient, what CSTs for mathematics did these students take in ninth grade and how well did they perform?
3. For those eighth graders who took and scored proficient or above on the CST for General Mathematics, what CSTs for mathematics did they take in ninth grade and how did they perform?
4. Can student performance on the CST for Grade Seven Mathematics predict which CSTs he or she will take at eighth grade between General Mathematics and Algebra I?

By examining these questions, we hope to shed greater light on whether having all students complete algebra in eighth grade promotes those students' success in future mathematics experiences in school. By analyzing such links, our data can inform the stance of educators and policymakers on promoting algebra for all in the eighth grade and whether other mathematics foci might instead provide students with greater future success in mathematics.

Method

This study relies on California's Standardized Testing and Reporting (STAR) program student data files. On the student level, data files include information such as the Statewide Student Identifier (SSID), grade level, test name, test raw score, test scale score, and performance level. Based on these data, we formulated a two-part analysis. First, to explore answers for the first research question, we aggregated the past CSTs for mathematics administration data from 2003 to 2011 into student test participation and performance in three cohorts. The first cohort is 8th graders in 2003, 9th graders in 2004, 10th graders in 2005, and 11th graders in 2006. The next two cohorts start with 8th graders in 2005 and 2008, respectively, with 9th through 11th graders in the 2006 to 2008 and 2009 to 2011 groups, respectively. We discuss the number of students and the percentage of the entire eighth-grade student population taking the CST for Algebra I in 8th grade, followed by the number of students in the following years as of 9th graders taking the CST for Geometry, 10th graders taking the CST for Algebra II, and 11th graders taking the CST for Summative High School Mathematics, along with their performance (the number of students and percentages of the specific test takers scoring proficient or above, as shown in Table 1).

By presenting these descriptive statistics for students taking the CSTs, which correspond to the California university system's "A-G mathematics requirement" courses of three 4-year periods, we explore the college mathematics preparation pipeline through California students' test taking and performance on CSTs for mathematics.

In the second part of our analysis, we used SSIDs to match 2006 and 2007 student-level data files. We extracted two longitudinal study data sets: one involving seventh graders in 2006 and eighth graders in 2007; the other focused on eighth graders in 2006 and ninth graders in 2007. Several reasons guided our decision to choose the years of 2006 and 2007 to explore longitudinal patterns. One of the reasons relates to the observed increase in the total number of students taking the CST for Algebra I between 2003 and 2009 and then a decrease in 2010 and 2011 (Torlakson, 2011, Table 8). Another reason is that 2006 was the last year all seventh-grade students were required to take the CST for Grade Seven Mathematics. (Since 2007, seventh graders have been allowed to take the CST for Algebra I if they take an algebra course.) In addition, the use of SSIDs was first implemented in 2006 on a voluntary basis, but the participation rate (over 95%) is satisfactory for this study. The SSID became mandatory in 2007.

For the seventh- and eighth-grade group, our search identified 456,392 matched records of students who were seventh graders in 2006 and became eighth graders in 2007, which is 96% of the total number of 476,015 eighth-grade CST mathematics test takers and 93% of the total eighth-grade enrollment of 492,128 in 2007. For the eighth- and ninth-grade group, we identified 471,481 matched records of students who were eighth graders in 2006 and became ninth graders in 2007, which is 95% of the 496,175 ninth-grade students who took the CSTs for mathematics and 90% of the total ninth-grade enrollment of 525,938 in 2007.

To answer Research Questions 2 and 3, we focus on the matched records of students in eighth grade in 2006 and ninth grade in 2007. There are two major cohorts of eighth graders in these matched data sets: one cohort took the CST for Algebra I; the other took the CST for General Mathematics in 2006. Among these two cohorts, there are four subgroups: (a) students who scored proficient or above on the CST for Algebra I, (b) students who scored below proficient on the CST for Algebra I, (c) students who scored proficient or above on the CST for General Mathematics, and (d) students who scored below proficient on the CST for General Mathematics. Our focus is on the students on the borderline between passing or failing CSTs. We assume that students in the first group (students scoring proficient or above on the CST for Algebra I) are rightfully placed in eighth-grade algebra courses and students in the last group (students scoring below proficient on the CST for General Mathematics) have little chance to succeed in algebra next year. This assumption is supported by the findings of Williams, Haertel, Kirst, Rosin, and Perry (2011a).

The establishment of these two conditions led us to then focus on the second and third groups. We named the second group as Subgroup A, which includes students who scored below proficient on the CST for Algebra I at eighth grade, and the third group as Subgroup B, which includes students who scored proficient on the CST for General Mathematics at eighth grade. Because these two groups of students may or may not be fully prepared to succeed on the test, their test taking and performance may assist in

TABLE 1

Three Cohort California Standards Test Participation and Performance by 8th Through 11th Graders

	8th Graders Taking Algebra I		9th Graders Taking Geometry		10th Graders Taking Algebra II		11th Graders Taking Summative High School Math	
	Students Tested	Proficient and Above	Students Tested	Proficient and Above	Students Tested	Proficient and Above	Students Tested	Proficient and Above
2003–2006	*N* = 476,822 (2003)		*N* = 515,713 (2004)		*N* = 482,164 (2005)		*N* = 461,753 (2006)	
	151,714 (32%)	59,168 (39%)	89,873 (17%)	38,645 (43%)	85,205 (18%)	30,674 (36%)	83,767 (19%)	36,020 (43%)
2005–2008	*N* = 501,334 (2005)		*N* = 535,336 (2006)		*N* = 500,655 (2007)		*N* = 466,005 (2008)	
	224,291 (45%)	76,259 (34%)	112,194 (21%)	50,487 (45%)	102,696 (21%)	35,944 (35%)	98,327 (21%)	42,281 (43%)
2008–2011	*N* = 490,869 (2008)		*N* = 522,400 (2009)		*N* = 497,957 (2010)		*N* = 473,085 (2011)	
	248,155 (51%)	104,225 (42%)	128,701 (25%)	60,489 (47%)	118,490 (24%)	47,396 (40%)	116,918 (25%)	58,459 (50%)

determining if placing them in eighth-grade algebra courses benefits their future learning success on these CSTs (Liang & Guo, 2007).

For these two subgroups, we analyzed two pivotal factors: the CST for mathematics they took in the following year and their performance on the tests. Because 64.03% of students in Subgroup A took the CST for Algebra I again at ninth grade and 82.86% students in Subgroup B took the CST for Algebra I as well, though for the first time, we were able to compare these students' success rates in passing the test (scoring proficient or above).

To explore and answer the last research question, can student performance on the CST for Grade Seven Mathematics predict which CST he or she will take at eighth grade between General Mathematics and Algebra I, we performed a multiple discriminant analysis with the seventh- and eighth-grade data set involving several steps.

First we created a dummy variable to indicate the CST students took at grade eight. We assigned a value of 0 for the CST for General Mathematics and 1 for the CST for Algebra I. The dummy variable was then used as a grouping variable in a multiple discriminant model in which the student's performance in mathematics, English language arts (ELA) scores, and parent education level were used as the discriminating variables. This model provides information on the power of the CST for Grade Seven Mathematics and ELA scores in predicting which CST the student took at grade eight between the CST for Algebra I and the CST for General Mathematics. Then we conducted a multivariate ANOVA (analysis of variance) to compare the means of seven grade CST raw scores in both ELA and mathematics categorized by the CST for General Mathematics and CST for Algebra I that those students took in eighth grade.

Results

Three Cohorts' CST Participation and Performance

Research Question 1 asks during a 4-year period from grades 8 through 11, how many students took the CST for Algebra I at 8th grade and then in subsequent years, how many of these students continued taking higher level math CSTs? How did students perform on each of the CSTs for each of the subsequent years? Table 1 presents the number of students taking grade-level CSTs and their performance, organized in three cohorts.

We identified two emerging trends from these descriptive statistics: more and more California students in the 8th, 9th, 10th, and 11th grades participated in taking the CSTs for Algebra I, Geometry, Algebra II, and Summative High School Mathematics, respectively, from 2003 to 2011; also, the increases in the number of students in 9th through 11th grades taking higher level CSTs for mathematics are much smaller than are the increases in the number of students in 8th grade taking the CST for Algebra I. For example, in 2003, 151,714 eighth-grade students took the CST for Algebra I. By 2008, 248,155 eighth-grade students took the CST for Algebra I. This increase involved an additional 96,441 students (about an additional 19%) of eighth-grade students taking the CST for Algebra I from 2003 to 2008.

A more moderate pattern of increases exists for 9th- through 11th-grade students with regard to their participation in taking other higher level mathematics CSTs between 2004 and 2011. For example, an additional 38,828 (about an 8% increase) 9th-grade students took the CST for Geometry between 2004 and 2009, as shown in Table 1. Also, an additional 33,285 (an increase of about 6%) 10th graders took the CST for Algebra II between 2005 and 2010. Besides, there is also an additional 33,151 (about a 7% increase) 11th graders taking the CST for Summative High School Mathematics between 2006 and 2011.

This pattern of increased numbers and percentage points of students taking algebra may have various causes, including the algebra-for-all movement and California's accountability requirements that penalize schools and districts for having students take the CST for General Mathematics instead of higher level mathematics CSTs. The existence of these two trends suggests that the desire of policymakers to increase attention and participation in algebra and higher level mathematics appears to be having a desired effect.

Yet that leads to a question to be discussed next. Despite the impressive increases in eighth-grade students taking the CST for Algebra I, there is not a corresponding increase in number of students taking higher level CSTs for mathematics. This may suggest that these policies may be only engendering increases in students' involvement in algebra. Students may not be able to move beyond this entry level of higher mathematics experience. Whereas there have been increases in the numbers of students taking higher level mathematics CSTs, they are not as large as the increase in numbers of students taking the CST for Algebra I. Examining the performance of students on the CSTs for Algebra I, and some of the other CSTs in higher mathematics, may provide additional insights about what might be going on here.

The expectation for having greater student participation in algebra courses and on algebra knowledge and skills involves improved student achievement—in the case of CSTs, an increase in scoring at least proficient in these areas of higher mathematics CSTs. We, then, turn to the second part of Research Question 1, which examines students' performance on each of the CSTs.

The actual numbers of students increased who took the CSTs and scored proficient or above in Algebra, Geometry, Algebra II, and Summative High School Mathematics during this time period. For example, in 2003, 59,168 eighth-grade students scored proficient or above on the CST for Algebra I. By 2008, those numbers increased to more than 104,225 eighth grade students who had proficient or higher CST scores, with a gain of 45,057 eighth-graders scoring proficient or above on the CST for Algebra I. These changes in percentages of eighth graders who scored proficient or above on the CSTs for Algebra I reflect a relatively small increase, in the range of 3%. But these are important gains.

In addition, in 2004, there were 38,645 ninth-grade students scoring proficient or above on the CST for Geometry. This number increased to 60,489 in 2009 with an additional 21,844 (about a 4% increase) ninth graders scoring proficient or above on the CST for Geometry.

As for 10th graders who took the CST for Algebra II, in 2005, there are 30,674 scoring proficient or above. In 2010, the number of 10th graders scoring proficient or above on the CST for Algebra II increased to 47,396, with an additional 16,722 (about a 4% increase) students meeting the state's expectation for performance. In 2006, there are 36,020 students in 11th grade who scored proficient or above on the CST for Summative High School Mathematics. In 2011, this number increased to 58,495, with an additional 22,475 (about a 7% increase) 11th graders meeting the state's performance expectation.

However, despite these gains, there are a great number of students who do not continue on to take the CST for Geometry after taking the CST for Algebra I at eighth grade. This fact led us to explore trends for what happened with students' test-taking patterns after eighth-grade algebra. We examined the students' following year's test-taking and performance trends if they

TABLE 2

Subgroup A for Students Who Scored Below Proficient on the CST for Algebra I in Eighth Grade: Percentage of Test Taking and Performance in Ninth Grade in 2007

	Below Proficient		Proficient and Above		Total	
Test Name	*N*	%	*N*	%	*N*	%
CST for General Mathematics	8,296	7.07	1,188	1.01	9,484	8.08
CST for Algebra I	63,879	54.42	11,273	9.61	75,152	64.03
CST for Geometry	28,037	23.89	3,192	2.72	31,229	26.61
Other[a]	1,121	0.95	386	0.33	1,507	1.28
Total	101,333	86.33	16,039	13.67	117,372	100.00

CST = California Standards Test.

[a]Other tests include the CSTs for Integrated Mathematics I, II, and III and the CST for Algebra II.

failed the CST for Algebra I at eighth grade. We also examined the trends for those students who did not take the CST for Algebra I but demonstrated their mathematics competency by scoring proficient or above on the CST for General Mathematics.

Tracking Student-Level Data: Failing Algebra Versus Passing General Mathematics at Eighth Grade

In analyzing the second data set, grades eight and nine matching records, we followed two subgroups of 2006 eighth graders and studied their mathematics test-taking patterns and performance in the next year. Subgroup A included the eighth graders taking the CST for Algebra I and scoring below proficient. Subgroup B included the eighth graders taking the CST for General Mathematics and scoring proficient or above. We matched these students' SSIDs with their 2007 STAR data file to examine their following year's performance on the CSTs.

There are 201,698 matched records according to 2007 SSIDs; these show which students took the CST for Algebra I at eighth grade in 2006. Among these students, 41.81% scored proficient or above, and 58.19% scored below proficient, which comprises our Subgroup A with 117,372 records. Table 2 illustrates these students' performances on various CSTs in 2007.

In Subgroup A, 8.08% of students took the CST for General Mathematics in 2007 in ninth grade, as shown in Table 2. Of those test takers, for every student who scored proficient or above, about 7 students scored below proficient. Because students who took the CST for General Mathematics could take any mathematics course below algebra or not take any mathematics course (California Department of Education, 2008b), it is not clear whether taking algebra courses in the previous year helped their performance on the CST for General Mathematics.

The majority of Subgroup A students retook the CST for Algebra I in 2007 in ninth grade. In other words, they may have repeated taking an algebra course in high school. We do not know the reason why these students repeated the test because we did not have access to student course-taking information. Nonetheless, as shown in Table 2, 64.03% of students took the CST for Algebra I again in 2007 at ninth grade. Of those CST Algebra I repeaters, for every student who scored proficient or above, about 5 students scored below proficient. Again, we do not know the previous year's experiences in algebra courses and whether such experiences may have helped these students. Student course-taking patterns remain an interesting and important question for further study.

Among Subgroup A, 26.61% of students took the CST for Geometry in 2007 in ninth grade. Of the Geometry test takers, for every student who scored proficient or above, about 10 students scored below proficient.

For the eighth-grade students who took the CST for General Mathematics in 2006, we found 188,482 matched records. Among these students, 27.51% scored proficient or above

TABLE 3

Subgroup B for Students Who Scored Proficient or Above on the CST for General Mathematics in Eighth Grade: Percentage of Test Taking and Performance in Ninth Grade in 2007

	Below Proficient		Proficient and Above		Total	
Test Name	*N*	%	*N*	%	*N*	%
CST for General Mathematics	2,248	4.34	4,215	8.13	6,463	12.47
CST for Algebra I	26,652	51.40	16,311	31.46	42,963	82.86
CST for Geometry	1,377	2.66	659	1.27	2,036	3.93
Other[a]	307	0.59	79	0.15	386	0.74
Total	30,584	58.99	21,264	41.01	51,848	100.00

CST = California Standards Test.

[a]Other tests include CSTs for Integrated Mathematics I, II, and III, and the CST for Algebra II.

while 72.49% scored below proficient. Students who scored proficient or above on the CST for General Mathematics in 2006 (51,848 records) comprise our Subgroup B.

We then asked the following question: how did those eighth graders who scored proficient or above on the CST for General Mathematics, Subgroup B, perform on various CSTs in ninth grade? To answer that question, we undertook the analysis reflected in Table 3. It shows Subgroup B's test-taking patterns and performance.

In Table 3, the last column shows the students who took the CST for General Mathematics and scored proficient or above in eighth grade. Of these, 12.47% retook the CST for General Math at ninth grade, 82.86% took the CST for Algebra I, and 3.93% took the CST for Geometry. Of the General Mathematics repeaters, the ratio of students scoring proficient or above to students scoring below proficient is about 2 to 1 (8.13%:4.34%); that is, for every student scoring below proficient, two students scored above proficient.

The repeating CST for General Mathematics passing rate raises two significant questions. First, why did those students retake the CST for General Mathematics? Second, why did their performance levels decrease from 2006, when they scored proficient or above on the same test? To answer the first question, we have to examine the students in ninth grade who are eligible for taking the CST for General Mathematics. There are only two groups of these students: those who are taking a mathematics course below algebra and those who are not taking any mathematics course (California Department of Education, 2008a). It is difficult to speculate about why students performed worse in repeating the CST for General Mathematics because we do not know from our data sets what if any school mathematics courses or experiences students had during the year that they took the CSTs. If they did not take any mathematics courses or had limited mathematics experiences during the year, that lack could have affected their performance on the CST. But we do not know.

The decreases in performance may also be related to the reliability estimate for the test. According to the 2007 CST Technical Report, the reliability estimates (Cronbach's α) for the CST for General Mathematics is .88 (California Department of Education, 2008c, p. 439), which means that students' performance on the test may fluctuate if they repeat taking the same test.

Nonetheless, of the students who took the CST for Algebra I in ninth grade, the ratio of students scoring proficient or above to students scoring below proficient is about 3 to 5 (31.46%:51.49%). This number is significantly higher than the overall ninth-grade performance on Algebra I in 2007, when only 17% of students scored proficient and above (California Department of Education, 2007). In percentages, the ratio of students scoring proficient or above on the CST for Geometry to students scoring below proficient is about 1 to 2 (1.27%:2.66%). Again, this is a better ratio than for the other comparisons discussed earlier.

Linking Students Prior Year's CST Scores to Following Year's CST Test Taken Between CST for General Mathematics and CST for Algebra I

After comparing ninth graders' algebra success between students who took the CST for Algebra I in eighth grade and scored below proficient and students who took the CST for General Mathematics and scored proficient, we now turn to investigate the decisions students—or, more likely, schools through teachers or counselors—made in determining which mathematics course students take, and, therefore, which CST to take in eighth grade between algebra and general mathematics. Is there a link between their CST scores for Grade Seven Mathematics and their eighth-grade CST participation? Our fourth research question asks, can student performance on the CST for Grade Seven Mathematics predict which CSTs he or she will take in eighth grade between General Mathematics and Algebra I?

We now present the results of our analysis on seventh-grade CST achievements in relationship to which mathematics CST students took during the following year. A multivariate ANOVA produced the mean comparison of students' 2006 grade-seven CST scores in ELA and mathematics between their 2007 CSTs for General Mathematics and Algebra I. Table 4 presents means, standard deviations, and numbers for seventh-grade students in 2006 and their raw scores of CSTs for ELA and Mathematics categorized by their eighth-grade CSTs participation in either General Mathematics or Algebra I.

TABLE 4

Scores of CSTs for Seventh-Grade ELA and Mathematics by Eighth-Grade Math CST Choice (General Mathematics versus Algebra I)

CST Taken in Eighth Grade	Seventh-Grade ELA	Seventh-Grade Mathematics
General Mathematics		
N	197,587	197,597
M[a]	42.27	30.62
SD	14.54	12.28
Algebra I		
N	225,695	225,695
M[a]	53.81	42.37
SD	13.33	12.83

CST = California Standards Test; ELA = English Language Arts.

[a]The total raw scores for the CST for seventh-grade ELA is 83, for the CST for General Mathematics and Algebra I is 65.

As it can be seen from the data in Table 4, students who are performing lower on average in both CSTs for ELA and Mathematics tend to take the CST for General Mathematics in eighth grade. Those who score higher take the CST for Algebra I in eighth grade. For example, the mean of eighth-grade ELA scores for those students who took the General Mathematics CST is 42.27 (*SD* = 14.54) as compared with the mean of 53.81 (*SD* = 13.33) for those who took the CST for Algebra I.

We found the difference to be highly significant ($f = 67318.58$, $p = .0000$). Similarly, we found CST for Grade Seven Mathematics scores for the students who took CST for General Mathematics in eighth grade (*M* = 30.62, *SD* = 12.28) to be substantially and significantly lower than the mean for the students who took the CST for Algebra I (*M* = 42.37, *SD* = 12.83). These results clearly suggest that students at the lower level of performance in ELA and mathematics CSTs in seventh grade are more likely to take the CST for General Mathematics than the CSTs for Algebra I.

The fact that students' ELA and mathematics scores in seventh grade appear to predict what CSTs they take in eighth grade between Algebra and General Mathematics led us to further investigate how much each affects which CST they took. In addition to the seventh-grade CST raw scores in ELA and mathematics, we also included parent education level as a variable in the discriminant model to have a comprehensive look of the variables that may be contributing to the prediction other than CST scores.

Table 5 presents a summary of the discriminant analyses results. As the data in Table 5 show, the variable with the highest level of discriminating power between the General Mathematics and Algebra groups is the mathematics score (discriminant coefficient of .791). This is quite consistent with the expected trend of a discriminant model. The students' prior mathematics achievement in high scores is an

TABLE 5
Summary Results of the Multiple Discriminant Analyses

Variable	Correlation	Coefficient
CST for seventh-grade mathematics scores	.983	.791
CST for seventh-grade English Language Arts scores	.840	.289
Parent education	–.259	.012

CST = California Standards Test.

important factor in determining their taking the CST for Algebra I instead of taking the CST for General Mathematics. The second variable with the highest discrimination power is ELA test score (.289). Parent education level did not seem to have much power in discriminating between students who took the two different tests with a discrimination power of .012. This is a surprise finding because parent education level usually serves as a proxy for socioeconomic status. Almost all large-scale standardized test results show that students' achievement is highly correlated to their socioeconomic status, which is part of the achievement gap that educators and policymakers are putting great efforts to close. However, there may be some other variable confounding this result that we did not explore.

Results of these analyses, therefore, suggest that students' decision in taking either the CST for Algebra I or General Mathematics in eighth grade can be fairly predicted from their performance on their prior year's CSTs. The higher students' seventh-grade CST scores in ELA and mathematics, the more likely they would take the CST for Algebra I; the lower students' seventh-grade CST scores in ELA and mathematics, the more likely they would take the CST for General Mathematics. The CST for Grade Seven Mathematics is a dominant determining factor between taking the two CSTs in eighth grade.

Discussion

The CST data show that the increase of 8th graders taking the CST for Algebra I comes with increases of 9th- through 11th-grade students who take the higher level CSTs for mathematics. The additional 96,441 eighth graders taking the CST for Algebra I between 2003 and 2008 come with an additional 33,151 eleventh graders taking the CST for Summative High School Mathematics between 2006 and 2011. The CST data also show that the increase of 8th graders scoring proficient or above on the CST for Algebra I was accompanied by increases of 9th- through 11th-grade students scoring proficient or above on the higher level CSTs. The additional 45,047 eighth graders scoring proficient or above on the CST for Algebra I is accompanied by an additional 22,475 eleventh-graders scoring proficient or above on the CST for the Summative High School Mathematics at the same time period (see Table 1). These numbers confirm the improvements in the number of students taking higher level CSTs for mathematics and their performance. Advocates for increasing students' attention to taking algebra and other mathematics courses could be encouraged by these positive trends.

However, in examining each grade level's test-taking and performance in this pipeline of students advancing and taking higher level mathematics CSTs, we found that the additional 96,441 eighth-grade students taking the CST for Algebra I between 2003 and 2008 becomes a much smaller number of 38,828 additional ninth-grade students taking the CST for Geometry between 2004 and 2009. This increase further shrinks to 33,285 additional tenth-graders taking the CST for Algebra II between 2005 and 2010 and 33,151 additional eleventh-graders taking the CST for Summative High School Mathematics between 2006 and 2011. Also, in examining students' performance on these CSTs, the 45,047 increase of eighth graders scoring proficient or above between 2003 and 2008 shrank from almost a half to 21,844 in ninth-graders (a 48% decline) taking the CST for Geometry between 2004 and 2009. This number deteriorated further to 16,722 in tenth graders taking the CST for Algebra II between 2005 and 2010 and bounced to 22,475 in the number of eleventh graders taking the CST for Summative High School Mathematics.

The significant deterioration between the number of eighth graders taking the CST for Algebra I and the number of ninth graders taking the CST for Geometry signifies a decline and leads us to suggesting this idea of a leak in the pipeline. It appears that simply encouraging more students to take eighth-grade algebra does not by itself lead to significantly more students taking advanced mathematics in high school, nor does it lead to substantial increases in performances in higher mathematics CSTs.

Our results somewhat correspond with Loveless's (2008) finding that enrolling more students in algebra courses may have little impact on students' learning success. Like our findings, Loveless found similar declines in scores on the National Assessment of Educational Progress eighth-grade mathematics test scores.

The fact that the leaking pipeline of students' success in mathematics, beginning with eighth-grade algebra, shows deteriorations in the increase of higher level CST participation and performance suggests that more has to be done than simply requiring a course or designating a set of knowledge and skills to be learned. Such encouragement for students to take courses is certainly necessary, but it is not sufficient for realizing students' understanding and encouraging their motivation to continue to learn higher mathematics.

The reductions in gains in students' participation in higher level CSTs for mathematics as well as the less-than-dynamic student performance on the CST scores of students through their high-school advancements led us to examine more closely student participation in eighth-grade mathematics classes, their passing or failing the CST, and the correlations of these factors with higher scores on CST for Algebra I among ninth-grade students.

Our longitudinal data analysis (Table 2) indicates that Subgroup A members have much less chance of passing the CST for Algebra I in 9th grade compared to Subgroup B members (9.61% vs. 31.46%, see Tables 3 and 5). In other words, those students who failed the CST for Algebra I in 8th grade and retook the same test in 9th grade had a 69% (1 – 0.0961 / 0.3146) less chance of passing the test compared to those students who passed the CST for General Mathematics in 8th grade and took the CST for Algebra I in 9th grade for the first time. This striking failure rate is highlighted in a California Department of Education press release that states that for grades 8 through 11, only 15% of students repeating the CST for Algebra I scored proficient or above compared to 26% of first time algebra test-takers in all grades for the 2007 test administration. More recent data from the 2011 test administration show that 36% of first-time Algebra I CST takers scored proficient or above compared to 24% of the retakers scoring proficient or above (Torlakson, 2011, Table 6). The difference between first-time algebra test takers and repeaters in success rates and the fact that it appears to be continuing through 2011 raise serious questions about giving algebra 1 year sooner to those students who scored below proficient. These rates also suggest that such a practice may not help them succeed in algebra in following years.

Our conclusions contrast with those of Smith (1996), Spielhagen (2006), and Stevenson, Schiller, and Schneider (1994). Based on the data from the National Educational Longitudinal Study of 1988, these studies found that students taking algebra in eighth grade acquired long-term benefits in learning algebra, irrespective of their abilities. Instead, our study finds that students who score below proficient in the eighth-grade CST have a lower chance of successfully passing the following year's mathematics test (CST for Algebra I) compared to students who passed the CST for General Mathematics.

Although policymakers have intended algebra for all to democratize access to college and learning success (Moses, 1995), Loveless (2008) viewed this mantra as a false democratization. He concluded, "No social benefit is produced by placing students in classes for which they are unprepared. Indeed, it is difficult to imagine any educational benefit accruing to these students" (p. 10).

To further understand the variations between the Smith (1996) and other studies, the Loveless (2008) study, and our present study, the reader must look at the sampling techniques used in each study. In the Smith and other above studies, about one in six students were taking algebra and the studies were based on data from the National Educational Longitudinal Study of 1988. About one of every two students Loveless studied took algebra in the California sample.

On the other hand, we studied a more specific sample of students who scored proficient and not proficient on the CST for Algebra I (Liang, 2009). Given these various samples, it is understandable that Smith (1996) and other studies found that 1 in 6 students benefited from early algebra, while this study and the Loveless (2008) study found more differentiated evidence that prepared students benefited and unprepared students did not benefit from taking algebra in eighth grade.

Our discriminant model clearly indicates that the CST for Grade Seven Mathematics is a strong predictor of students' eighth-grade CST participation in General Mathematics and Algebra I CSTs. This result supports Williams et al.'s finding (2011a): "Students' prior academic performance and CST scores were the most common considerations for both general mathematics and Algebra I placements" (p. 39). Our surprising finding that students' socioeconomic status does not influence much of students' test participation also supports Williams et al.'s finding, as they reported that "schools serving predominantly lower-income students placed greater proportions of students into Algebra I than did schools serving predominantly middle-income students" (p. 50).

If placing students based on their preparation leads to a better success rate for students' learning and passing the algebra test, it leads us to ask the question, what is the preparation that students need to succeed in algebra? In 2008, the National Mathematics Advisory Panel recommended Critical Foundations of Algebra (p. 17) to be included in the grades PreK–8 algebra preparation curricula. These Critical Foundations of Algebra largely come from the panel's professional judgments (Thompson, 2008) or from preferences noted by individuals taking a teachers' survey (Loveless, Fennell, Williams, Ball, & Banfield, 2008). Further investigations are needed to provide empirical evidence as what specific math concepts or skills and conditions for learning prepare students for algebra success.

There are indications, which we have noted earlier, that conceptual understanding remains critical for student success in mathematics. Rakes, Valentine, McGatha, and Ronau (2010) made this point about this kind of mathematical understanding:

> The persistence of a procedural emphasis in traditional mathematics pedagogy suggests that although a great deal of evidence supports the importance of teaching mathematics conceptually, the information from that body of research has not yet influenced the teaching profession enough. (p. 391)

For those understandings and student motivation to be encouraged and realized, as well as characterizing the experiences of students in secondary education of higher level mathematics, educators may have to challenge and move away from the weak or absent classroom learning conditions that now appear to characterize students' school learning in mathematics, namely the extreme focus on procedural knowledge. If we and others are correct about the importance of conceptual understanding and the learning conditions noted earlier, greater attention may have to go to promoting these ideas among policymakers, school district leaders, and teacher education programs as well as the educators working now in classrooms and schools in California.

We do not know about the nature of the courses or learning experiences students would have experienced prior to or after they took the CST for Algebra I or other higher mathematics CSTs. Nonetheless, a belief does exist that testing signals essential schooling courses, experiences, and knowledge and skills to be learned by students in school (Paris, Lawton, Turner, & Roth, 1991). Alone, the signaling may have limitations without other conditions for student learning and engagement. As Paris et al. (1991) suggested more than 20 years ago,

> The tests are aligned with outdated educational theories which assume that cognition and learning can be decomposed into isolated skills and can be decontextualized from the situations of acquisition and application of those skills. Research during the past 20 years in cognitive, instructional, educational, and developmental psychology has shown that students' learning is more than a collection of discrete skills. The motivation and purpose of the learner, as well as the content and setting of the task, have strong effects on learning. (p. 12)

Our analysis has provided insights into answers to our questions about whether other mathematics focuses in eighth grade besides algebra might, instead, provide students with greater future success in mathematics.

The results of our study also raise questions about the stance educators and policymakers have taken towards the role of policies, like algebra for all, in altering students' success in algebra and the learning conditions in classrooms so students gain the most important knowledge and skills of a subject discipline, like mathematics. In other words, how far can the reach of policy extend in changing positively what and how teachers think about and enact in their classroom curricula in areas like mathematics and how students learn those knowledge and skills? The algebra policy did encourage schools and districts to presumably enroll more students into algebra courses and then take the CST for Algebra I.

However, among the students in our study, the algebra-for-all policy did not appear to have encouraged a more compelling set of classroom and school-wide learning conditions that enhanced student understanding and learning of critical knowledge and skills of algebra, as we have previously discussed. Policy alone, and the rewards and sanctions that often accompany policy requirements, is unable to elicit those kinds of substantial changes in classroom practices for several important reasons. This has been known for some time.

First, as early as 1950, Bailey acknowledged the difficulty of counting on a policy to be interpreted and enacted in the way intended by the maker of policy:

> In a study of policy-making it is not enough that we understand influences external to the policy-maker. Constitutions and statutes, public opinion and pressures, facts and arguments, parties and patronage—these are factors which are important only as they reach and are interpreted and accepted by men's minds and prejudices. Like the action of light on variegated surfaces, external factors are absorbed, refracted, as reflected, according to the peculiar qualities of the minds they reach. (p. 218)

More recently, Spillane, Reiser, and Reimer (2002) further amplified the importance of the minds of the educators that are to be affected by policy by using today's insights from cognitive science—both impediments to and opportunities for advancing greater implementation of policies. They have implicated the mind's schemata, mental models, as useful in considering effective ways to understand the implementation of programs and policies:

> But attention to policy ideas is more complex than attention to a policy initiative. Policy ideas work as levers for change only if policymakers convince implementing agents to think differently about their behavior, prompting them to raise questions about their existing behavior and encouraging them to construct alternative ways of doing business. (p. 421)

This is much more than conveying and transmitting information about the importance of a policy and providing rewards and sanctions for implementing it, like having all students succeed in algebra and perform successfully on a measure like the CST.

Second, the learning sciences have revealed a number of important features of learning that have to be involved if children, youth, and adults are to learn and alter their thoughts and actions in any setting, including schools (Bransford, Brown, & Cocking, 1999). Changing classroom practice involves learning, especially among the educators who support students' learning. Teachers will not change their practices as a result of only being given directions and information about required changes (Richardson, 1996). For example, motivation is critical to undertaking learning (Ryan & Deci, 2000), especially complex thinking and behavior. That is the learner, either student or teacher, has to desire to change and learn, especially if these changes require more than routine alterations in their thoughts and actions. With regard to classroom changes to encourage algebra learning, this means the teachers have to be involved, for example, in the creation of their classroom actions and the ways they think about those actions they are changing to encourage student learning, if policies like algebra for all are to be realized in classrooms (Heckman & Montera, 2009).

With regard to student learning, students also must be engaged by their activities and tasks. Motivation to learn brings about engagement. When attention in classrooms goes to students' prior knowledge, their interests, and meaningful activities and tasks, students are more likely to be engaged (National Research Council and the Institute of Medicine, 2004). If these conditions for learning and motivation are missing or weakly focused on in students' learning experiences with algebra or other higher level mathematics courses, little student learning or motivation will exist. Those missing ingredients certainly could account for the fact that younger students find themselves responding to their schools', teachers', and/or parents' demands and exhortations to take this entry-level high mathematics course, algebra. But as they progress through the grades and become older, if they are not comprehending and sensing their own efficacy with these important concepts and procedures, they will not be likely to persist or succeed in these important areas of mathematics.

Finally, one consideration for promoting the success of algebra involves an examination of learning conditions that exist in schools today and those that have to be established in schools for students to be motivated, engaged, and learning the important knowledge and skills of algebra and other mathematics. Teachers in schools have to also be motivated and focused on determining and creating these learning conditions with other teachers inside of classrooms and schools (Webster-Wright, 2009). Many other conditions outside of school, including the assessment practices that will reveal students' understanding of algebra and other areas of mathematics, will also encourage teacher and student learning. Spillane et al. (2002) summarized the point we are urging here:

> In our scheme, the ideas about changing behavior that implementing agents construct from policy are a function or interaction of (a) the policy signal; (b) the implementing agents' knowledge, beliefs, and experience; and (c) the circumstances in which the local actor attempts to make sense of policy. (p. 420)

Without this scheme, the likely weak effects of a policy like algebra for all are more probable.

It is also important to point out that the CSTs students took and the scores that constitute our data may not reflect the courses students took. The STAR program does not verify school districts' self-reporting of their submitted data. This fact somewhat limits the interpretation of this study. A future study could be focused on following individual students for a longer period of time to track their course taking, test taking, and performance patterns in higher mathematics. As the California Longitudinal Pupil Achievement Data System (CALPADS) begins to be implemented, we may be able to use that system's information on the courses students take, their grades, and CST taking and proficiency patterns in a future study using their matched data sets.

In concluding this study, we acknowledge another limitation. The statistical analyses presented here tell us what has happened relative to student performance in mathematics but cannot answer why the performance patterns emerge as we show them. The myriad of factors that influence a student's success in algebra underscores the complexity of any efforts to require algebra for all eighth graders or others as well as the need for further studies. Such studies may illuminate why certain students are not succeeding and consequently lead to developing viable alternatives that move beyond arguing for more of the same. While policymakers and educators are pushing eighth-grade algebra for all in California, classrooms remain a long way from success for all students in eighth-grade algebra and beyond.

Author Note

The opinions expressed by Jian-Hua Liang are of the author alone and do not reflect opinion or policy of the California Department of Education.

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