



What's Happening

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# Using assessment data to guide math course placement of California middle school students

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## Key findings

Are there effective ways to identify which students will be most likely to succeed in algebra I in grade 8? This study finds that using results from the Mathematics Diagnostic Testing Project's grade 7 test of algebra readiness can improve the probability of selecting students for algebra I in grade 8 who will successfully complete the course. Depending on the assessment and the type of score used, the prediction accuracy of student placement decisions ranges from 69 percent to 78 percent.

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## Summary

Recent studies show that enrolling in algebra I in grade 8 works well for some students but backfires for others. The consequences of misplacement are most pronounced for students with weaknesses in key foundational areas that support algebra readiness, which frequently translates into difficulty reaching proficiency in higher level math in high school (Finkelstein et al., 2012).

One study of California students concludes that placing all grade 8 students in algebra I, regardless of their preparation, sets up many students to fail (Williams et al., 2011). Recent longitudinal analysis of California statewide assessment data suggests that students who do not take algebra I in grade 8 but are successful in general math have a better chance of succeeding in algebra I when they wait until grade 9 (Liang, Heckman, & Abedi, 2012).

Are there effective ways to identify which students will be most likely to succeed (achieve proficiency) in algebra I in grade 8? To answer this question, Regional Educational Laboratory West, in collaboration with the eight members of the Silicon Valley Research Alliance (SVRA) districts, estimated the relationships between two assessments available to the SVRA districts and students' likelihood of achieving proficiency in algebra I. These estimates were then used to determine how well different assessments identified students who were more likely to achieve proficiency in algebra I in grade 8.

Key findings are:

- Many SVRA districts use proficiency on the grade 6 math California Standards Test (CST) as the primary criterion for deciding whether to place students in algebra I in grade 8.
  - Students who score exactly at the proficiency cutpoint in grade 6 have less than a 40 percent chance of achieving proficiency in algebra I.
  - Students who score at least 17 points above the proficiency cutpoint (0.27 standard deviation) in grade 6 have a more than 50 percent chance of achieving proficiency in algebra I.
- Other methods can boost the accuracy of algebra placement decisions in grade 8 to 75 percent or higher:
  - Using the cutpoint on the grade 6 math CST associated with at least a 50 percent chance of algebra I success instead of the cutpoint for proficiency status raises the accuracy of placement decisions from 69 percent to 75 percent.
  - Prediction accuracy reaches 77 percent using student results on a grade 7 test of algebra readiness developed as part of the newly available Mathematics Diagnostic Testing Project (MDTP). Students who achieve mastery in five or more MDTP topics have a 75 percent chance of achieving proficiency in algebra I.
  - Prediction accuracy reaches 78 percent using grade 7 CST scale scores. However, grade 7 scale scores are typically not available until after initial algebra I placements are made.
- Predictions based on grade 7 MDTP results are consistent with those based on the grade 7 math CST more than 80 percent of the time.
- Among students with discrepant predictions on the MDTP test and the CST, algebra I proficiency rates drop from about 78 percent to about 50 percent. In other words, even if students perform well on the grade 7 math CST, if they do not also

perform well on the MDTP test at the end of grade 7, they have no more than a 50–50 chance of achieving proficiency in algebra I. The same is true for students who perform well on the MDTP test but not on the grade 7 math CST.

The findings suggest that the MDTP test makes a valuable contribution to decisions about algebra I placement. The MDTP results are largely consistent with those of the grade 7 math CST, and they are available several months earlier than the CST results, which are often not available until the summer or fall of the grade 8 school year. Moreover, even after controlling for grade 6 math CST performance, these results indicate that the MDTP test identifies a set of measurable skills that predict algebra I proficiency. Practitioners may want to consider using MDTP results to aid in algebra I placement decisions and to identify areas for focused support aimed at helping students succeed in algebra I.

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## Why this study?

Math course placement decisions matter. Identifying students in grades 6 and 7 who are likely to succeed in algebra I in grade 8 can improve the ability of schools and districts to make appropriate placement decisions and provide appropriate instructional supports. In turn, this can help improve student success rates in algebra I.

### The importance of algebra I placement and proficiency rates

Middle school math placement and progression are topics that are part of an active policy and practice discussion in California and elsewhere. Beginning in the 2008/09 school year, California's State Board of Education recommended that students complete algebra I by the end of grade 8. Recent studies show that this strategy works well for some students but backfires for others.

Between 2003 and 2009 the proportion of grade 8 students taking algebra I rose from 32 percent to 54 percent (Williams et al., 2011). This increase resulted in a larger percentage of grade 8 students scoring "proficient" or "advanced" (achieving proficiency) on the algebra I California Standards Test (CST; see box 1 for definitions of key terms used in this report) and in a larger number of grade 8 students scoring "far below basic" or "below basic" on the test (Williams et al., 2011). Williams et al. (2011) conclude that placing all grade 8 students in algebra I, regardless of their preparation, sets up many students to fail.

The consequences of misplacement are most pronounced for students whose weaknesses in key foundational areas that support algebra readiness translate into difficulty reaching proficiency in higher level math in high school (Finkelstein et al., 2012). A 2012 California study based on data for 24 districts found that most students who score proficient or advanced on standardized state tests in algebra I, geometry, and algebra II by grade 10 had participated in an accelerated math track beginning in middle school (Finkelstein et al., 2012). However, that accelerated path is not available to students who do not demonstrate proficiency in grade 7 math. Another recent longitudinal analysis based on statewide assessment data revealed that students who fail the algebra I CST in grade 8 have a greater chance of repeating the course and failing the assessment again in grade 9 than their peers who pass the general math CST in grade 8 and then take algebra I in grade 9 for the first time (Liang et al., 2012).

The discussion of students' preparation for and placement in algebra I is part of a much larger conversation across the United States about the progression of math instruction from early grades through high school. California is one of 45 states that recently adopted the Common Core State Standards in math, which were developed, in part, to address the common criticism that math education in the United States is "a mile wide and an inch deep." The new standards "significantly narrow the scope of content and deepen how time and energy are spent in the math classroom ... so students gain strong foundations; [and the standards] carefully connect the learning within and across grades so that students can build new understanding onto foundations built in previous year" (Cocuzza, 2012). The standards are also intended to increase math proficiency for graduating high school students and to decrease the need for costly remediation in postsecondary education, which often results in a failure to complete the postsecondary degree (Venezia, Bracco, & Nodine, 2010; Complete College America, 2012).

*The discussion of students' preparation for algebra I is part of a much larger conversation across the United States about the progression of math instruction from early grades through high school*

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## Box 1. Definition of terms used in this report

Although some terms may have more general meanings, the following terms are used in this report with these specific definitions.

**Accuracy.** The percentage of students placed in algebra I in grade 8 who, based on their prior assessment scores, meet or exceed the probability cutoff for determining whether a student is predicted to achieve proficiency (score proficient or advanced) on the algebra I California Standards Test (CST) in grade 8 and who actually achieve proficiency. Formally, it is the number of students who are predicted to achieve proficiency on the algebra I CST in grade 8 and actually do so, divided by the total number of students who are predicted to achieve proficiency on the algebra I CST in grade 8. This percentage is also called the “positive predictive value.”

**Algebra ready.** Students who, based on their prior assessment scores, exceed the probability cutoff and who are predicted to achieve proficiency on the algebra I CST in grade 8.

**Algebra success.** Students who actually achieve proficiency on the algebra I CST in grade 8.

**Correct classification.** Whether students’ predicted outcomes (based on a probability cutpoint) from a logistic regression match students’ actual outcomes. In other words, whether students who are predicted to achieve proficiency on the algebra I CST in grade 8 actually do so and whether students who are predicted not to achieve proficiency actually do not.

**CST score.** Student scale scores on the CST content test are classified into one of five levels: far below basic, below basic, basic, proficient, or advanced. Only students scoring at the proficient or advanced level are considered to have achieved proficiency in the content area being tested. Table A7 in appendix A lists the cutpoints for the grade 6 math, grade 7 math, and algebra I CSTs.

**Odds ratio estimate.** The estimated change (increase or decrease) in odds of achieving proficiency on the algebra I CST in grade 8 associated with a unit increase in the predictor variable, as estimated in a logistic regression. An odds ratio of more than 1 indicates that the odds of achieving proficiency increase with a one-unit increase in the predictor variable. An odds ratio of less than 1 indicates that the odds of achieving proficiency decrease with a one-unit increase in the predictor variable. An odds ratio of 1 indicates that the odds of achieving proficiency remain the same with a one-unit increase in the predictor. For example, for a model using grade 6 math CST scale scores as the predictor, an odds ratio estimate of 1.03 means that achieving proficiency on the algebra I CST in grade 8 is 1.03 times as likely for each one-point increase in the grade 6 math CST scale score. That is, the odds increase by 3 percent with each one-point increase in the score.

**Probability cutoff.** The probability cutoff is a threshold probability used to determine whether a student is predicted to achieve proficiency on the algebra I CST in grade 8. The probability ranges from 0 to 1. If the predicted probability is equal to or higher than the cutoff, the student is predicted to achieve proficiency. If the predicted value is lower than the cutoff, the student is predicted not to achieve proficiency. This study applies various probability cutoffs from 0.5 to 0.9, in increments of 0.1.

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As school districts across the country move toward full implementation of the Common Core State Standards in math, districts will be examining course sequencing and the placement of students in existing and new courses. For example, how pre-algebra content is distributed across the years leading up to middle-school algebra will trigger discussions about which students should be following specific content sequences and at what pace. If the Common Core unfolds as envisioned, the result could be more students developing strong foundations in math concepts in the middle school years, leading to greater success in high school and beyond.

### Measures used to guide decisions on math course placement

Increasing the number of students taking and achieving proficiency in algebra I in grade 8 requires identifying students who are ready for algebra. Previous research on how schools and districts in California make placement decisions suggests an increasing reliance on test scores.

The criteria used to determine math placement and the weights assigned to each criterion vary across the country and across school districts. Most districts rely on teacher recommendations and course grades (Bitter & O’Day, 2010), with standardized math test scores, student/parent preferences, and counselor recommendations also factoring into the decision (Hallinan, 2003). “Increasingly, school systems do not use fixed criteria to assign students to particular course levels. Teacher and counselor track-placement recommendations include, in addition to test scores and grades, highly subjective judgments about students’ personalities, behavior and motivation” (Oakes, Muir, & Joseph, 2000, p. 16).

Over the last decade, school districts in California have been using multiple data sources to evaluate student preparation in grades 6 and 7 for algebra I in grade 8 (Williams et al., 2011). These sources include scores on the math CST and on other assessments, as well as students’ grades in previous math courses and teacher recommendations.

Despite the use of multiple measures in California, research suggests that CST scores have begun to figure more prominently in course placement decisions. Teachers report that CST scores and students’ prior academic performance were the most common considerations for placement decisions for grade 7 and grade 8 general math and algebra I courses (Williams et al., 2011). Evidence supports this approach, suggesting that CST scores are effective indicators of likely success in future math courses (Kriegler & Lee, 2006; Anderson & Newell, 2008).

***Despite the use of multiple measures in California to evaluate student preparation in grades 6 and 7 for algebra I in grade 8, research suggests that California Standards Test scores have begun to figure more prominently in course placement decisions and that they are effective indicators of likely success in future math courses***

### What the study examined

Regional Educational Laboratory West, in collaboration with the eight members of the Silicon Valley Research Alliance (SVRA) districts (Santa Clara County, California), looked at whether there are effective ways to identify which students will be most likely to achieve proficiency in algebra I in grade 8. To do that, they first looked at the placement strategies implemented in the SVRA districts and then estimated the relationships between the various assessments employed and students’ chances of achieving proficiency in algebra I. These estimates were then used to determine how well different assessments identified students who were more likely to achieve proficiency.

## Algebra I placement strategies implemented in the Silicon Valley Research Alliance

The participating SVRA districts<sup>1</sup> use multiple criteria for course placement decisions. In particular, feeder school districts to the East Side Union High School District have agreed to place students in algebra I based on the strategies presented in a 2010 memorandum of understanding that supports the use of multiple criteria (including course performance, teacher recommendations, diagnostic tests, and CST performance) and indicates that students who achieve proficiency on the grade 6 or grade 7 math CST should be placed in algebra I in grade 8. Despite the memorandum, there appears to be a great deal of variation within and across the districts in the criteria used for algebra I placement—though many districts continue to emphasize CST performance.

This process is further complicated by the availability of results from new diagnostic assessments of grade 7 students' math performance (and perhaps algebra readiness) before grade 7 math CST results are available. In the past, the SVRA districts relied on students' prior math CST scores in making algebra I placement decisions. In 2010 some SVRA districts began to use the tests developed under the Mathematics Diagnostic Testing Project (MDTP), a joint project of the California State University and University of California higher education systems, to assist with these decisions.

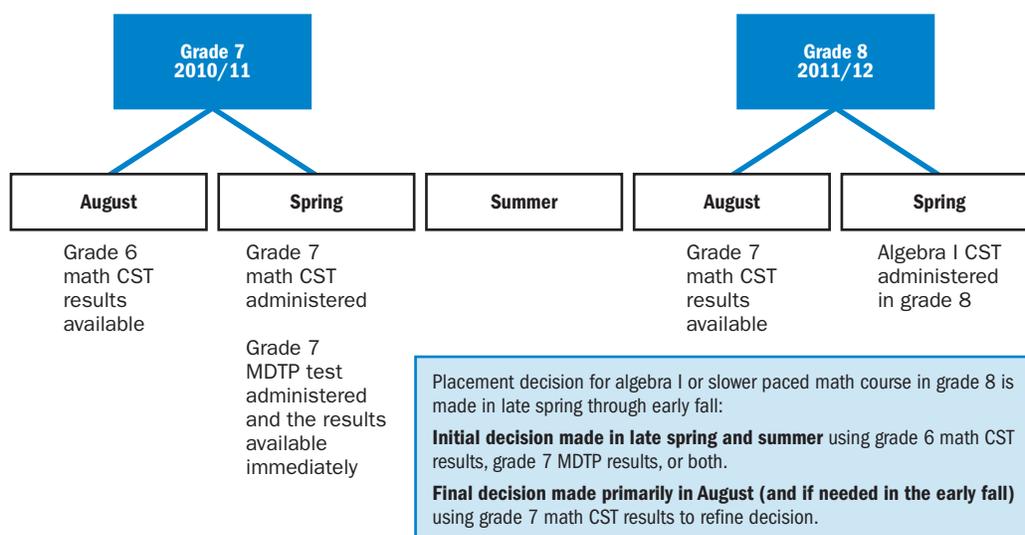
The MDTP offers cognitive diagnostic tests designed to provide students and teachers with information about student readiness for a broad range of math courses. This information can help students identify areas where additional study or review is needed and help teachers identify topics and skills that need more attention in courses. Three types of MDTP results are available: the number of MDTP topics mastered, the level of mastery of each topic, and the topic scores. The MDTP tests can be administered online, and the results are available immediately after completion. CST results, by contrast, are not available until August, and in some years are not available until after the next school year begins. Therefore, some districts are exploring the use of MDTP results to assist with initial placement decisions.

However, exactly which combination of tests would ensure the highest number of accurate placements remains unclear. The SVRA districts are interested in knowing whether and how to incorporate these different assessments into their math placement decisions in grade 8 and how different approaches would affect their students' algebra I proficiency rates in grade 8. To address the districts' interests, this study focuses on the relationships between students' performance on these different assessments and their proficiency on the algebra I CST.

The primary placement challenge is whether to assign students who have completed grade 7 math to a regular algebra I course or to a slower paced algebra/general math course in grade 8.<sup>2</sup> The grade 8 course placement process begins in the spring, as students are completing grade 7 (figure 1). Despite the existence of the memorandum of understanding, the factors applied and how they are incorporated in placement decisions vary. However, while math instructional teams rely on a variety of data, including course grades, teacher recommendations, and other subjective factors, in most cases assessment data factor heavily into the decision.

***The primary placement challenge is whether to assign students who have completed grade 7 math to a regular algebra I course or to a slower paced algebra/general math course in grade 8***

**Figure 1. Timing of math assessments and placements in Silicon Valley Research Alliance districts**



CST is the California Standards Test. MDTP is Mathematics Diagnostic Testing Project.

**Source:** Authors' construction based on information shared by the districts.

Math instructional teams and counselors in the SVRA districts have access to three sources of formal assessments of math performance in making these decisions:

- The grade 6 math CST, administered in the spring, with results generally available in August, around the time students begin grade 7.
- The grade 7 MDTP test (also called the Algebra Readiness test), administered in the spring, a few weeks before the CST administration, with results available immediately.
- The grade 7 math CST, administered in the spring, with results generally available in August, around the time students begin grade 8.

Initial placement decisions, which have to occur before August, are made on the basis of grade 6 math CST scores.<sup>3</sup> If students achieve proficiency on the grade 6 math CST, they are generally placed in algebra I in grade 8. If results are available in time, districts sometimes use grade 7 math CST scores to refine the placement decisions right before the school year begins. In particular, if a student was placed into a class below algebra I but achieves proficiency on the grade 7 math CST, the student may be given an opportunity to enroll in algebra I at the beginning of the year. This process typically occurs after the master schedule has been set and students have received their class schedules. Students sometimes do not learn that they have the opportunity to attend a more advanced math class until they arrive in their initially assigned math class on the first day of school.

### Research questions

This report addresses two broad research questions:

1. What is the relationship between proficiency on the algebra I CST in grade 8 and scores on the grade 6 math CST, the grade 7 MDTP test, and the grade 7 math CST?
2. How can test scores better assist with initial placement decisions?

With MDTP scores now available in the spring of students' grade 7 year, the SVRA districts were interested in learning whether and how to use these data to improve the placement process. Specifically, the districts wanted to understand how well the MDTP test measures students' content knowledge on the grade 7 math concepts that are important for proficiency in algebra I and whether MDTP scores are more accurate than grade 6 math CST scores in placing students in algebra I in grade 8. The districts also wanted to know whether using scores on both the grade 6 math CST and the grade 7 MDTP test might improve placement decisions compared with using scores on either test alone. And, since placement decisions are sometimes revisited once grade 7 CST scores are available, the SVRA districts are interested in whether placement decisions based on scores on the grade 6 math CST and the grade 7 MDTP tests have a different success rate than decisions based on scores on the grade 7 math CST alone.

The study used grade 6 and 7 math CST scores, grade 7 MDTP test scores, and algebra I CST scores for students enrolled in algebra I in grade 8 in the 2011/12 school year in SVRA districts (2,579 students from five districts; see table A1 in appendix A). The study used cross-tabulation and logistic regression analyses to study the association between students' proficiency on the algebra I CST in grade 8 and their prior performance on the grade 6 math CST, grade 7 MDTP test, and grade 7 math CST. In particular, the analysis examined how algebra I proficiency rates in grade 8 varied with grade 6 math CST proficiency (see details of the analysis in appendix A).

Next, the percentage of students achieving proficiency on the algebra I CST in grade 8 was calculated for each grade 6 math CST scale score to identify the grade 6 math CST scale score associated with students having at least a 50 percent probability of achieving proficiency on the algebra I CST in grade 8. The predictive accuracy of this cutpoint score was then compared with that of the CST cutpoint for proficiency status. Logistic regression was used to compare the accuracy of predictions based on different scores, including grade 6 math CST scale scores, grade 7 MDTP scores, and grade 7 math CST scale scores. These results were used to examine the implications of algebra I placement decisions in grade 8 made using different sources of information. Appendix A describes the analysis methods in detail. Appendix B summarizes the logistic regression models used in the study, specifies which predictors were included in each model, and provides information about how each model performed in predicting algebra I success in grade 8.

The evidence presented in this report could help the SVRA districts better understand the indicators that predict algebra I success, refine their placement criteria, streamline their placement process, and increase the number of algebra-ready students placed in algebra I in grade 8. The findings from this study could also inform discussions and further analysis of success indicators and placement criteria for math courses in other districts in California as well as the rest of the nation.

## **Findings**

Study findings are reported on the relationship between algebra I proficiency in grade 8 and scores on the grade 6 math CST, the grade 7 MDTP test, and the grade 7 math CST and on how accurately the different assessments predict proficiency among students placed in algebra I in grade 8.

*The findings from this study could inform discussions and further analysis of success indicators and placement criteria for math courses in California as well as the rest of the nation*

**Placing students in algebra I in grade 8 based on achieving proficiency on the grade 6 math CST results in an accurate placement for 69 percent of students**

Most SVRA districts place students in algebra I in grade 8 if they score at or above the proficiency threshold on the grade 6 math CST. To examine the accuracy, or positive predictive value, of this placement measure, the study calculated the percentage of students who achieved proficiency on the grade 6 math CST who also achieved proficiency on the algebra I CST in grade 8.

Among the 1,451 students who achieved proficiency on the grade 6 math CST, 69 percent (996) also achieved proficiency on the algebra I CST in grade 8 (table 1). The remaining 31 percent (455) of the students identified as algebra ready based on the grade 6 math CST failed to achieve proficiency.

**Using students' grade 6 math CST scale score rather than proficiency status increases the accuracy of algebra I placement decisions in grade 8 from 69 percent to 75 percent**

Moving beyond the simple zero or one indicator of proficiency status (achieving proficiency or not), the study used continuous grade 6 math CST scale scores and a logistic regression (see appendix A) to predict student probability of achieving proficiency on the algebra I CST in grade 8. Each student was assigned a predicted probability based on the grade 6 math CST scores. Students who had a predicted probability of 50 percent or higher were considered algebra ready.

Compared with decisions based on proficiency alone, this approach increased the accuracy of algebra I placement decisions in grade 8 by 6 percentage points, suggesting that it is a more accurate way to predict proficiency on the algebra I CST in grade 8. Some 75 percent of students who had been classified as algebra ready based on their grade 6 math CST scale score achieved proficiency on the algebra I CST in grade 8 (857 of a total of 1,145 students; table 2), compared with 69 percent classified as algebra ready based on their grade 6 math CST proficiency status alone (see table 1).

*Among students who took algebra I in grade 8, 75 percent who had been classified as algebra ready based on their grade 6 math CST scale scores achieved proficiency on the algebra I CST in grade 8, compared with 69 percent classified as algebra ready based on their grade 6 math CST proficiency status alone*

**To have more than a 50 percent chance of achieving proficiency on the algebra I CST in grade 8, students need to score at least 17 points above the proficiency cutpoint on the grade 6 math CST**

A predicted probability of achieving proficiency on the algebra I CST in grade 8 was calculated for each grade 6 math CST score (figure 2). Simply scoring at the proficient level (a scale score of 350) is not enough to give a student a greater than 50 percent chance of achieving proficiency on the algebra I CST in grade 8. Students who scored 350 had

**Table 1. Some 69 percent of students who achieved proficiency on the grade 6 math CST also achieved proficiency on the algebra I CST in grade 8 (percent)**

Status on grade 6 math CST	Status on algebra I CST in grade 8	
	Proficient	Not proficient
Proficient (n = 1,451)	69	31
Not proficient (n = 1,128)	20	80

CST is the California Standards Test.

**Source:** Authors' analysis of primary data collected for the study; see appendix A.

**Table 2. Some 75 percent of students predicted to be proficient on the algebra I CST in grade 8 based on their grade 6 math CST scale score actually achieved proficiency (percent)**

Predicted status on algebra I CST in grade 8 based on grade 6 math CST scale score	Actual status on algebra I CST in grade 8	
	Proficient	Not proficient
Proficient (n = 1,145)	75	25
Not proficient (n = 1,434)	26	74

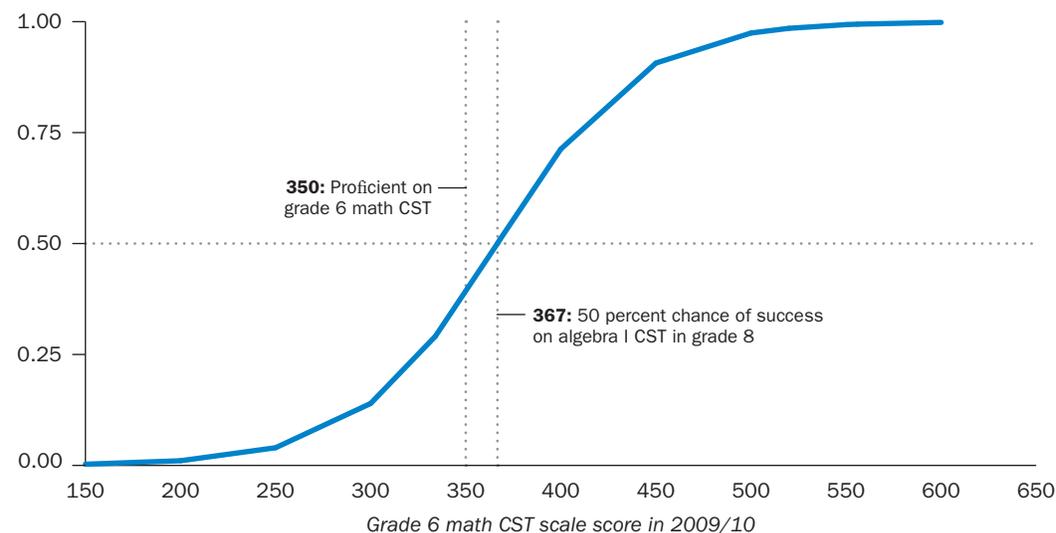
CST is California Standards Test.

**Note:** A probability cutoff of 0.5 was used.

**Source:** Authors' analysis of primary data collected for the study; see appendix A.

**Figure 2. Students who scored at the proficient level on the grade 6 math CST had less than a 40 percent chance of achieving proficiency on the algebra I CST in grade 8**

Predicted probability of proficiency on algebra I CST in grade 8



CST is California Standards Test.

**Source:** Authors' analysis of primary data collected for the study; see appendix A.

only a 39 percent probability of achieving proficiency. Thus, classifying students as algebra ready based on proficiency on the grade 6 CST ends up including some students who have less than a 40 percent chance of achieving proficiency on the algebra I CST in grade 8. Raising the probability to 50 percent required a scale score of 367 or higher on the grade 6 math CST (0.27 standard deviation above the proficiency threshold).

**Depending on the assessment used to predict algebra I proficiency in grade 8, prediction accuracy ranges from 75 percent to 78 percent**

To assess the potential contribution of the MDTP test to accurate placement decisions, several combinations of grade 6 and 7 assessments were used to predict algebra I proficiency in grade 8. The combinations were chosen to assess the options most readily available to the SVRA districts for adding the MDTP test to the placement process, including using

**Table 3. The accuracy of the assessment measures used for predicting proficiency on the algebra I CST in grade 8 ranges from 75 percent to 78 percent (percent)**

Model	Predictor	Accuracy
1	Grade 6 math CST scale score	75
2	Grade 7 MDTP (number of topics mastered)	77
3	Grade 7 MDTP (seven topic scores)	76
4	Grade 6 math CST scale score and grade 7 MDTP (seven topic scores)	77
5	Grade 7 math CST scale score	78

CST is California Standards Test. MDTP is the Mathematics Diagnostic Testing Project.

**Note:** A probability cutoff of 0.5 was used because it typically yields the highest percentage of correctly classified students (see table B2 in appendix B). The accuracy based on other probability cutoffs is reported in table B3 in appendix B.

**Source:** Authors' analysis of primary data collected for the study; see appendix A.

the MDTP test alone, using it in combination with the grade 6 math CST results, and using the MDTP topic scores or using MDTP mastery indicators.

The model including both grade 6 math CST scale score and grade 7 MDTP topic scores (model 4, deemed to be the best-fitting model as shown in table B1 in appendix B) resulted in accurate predictions of success 77 percent of the time, compared with 75 percent accuracy for the model based on grade 6 math CST scale score alone (model 1), 77 percent for the model based on the number of MDTP topics mastered (model 2), 76 percent for the model based on seven MDTP topic scores (model 3), and 78 percent for the model based on grade 7 math CST scale score alone (model 5; table 3). Other than the low success rate of using grade 6 math CST proficiency alone for algebra I placement decisions in grade 8, these findings suggest few differences in assignment decisions and proficiency rates among the other assessment options.

The findings also indicate that relying solely on reports of the number of topics mastered on the grade 7 MDTP, which are available in the spring preceding grade 8 and require no matching of student records across years, results in an accuracy rate that is within a single percentage point of the success rates generated using either the grade 7 math CST or a combination of grade 6 math CST and grade 7 MDTP topic scores.

#### **Using grade 7 math CST scores to fine-tune placement decisions before the beginning of grade 8 does not necessarily result in more accurate placement outcomes**

Schools and districts often revisit spring placement decisions once grade 7 math CST scores are available, generally around August. They use these results to place students who achieve proficiency on the grade 7 math CST in algebra I in grade 8 even if their grade 6 math CST score was not high enough to merit algebra I placement. To examine the potential effects of such a policy, this study compares the consistency of placement decisions based on the data available at the end of grade 7 (grade 6 math CST scale scores and grade 7 MDTP topic scores) with the consistency of placement decisions based on grade 7 math CST scale scores (not available until the summer). To the extent that placement decisions based on the combination of grade 6 CST scale scores or grade 7 MDTP topic scores align with the predictions based on grade 7 CST scale scores, revised placements might be considered unnecessary. To the extent that students placed in algebra I in grade 8 based on the addition of the grade 7 math CST scale scores are less likely to achieve proficiency, using those data might even be contraindicated.

*Other than the low success rate of using grade 6 math CST proficiency alone for algebra I placement decisions in grade 8, the findings suggest few differences in assignment decisions and proficiency rates among the other assessment options*

In general, there is a high degree of overlap in the predictions based on the combination of grade 6 math CST scale scores and grade 7 MDTP topic scores and predictions based on grade 7 math CST scale scores alone. Of students predicted to achieve proficiency in algebra I in grade 8 based on the combination of grade 6 math CST scale score and grade 7 MDTP topic scores, 81 percent (970 of a total of 1,201 students) are also predicted to do so based on their grade 7 math CST scale score alone (table 4). Similarly, 83 percent of the students predicted not to achieve proficiency based on their grade 7 math CST scale score are also predicted not to do so based on the combination of their grade 6 math CST scale score and grade 7 MDTP topic scores.

Further, 52 percent of the students who were predicted not to achieve proficiency on the algebra I CST in grade 8 based on the combination of grade 6 math CST scale score and grade 7 MDTP topic scores but were predicted to do so based on grade 7 math CST scale score alone did achieve proficiency (table 5). Similarly, 51 percent of students who were predicted not to achieve proficiency based on grade 7 math CST scale score but were predicted to do so based on the grade 6 math CST scale score and grade 7 MDTP topic scores did achieve proficiency.

*Relying on grade 7 math CST scale scores in late August or early September to place students in algebra I in grade 8 is unlikely to increase the overall percentage of students achieving proficiency on the algebra I CST in grade 8*

**Table 4. Of students predicted to achieve proficiency in algebra I in grade 8 based on the combination of grade 6 math CST scale score and MDTP topic scores, 81 percent are also predicted to do so based on their grade 7 math CST scale score alone**

Predicted status on algebra I CST in grade 8, based on the combination of grade 6 math CST scale score and grade 7 MDTP topic scores (model 4)	Predicted status on algebra I CST in grade 8 based on grade 7 math CST scale score alone (model 5)	
	Proficient	Not proficient
Proficient (n = 1,201)	81	19
Not proficient (n = 1,378)	17	83

CST is the California Standards Test. MDTP is the Mathematics Diagnostic Testing Project.

**Note:** A probability cutoff of 0.5 was used.

**Source:** Authors' analysis of primary data collected for the study.

**Table 5. Students with discrepant predictions had a 51–52 percent chance of achieving proficiency on the algebra I CST in grade 8**

Prediction	Total number of students with discrepant predictions	Number of these students who achieved proficiency on algebra I CST in grade 8	Percentage who achieved proficiency on algebra I CST in grade 8
Grade 6 math CST scale score and grade 7 math MDTP topic scores = Not proficient Grade 7 math CST = Proficient	230	119	52
Grade 6 math CST scale score and grade 7 math MDTP topic scores = Proficient Grade 7 math CST = Not proficient	231	110	51

CST is the California Standards Test. MDTP is the Mathematics Diagnostic Testing Project.

**Source:** Authors' analysis of primary data collected for the study.

These findings indicate that relying on grade 7 math CST scale scores in late August or early September to place students in algebra I in grade 8 is unlikely to increase the overall percentage of students achieving proficiency on the algebra I CST in grade 8. In fact, the findings suggest that adding students to algebra I courses in this manner (top row of table 5) could lower algebra I proficiency rates, since only 52 percent of students placed in this way would achieve proficiency. The findings also suggest that placing students in non-algebra math classes because grade 7 math CST scale scores were lower than the grade 6 CST scale scores and grade 7 MDTP topic scores (bottom row) could reduce the number of students who enroll in algebra I in grade 8 and achieve proficiency on the algebra I CST in grade 8.

**MDTP scores in five of the seven topics are significant predictors of algebra I proficiency**

Scores on five of the seven MDTP topics are significant predictors of students’ odds of achieving proficiency on the algebra I CST in grade 8, even after controlling for grade 6 CST scale score (table 6). The exceptions are data analysis, probability, and statistics and geometric measurement and coordinate geometry. The estimated odds ratios associated with the five significant topics are all larger than 1, indicating that a one percentage point increase in scores on any of those topics is associated with an increase in the odds of achieving proficiency. For example, holding other predictor scores constant, a one percentage point increase on MDTP topic area 6, integers, is associated with a 26 percent increase in the odds of achieving proficiency on the algebra I CST in grade 8.

*MDTP results could be used to identify individual student needs with respect to several dimensions of skills that are significant predictors of algebra I proficiency in grade 8*

This finding suggests that educators in the SVRA districts could consider emphasizing the skills identified by the five topic tests that are significant predictors of the likelihood of algebra I success in grade 8. The findings also suggest that the MDTP results could be used to identify individual student needs with respect to several dimensions of skills that are significant predictors of algebra I proficiency in grade 8.

**Table 6. When including both grade 6 math CST scale scores and grade 7 MDTP topic scores as predictors, five of the seven MDTP topics were significant predictors of algebra I success in grade 8**

Predictor	Odds ratio	Standard error <sup>a</sup>
Grade 6 math CST scale score	1.02**	0.003
MDTP topic		
1 data analysis, probability, and statistics	1.00	0.062
2 decimals, their operations and applications; percent	1.12**	0.036
3 exponents and square roots; scientific notation	1.22**	0.048
4 fractions and their applications	1.19**	0.094
5 geometric measurement and coordinate geometry	1.02	0.060
6 integers	1.26**	0.035
7 literals and equations	1.18**	0.052

CST is the California Standards Test. MDTP is the Mathematics Diagnostic Testing Project.

\*\*significant at p<.05.

a. Adjusted for taking into account the nested nature of the data (students are nested in districts).

**Source:** Authors’ analysis of primary data collected for the study; see appendix A.

**Table 7. Student proficiency on the algebra I CST in grade 8 is linearly correlated with the number of MDTP topics mastered**

Number of topics mastered on the grade 7 MDTP	Proficient on the algebra I CST in grade 8 (percent)
0	11
1	23
2	35
3	52
4	68
5	75
6	85
7	94

CST is the California Standards Test. MDTP is the Mathematics Diagnostic Testing Project.

**Source:** Authors' analysis of primary data collected for the study.

*Districts might consider using the number of topics students master in the grade 7 MDTP to assist with course placement decisions. MDTP accuracy rates are the same as those generated by the CST*

### Students who master four or more topics on the grade 7 MDTP have a nearly 70 percent or higher chance of achieving proficiency on the algebra I CST in grade 8

In addition to providing continuous measures of skills, the MDTP test indicates whether students have mastered the seven topics it assesses. The findings suggest a strong, positive relationship between proficiency on the algebra I CST in grade 8 and the number of grade 7 MDTP topics students master in grade 7 (table 7). The more MDTP topics students master, the higher the probability they will achieve proficiency on the algebra I CST in grade 8. Students who master three MDTP topics have a 52 percent probability of achieving proficiency. For students who master four topics, the probability rises to 68 percent, and for those who master five, it rises to 75 percent. This suggests that a threshold of mastering four MDTP topics would have a prediction accuracy close to that of grade 6 math CST proficiency and that a threshold of five MDTP topics would perform as well as a regression model based on grade 6 math CST scale scores.

This result reinforces the finding that the MDTP is an effective tool for identifying student progress on a set of specific skills that predict algebra I proficiency in grade 8. SVRA districts might consider using the number of topics students master in the grade 7 MDTP to assist with course placement decisions. MDTP accuracy rates are the same as those generated by the CST.

### What the findings mean

In addition to the questions on the relationship between different assessments and algebra I proficiency in grade 8, the study was motivated by an interest in understanding how test scores can be used to potentially improve algebra I placement decisions.

#### How can test scores better assist with initial placement decisions?

Increasing the number of students who pass algebra I by the end of grade 8 is an important policy objective in California and other states. As the number of students taking algebra I in grade 8 has increased, so has the number of students who fail to achieve proficiency on the algebra I CST in grade 8. The findings of this study have several implications for

policy and practice related to accurately identifying students who are likely to achieve proficiency in algebra I in grade 8.

By itself, proficiency on the grade 6 math CST is not an effective indicator of algebra readiness: Most students who score at the proficient level (a score of 350) do not achieve proficiency on the algebra I CST in grade 8. Students have to score at least 0.27 standard deviation above the proficiency cutpoint to have even a 50 percent probability of achieving proficiency.

This finding suggests that the accuracy of placement decisions could be improved by moving beyond proficiency on the CST and relying instead on CST scale scores to identify students who have at least a 50 percent chance of succeeding in algebra I.

Moving grade 8 students into algebra I based on their grade 7 math CST scale score is unlikely to increase the overall percentage of students who achieve proficiency on the algebra I CST in grade 8. Combining grade 6 math CST scale score and grade 7 MDTP topic scores yields largely the same placement decisions as relying on grade 7 math CST scale score. And in cases when grade 7 math CST scale scores suggest a higher placement than do the combination of grade 6 math CST scale score and MDTP topic scores, the probability of student success in algebra I in grade 8 drops from 78 percent to about 50 percent. The probability also drops to about 50 percent for students who perform well on the grade 6 math CST and grade 7 MDTP test but not on the grade 7 math CST.

***Moving students who perform poorly on the grade 7 math CST into a lower level math class could reduce the number of students who take algebra I in grade 8 but fail to achieve proficiency***

This suggests that even if placing students in algebra I in grade 8 based on grade 7 math CST scale score, after initial placements have been made based on the combination of grade 6 CST scale score and grade 7 MDTP topic scores, increases the number of students enrolled in algebra I in grade 8, it is unlikely to increase the percentage of students who achieve proficiency on the algebra I CST in grade 8. This result also suggests that moving students who perform poorly on the grade 7 math CST into a lower level math class could reduce the number of students who take algebra I in grade 8 but fail to achieve proficiency. So, since revising placements “up” based on grade 7 CST scale scores is unlikely to increase the number of students who achieve proficiency, districts and schools might want to consider revising placements “down” or identifying students for additional support based on their grade 7 math CST scale scores.

### **Implications for education practitioners**

The MDTP test clearly identifies a set of measurable skills that predict algebra I proficiency and thus can make a timely and valuable contribution to algebra I placement and support decisions in grade 8. Education practitioners might consider using MDTP results to identify topics for focused support. For example, SVRA districts could consider placing more emphasis on the skills that these analyses show are strongly related to algebra I proficiency. Districts could also consider providing additional support (such as instruction tailored to specific topics) to students based on the MDTP topics in which they fail to achieve mastery and using mastery on five MDTP topics as an instructional target, because 75 percent of the students who reach this degree of mastery achieve proficiency in algebra I in grade 8. For example, districts could conduct a content analysis of grade 5–7 math courses to determine how closely the content taught is aligned with the MDTP topics that predict algebra I proficiency.

Staff in SVRA districts could consider relying primarily on MDTP results to make algebra I placement decisions in grade 8. The MDTP results are particularly useful for new students from other states who did not take the grade 6 or 7 math CST. MDTP results are as accurate at predicting algebra I proficiency as grade 6 math CST scale score. The MDTP results are readily available without complicated merging of data from the previous academic year, reflect performance in the most recent school year, and provide specific diagnostic information on each student's strengths and weaknesses. Moreover, evidence suggests that revising algebra I placement decisions based on grade 7 math CST scale score does not necessarily increase the percentage of students who are likely to achieve proficiency on the algebra I CST in grade 8.

Because many districts in California administer the optional MDTP tests in addition to the mandatory CSTs, those districts could also benefit from the results of this study.

Finally, understanding the relationships between prior performance on various assessments and future achievement in algebra I in grade 8 can inform course placement decisions during and after the districts' transition to the Common Core State Standards in math. Since the transition in assessment strategies at the state level includes the phasing out of the CSTs, the information provided by the MDTP test will provide districts with a consistent assessment tool for making placement decisions.

The math CSTs and grade 7 MDTP test used in this study may not fully align with the Common Core math standards, but during and after the assessment transitions, school districts can make their placement decisions based on the study findings. In particular, the SVRA districts can use grade 7 MDTP topic scores to determine whether students have mastered specific topics as well as to make algebra I placement decisions in grade 8. In addition, MDTP results could help districts identify needed instructional support consistent with implementation of the algebra I Common Core State Standards. Once enough student assessment data related to the Common Core State Standards are available for secondary analyses, those data along with the revised MDTP results<sup>4</sup> can be used to adapt and revise the current study to assist districts with their placement decisions.

***The MDTP test clearly identifies a set of measurable skills that predict algebra I proficiency and thus can make a timely and valuable contribution to algebra I placement and support decisions in grade 8***

### **Study limitations**

The study was limited to students from the eight SVRA districts. Only the grade 8 cohort for 2011/12 had the data needed for analysis. The study did not examine the proficiency rates of students who were not placed in algebra I in grade 8. Because most of the SVRA districts emphasize use of assessments for placing students in math courses, the study focused on the test data used to assist with placement decisions rather than on other factors, such as course performance and teacher recommendations.

## Appendix A. Detailed study design

This appendix presents detailed information on the study design, including the study sample, data, methods, and limitations.

### Analytic sample

The analytic sample for this study consisted of the students enrolled in algebra I in grade 8 in Silicon Valley Research Alliance (SVRA) districts in the 2011/12 school year and for whom scores were available for all four of the tests of interest: grade 7 Mathematics Diagnostic Testing Project (MDTP), grades 6 and 7 math California Standards Tests (CSTs), and algebra I CST. Students who were enrolled in an individualized education program (141 students) were omitted from the sample because these students may receive a modified curriculum. The analytic sample consisted of 2,579 students (table A1).

### Data sources and key measures

This study relies on two types of assessment data: the grade 7 MDTP assessment and the grades 6–8 CSTs.

**The Mathematics Diagnostic Testing Project assessments.** Eight SVRA districts have started to use MDTP tests, specifically, the Algebra Readiness test for grade 7 students. That test consists of 45 multiple-choice items in seven topics (table A2). For each topic, the MDTP has designated a “critical level,” which is the minimum number of correct responses required for a student to show adequate preparation in that topic.

That information was used to create a set of dichotomous variables indicating whether students have mastered each area. These variables were also used to determine the number of grade 7 MDTP topics that students have mastered.

MDTP provides reports at the class and individual levels.<sup>5</sup> At the class level teachers can use the item-level analysis across students within a class to adjust and improve instruction.

**Table A1. Study sample**

District	Total number of students enrolled in grade 8 (2011/12)	Number of students with all four test scores	Number of students with an individualized education program	Analytic sample	
				Number of students	Percent of total enrollment
Alum Rock	1,273	522	9	513	40
Berryessa	933	370	16	354	38
Franklin-McKinley	956	286	9	277	29
Milpitas	738	0	0	0	0
Mt. Pleasant	291	0	0	0	0
Oak Grove	1,263	572	25	547	43
San Jose	2,394	970	82	888	37
Sunnyvale	593	0	0	0	0
Total	8,441	2,720	141	2,579	31

**Source:** Authors' analysis of enrollment data from <http://www.ed-data.k12.ca.us> (retrieved May 20, 2013).

**Table A2. Number of items by topic, grade 7 MDTP Algebra Readiness test**

Topic	Number of items	Critical level
1 data analysis, probability, and statistics	6	4
2 decimals, their operations and applications; percent	8	6
3 exponents and square roots; scientific notation	4	3
4 fractions and their applications	8	6
5 geometric measurement and coordinate geometry	6	4
6 integers	6	4
7 literals and equations	7	5
Total	45	

MDTP is Mathematics Diagnostic Testing Project.

**Source:** Provided by the MDTP test developer.

Analysis of responses to the sample question in figure A1 shows how item-level analysis can inform teachers about their students' progression in understanding math topics (table A3).

Because only 17 of 98 students (17 percent) answered the question correctly, the question is considered a difficult one. If the distractors (choices that are not the correct answer) consisted of random numbers, there would be no direct way to understand why most students failed to answer the question correctly. If the distractors are designed to reflect some common misconceptions, students' responses could provide information about where and why the difficulty occurred. In this example, choice C (incorrect) was the most popular (selected by 56 of 98 students). This outcome suggests the following:

"...most of the students converted the denominator to  $1/(a - b)$  before inverting and multiplying. It appears that they are still adding fractions by adding denominators instead of first finding a common denominator. Another explanation may be that each term in the denominator was first inverted, giving  $a - b$ , and then the result inverted and multiplied to yield (C). In any case, an analysis of the students' responses to this item would show that a large percentage of students are having difficulty with literal fractions" (MDTP website at <http://mdtp.ucsd.edu/TestResults.shtml>, retrieved May 31, 2012).

**Figure A1. A sample MDTP question**

$$\frac{a - b}{\frac{1}{a} - \frac{1}{b}} =$$

(A)  $-ab$   
(B)  $ab$   
(C)  $(a - b)^2$   
(D)  $a^2 + b^2$   
(E)  $2 - \left(\frac{a}{b}\right) - \left(\frac{b}{a}\right)$

MDTP is Mathematics Diagnostic Testing Project.

**Source:** MDTP website at <http://mdtp.ucsd.edu/TestResults.shtml> (retrieved May 31, 2012).

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**Table A3. Marked-up item-level analysis for the sample MDTP question**

Response	Number of students
A <sup>a</sup>	17
B	4
C	56
D	4
E	13
Omitted	4
Total	98

MDTP is Mathematics Diagnostic Testing Project.

a. Correct answer.

**Source:** Data were made up by the authors.

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Based on this information, the teacher can spend more time helping students find the common denominator for  $(1/a - 1/b)$  and explaining that the subtraction in the denominator needs to be done before the division or multiplication. The teacher could also demonstrate how to do this using numbers instead of letters.

Individual-level reports provide each student's raw score for each topic (figure A2). The critical level for each topic is also included to help teachers determine whether the student has mastered each topic.

The sample individual report in figure A2 indicates that the student mastered two topics and needed improvement on the rest. Teachers can use this information to help place students in appropriate math courses in the subsequent semester and to identify interventions that target the topics students have not yet mastered. These data could be used more effectively for both placement decisions and instructional intervention if teachers and districts had more information on the relationship between algebra I success in grade 8 and mastery of these topics.

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**Figure A2. Sample individual-level report from an MDTP test**

	Your Score	Critical Level	Total Possible
Congratulations! Your results indicate that you have done well in each of the following topics:			
Literals & Equations	3	3	4
Data Analysis, Probability, & Statistics	5	4	6
However, your results indicate you need review in the following topics:			
Integers	5	6	8
Fractions and their Applications	4	5	7
Decimals, their Operations & Applications; Percent	5	6	9
Exponents and Square Roots; Scientific Notation	2	3	4
Your results indicate you need substantial review in the following topics:			
Geometric Measurement and Coordinate Geometry	2	5	7

Your total score is 26 out of 45, which is 58%. We hope you find this information helpful. Please contact your teacher for specific activities and assignments that will aid in any necessary review.

MDTP is Mathematics Diagnostic Testing Project.

**Source:** MDTP website at <http://mdtp.ucsd.edu/pdf/StudentLetter.pdf> (retrieved May 31, 2012).

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*California Standards Tests for math for students in grades 6 and 7 and for algebra I.* As part of California’s accountability system, the math CST is given in the spring to monitor how well schools and students are performing.<sup>6</sup> Tables A4–A6 summarize the topics and the number of items associated with each topic for the grades 6–8 math CSTs.

On each CST student performance is categorized into one of the following levels: far below basic, below basic, basic, proficient, or advanced. Table A7 lists the performance-level cut-points for grade 6 math, grade 7 math, and algebra I CSTs. Only students performing at the proficient or advanced level are considered proficient in the content area being tested.

**Table A4. Topics included in the grade 6 math CST**

California content standard	Number of items	Percent of total
Number sense	25	39
Algebra and functions	19	29
Measurement and geometry	10	15
Statistics, data analysis, and probability	11	17
Mathematical reasoning	Embedded in other content standards	na
<b>Total</b>	<b>65</b>	<b>100</b>

CST is California Standards Test; na is not applicable.

**Source:** <http://www.cde.ca.gov/ta/tg/sr/technicalrpts.asp> (retrieved May 31, 2012).

**Table A5. Topics included in the grade 7 math CST**

California content standard	Number of items	Percent of total
Number sense	22	34
Algebra and functions	25	38
Measurement and geometry	13	20
Statistics, data analysis, and probability	5	8
Mathematical reasoning	Embedded in other content standards	na
<b>Total</b>	<b>65</b>	<b>100</b>

CST is California Standards Test; na is not applicable.

**Source:** <http://www.cde.ca.gov/ta/tg/sr/technicalrpts.asp> (retrieved May 31, 2012).

**Table A6. Topics included in the algebra I CST**

California content standard	Number of items	Percent of total
Number properties, operations, and linear equations	17	26
Graphing and systems of linear equations	14	22
Quadratics and polynomials	21	32
Functions and rational expressions	13	20
<b>Total</b>	<b>65</b>	<b>100</b>

CST is California Standards Test.

**Source:** <http://www.cde.ca.gov/ta/tg/sr/technicalrpts.asp> (retrieved May 31, 2012).

**Table A7. Performance-level cutpoints for grade 6 math, grade 7 math, and algebra I CSTs**

CST	Below basic	Basic	Proficient	Advanced
Grade 6 math	253	300	350	415
Grade 7 math	257	300	350	414
Algebra I	253	300	350	428

CST is California Standards Test.

**Note:** Performance-level cutpoints remain the same from year to year.

**Source:** California Department of Education, 2011.

**CST and MDTP content areas.** The CSTs are summative assessments with a focus on students' overall performance. The MDTP tests are diagnostic assessments, intended to guide efforts to improve student learning and teacher instructional practices. Depending on need, the MDTP tests can be administered before, during, or at the end of a semester. In general, the grade 7 MDTP test is given in the spring of grade 7 and used to assess student mastery of topics necessary for proficiency in algebra I. Despite the fundamental difference in test design and purpose, some of the topics covered in the grade 7 CST and MDTP test overlap (table A8). The approaches to reporting student performance differ in the two tests: The CST focuses on students' overall performance, whereas the MDTP reports student learning by topic.

### Research questions

This section describes the analytic strategies used to answer the following research questions:

- To what extent did grade 6 math CST scores predict student proficiency on the algebra I CST in grade 8?
- To what extent did grade 7 MDTP performance predict student proficiency on the algebra I CST in grade 8?

**Table A8. Topics assessed: grade 7 math CST and grade 7 MDTP test**

Topics/contents standards	CST	MDTP
Number sense	✓	
Algebra and functions	✓	
Measurement and geometry <sup>a</sup>	✓	✓
Statistics, data analysis, and probability <sup>a</sup>	✓	✓
Mathematical reasoning	✓	
Decimals, their operations and applications; percent		✓
Simple equations and operations with literal symbols		✓
Exponents and square roots; scientific notation		✓
Fractions and their applications		✓
Graphical representation		✓
Integers, their operations and applications		✓

CST is California Standards Test; MDTP is Mathematics Diagnostic Testing Project.

**a.** A formal alignment study would be required to verify whether the CST and MDTP cover the same content standards in the topic.

**Source:** Authors' analysis of primary data collected for the study.

- How accurately did the combination of grade 6 math CST scale scores and grade 7 MDTP topic scores predict proficiency on the algebra I CST in grade 8? How did this compare with the use of grade 7 math CST scale scores alone?
- How consistent were predictions based on grade 6 math CST scale scores and grade 7 MDTP test with predictions based on the grade 7 math CST scale scores alone?

### Analysis methods

**Research question 1.** To examine the relationship between grade 6 math CST scores and proficiency on the algebra I CST in grade 8, the analysis focused on two subquestions.

- 1a.** Were students who achieved proficiency on the grade 6 math CST in 2009/10 also likely to achieve proficiency on the algebra I CST in grade 8 in 2011/12?

The research team produced a two-by-two cross-tabulation of proficiency on these two assessments (proficient or not proficient on the grade 6 math CST by proficient or not proficient on the algebra I CST in grade 8).

- 1b.** To what extent did the grade 6 math CST scale score predict student proficiency on the algebra I CST in grade 8?
- How were differences in grade 6 math CST scale scores associated with differences in the probability of achieving proficiency on the algebra I CST in grade 8?
  - What scale score would yield a 0.5 or higher probability of achieving proficiency on the algebra I CST in grade 8?
  - How accurately did grade 6 math CST scale scores predict proficiency on the algebra I CST in grade 8?

The research team used a logistic regression to estimate the relationship between grade 6 math CST scale scores (the predictor) and a binary outcome of proficiency on the algebra I CST in grade 8.

The model takes the following form:

$$\Pr(\text{Proficiency} = 1) = \text{logit}^{-1}(\beta_0 + \beta_1 \text{CST}_{ij} + \zeta_{0j} + \varepsilon_{ij}),$$

where  $\text{CST}_{ij}$  is the grade 6 math CST scale score of student  $i$  in school district  $j$ .  $\beta_0$  and  $\beta_1$  are parameters estimated from the data presented as odds ratios, which identify how the odds of achieving proficiency on the algebra I CST in grade 8 change with a one-unit change in the independent variable. For example,  $\beta_1$  indicates how the odds of achieving proficiency on the algebra I CST in grade 8 vary with a one-unit change in the grade 6 math CST scale score.  $\zeta_{0j}$  is a district random effect, where  $\zeta_{1j} \sim N(0, \nu_1)$ , and  $\varepsilon_{ij}$  represents the residual error term where  $\varepsilon_{ijk} \sim N(0, \theta)$ . The logit function was used because the dependent variable is binary. This model is described more fully by Rabe-Hesketh and Skrondal (2012).<sup>7</sup>

The resulting estimates were used to plot the relationship between grade 6 math CST scale scores and the predicted probability of achieving proficiency on the algebra I CST in grade 8. This analysis addressed the subquestion on the association between differences in scale score and differences in the probability of proficiency and the subquestion on which scale score is associated with a 0.5 or higher probability of proficiency.

To assess how accurately grade 6 math CST scale scores predict proficiency on the algebra I CST in grade 8, the research team generated a cross-tabulation comparing predicted and actual proficiency outcomes using a 0.5 predicted probability as the cutoff for predicted success. Other probability cutoffs between 0.5 and 1.0 were also used for predicting success, to examine how changing the threshold for predicting proficiency affects the accuracy of the prediction (see tables B2 and B3 in appendix B).

**Research question 2.** To examine the relationship between grade 7 MDTP results and proficiency on the algebra I CST in grade 8, three analyses were conducted based on three types of MDTP results: the number of MDTP topics mastered, the level of mastery of each topic, and the topic scores.

- 2a.** What was the relationship between the number of topics mastered on the grade 7 MDTP test and proficiency on the algebra I CST in grade 8?
- Were students who mastered more topics more likely to achieve proficiency on the algebra I CST in grade 8?
  - If so, what was the minimum number of topics students needed to master on the grade 7 MDTP test to have a 0.5 or higher probability of achieving proficiency on the algebra I CST in grade 8?
  - How accurate was the prediction of proficiency based on the number of MDTP topics students mastered?

The grade 7 MDTP test provides information on student mastery of seven topics. The research team produced a two-by-two cross-tabulation of the number of grade 7 MDTP topics mastered and proficiency on the algebra I CST in grade 8 (number of topics mastered on the grade 7 MDTP by proficient or not proficient on the algebra I CST in grade 8).

The research team also analyzed the relationship between mastery of each MDTP topic and proficiency on the algebra I CST in grade 8, using a logit model.

- 2b.** What was the relationship between mastery of particular topics on the grade 7 MDTP test and proficiency on the algebra I CST in grade 8?
- How were differences in mastery of each topic associated with differences in the probability of proficiency on the algebra I CST in grade 8?
  - How accurately did a set of indicators of mastery of each topic predict proficiency on the algebra I CST in grade 8?

The logit model takes the following form:

$$\Pr(\text{Proficiency} = 1) = \text{logit}^{-1}(\beta_0 + \sum \beta_n T_{nij} + \zeta_{0j} + \varepsilon_{ij}),$$

where  $T_{nij}$  is a dichotomous indicator for whether student  $i$  in school district  $j$  achieved mastery of MDTP topic area  $n$  and  $\beta_n$  is the estimated difference in the odds of achieving proficiency on the algebra I CST in grade 8 associated with mastery of MDTP topic  $n$  (compared with nonmastery of that topic), with mastery of all other topics held constant.

Once again, these estimates were used to assess how accurately the number of topics mastered on the grade 7 MDTP topics predicts proficiency on the algebra I CST in grade 8, generating a cross-tabulation comparing predicted and actual proficiency. A 0.5 predicted

probability was used as the initial cutoff for predicted proficiency. Various probability cutoffs between 0.5 and 1.0 were also used for predicting proficiency to examine how changing the threshold for predicting proficiency affects the accuracy of the prediction (see tables B2 and B3 in appendix B).

The final analysis for research question 2 focused on the association between topic scores on the grade 7 MDTP test and proficiency on the algebra I CST in grade 8.

- 2c.** To what extent did the grade 7 MDTP topic scores predict proficiency on the algebra I CST in grade 8?
- How were differences in grade 7 MDTP topic scores associated with differences in the probability of achieving proficiency on the algebra I CST in grade 8?
  - How accurately did grade 7 MDTP topic scores predict proficiency on the algebra I CST in grade 8?

This analysis is similar to the analysis for research question 1b, except that the predictors were the continuous raw scores for the seven topics on the grade 7 MDTP test instead of the CST math scale scores. The model takes the following form:

$$\Pr(\text{Proficiency} = 1) = \text{logit}^{-1}(\beta_0 + \sum \beta_n R_{nij} + \zeta_{0j} + \varepsilon_{ij}),$$

where  $R_{nij}$  is a continuous measure of the raw score on topic area  $n$  for student  $i$  in school district  $j$  and  $\beta_n$  is the estimated difference in the odds of achieving proficiency on the algebra I CST in grade 8 associated with a one-unit change in the raw score for MDTP topic  $n$ , with the scores on all other MDTP topics held constant.

The research team assessed how accurately this model predicts proficiency on the algebra I CST in grade 8 using tabulations of actual proficiency rates among students with different predicted probabilities of achieving proficiency based on their MDTP scores.

**Research question 3.** This question examined the use of a combination of grade 6 math CST scale scores and grade 7 MDTP topic scores to predict proficiency on the algebra I CST in grade 8 and examined the use of grade 7 math CST scale scores alone to predict proficiency:

- 3a.** How accurately did a combination of grade 6 math CST scale scores and grade 7 MDTP topic scores predict proficiency on the algebra I CST in grade 8?

This analysis shed light on whether using grade 6 math CST scores and grade 7 MDTP topic scores together might improve algebra I placement decisions in grade 8. The research team estimated a logit model that used both grade 6 math CST scale scores and scores for each of the seven topics on the grade 7 MDTP test to predict proficiency on the algebra I CST in grade 8.

The model takes the following form:

$$\Pr(\text{Proficiency} = 1) = \text{logit}^{-1}(\beta_0 + \sum \beta_n R_{nij} + \beta_9 \text{CST}_{ij} + \zeta_{0j} + \varepsilon_{ij}),$$

where  $R_{nij}$  is a continuous measure of the raw score on topic  $n$  for student  $i$  in school district  $j$ .  $\beta_n$  is the estimated difference in the odds of achieving proficiency on the algebra I

CST in grade 8 associated with a one-unit change in the raw score for MDTP topic  $n$ , holding grade 6 math CST scale score and scores on all other MDTP topics constant.  $\beta_9$  is the difference in the odds of achieving proficiency on the algebra I CST in grade 8 associated with a one-unit change in the grade 6 math CST scale score, holding the scores on all other MDTP topics constant.

Model fit statistics (Tabachnick & Fidell, 2007) were used to examine whether this model provided a better fit to the data than either the model using grade 6 math CST scale scores alone (used in addressing research question 1b) or the model using the topic scores of the grade 7 MDTP test alone (used in addressing research question 2c). Actual grade 8 proficiency rates among students were cross-tabulated with different predicted probabilities of achieving proficiency based on this model. The coefficients, standard errors, and statistical significance tests associated with this model were also calculated.

- 3b. How accurately did the model based on grade 7 math CST scale scores alone predict proficiency on the algebra I CST in grade 8?

To address this question, the research team estimated a logit model using grade 7 math CST scale scores to predict proficiency on the algebra I CST in grade 8. This model is identical to the model used to answer research question 1b, except that it uses grade 7 math CST scale scores in place of grade 6 math CST scale scores. To assess the accuracy of predictions based on this model, actual proficiency rates were cross-tabulated with different predicted probabilities of achieving proficiency based on this model.

**Research question 4.** To shed light on the potential effects of reassigning students to algebra I in grade 8 based on their grade 7 math CST scale score, this research question compares the consistency of predictions based on the combination of grade 6 math CST scale score and grade 7 MDTP topic scores with predictions based on grade 7 math CST scale score alone.

4. To what extent were initial placement decisions based on the grade 6 math CST and the grade 7 MDTP test consistent with decisions based on the grade 7 math CST alone?

If using a combination of grade 6 math CST scale scores and grade 7 MDTP topic scores results in placement decisions that are similar to those based on grade 7 math CST scale scores alone, there would be no need to revisit spring placement decisions after grade 7 math CST scale scores become available.

To examine this question, the research team created a two-by-two cross-tabulation comparing predicted proficiency on the algebra I CST in grade 8 (assuming a threshold of 0.5 probability or higher) based on the model including a combination of grade 6 math CST scale scores and grade 7 MDTP topic scores and the model including the predicted proficiency based on grade 7 math CST scale scores alone.

Finally, the research team also examined proficiency rates on the algebra I CST in grade 8 among students who had discrepant predicted proficiency outcomes based on each model.

### Limitations of the study design, data, and analyses

First, the study sample was limited to the students from eight SVRA districts. Therefore, the findings might not be generalizable to students and districts outside the SVRA.

Second, only the 2011/12 student cohort in grade 8 could be used in this study since this was the only cohort for which all the necessary data were available. SVRA districts started to use the MDTP tests districtwide only in 2011.

This study does not provide evidence on the consequences of placing students who fall below certain passing thresholds into nonalgebra classes. Nor does it examine the course passing rates and academic trajectory of students who were not placed in algebra I in grade 8 because data are not available on what math courses students who scored below the placement threshold for algebra I took instead.

Finally, this study focused on the test data used to assist with algebra I placement decisions in grade 8 because most of the SVRA district placement policies emphasize the use of assessment data for that purpose. Other criteria, such as end-of-course grades or teacher recommendations, could be considered in a future study. The challenge of using such criteria is that the standards for assigning course grades and making recommendations may not be consistent across schools and districts.

## Appendix B. Model comparisons

This appendix summarizes the models used in the study, specifies which predictors were included in each model, and provides the resulting degrees of freedom along with the model fit statistics used to compare models (table B1). Three commonly used model fit statistics are reported: log likelihood function, Akaike information criterion, and Bayesian information criterion.

The log likelihood function is typically used to compare two nested models where there is at least one common predictor between models and one model is more complex than the other (includes additional predictors). For example, model 1 (in which the grade 6 math California Standards Test [CST] scale score is the predictor) is nested in model 4 (in which the grade 6 math CST scale score and grade 7 Mathematics Diagnostic Testing Project [MDTP] topic scores are the predictors). The Akaike information criterion and the Bayesian information criterion can be used to compare either nested or non-nested models. Because not all models in this study are nested in one another, these statistics were used to determine which model better fits the data. A model with a smaller Akaike information criterion and Bayesian information criterion is preferred.

Because model 4 has the lowest values for these two statistics, it fits the data better than other models, although the difference between this model and model 5 is small.

Another indication that model 4 outperforms the other models is that model 4 correctly classifies a slightly higher percentage of students (table B2).

The accuracy of the model by various probability cutoffs is presented in table B3. Across various probability cutoffs, all models being compared appear to perform equally well in terms of accuracy.

**Table B1. A model including the grade 6 math CST scale score and grade 7 MDTP topic scores (model 4) fits the data better than other models used in the study**

Model	Predictor	Log likelihood	Degrees of freedom <sup>a</sup>	Akaike information criterion	Bayesian information criterion
1	Grade 6 math CST scale score	-1,302.34	2	2,608.68	2,620.39
2	Grade 7 MDTP (mastery of seven topics)	-1,316.74	4	2,641.48	2,664.90
3	Grade 7 MDTP (seven topic scores)	-1,247.39	4	2,502.77	2,526.19
4	Grade 6 math CST scale score and grade 7 MDTP (seven topic scores)	-1,180.48	4	2,368.96	2,392.38
5	Grade 7 math CST scale score	-1,195.14	2	2,394.29	2,406.00

CST is California Standards Test; MDTP is Mathematics Diagnostic Testing Project.

a. Adjusted taking into account the nested nature of the data (students nested in districts).

**Source:** Authors' analysis of primary data collected for the study.

**Table B2. Across various probability cutoffs, the percentage of students correctly classified is the highest in a model including grade 6 math CST scale scores and grade 7 MDTP topic scores (model 4)**

Model	Predictor	Probability cutoff				
		0.5	0.6	0.7	0.8	0.9
1	Grade 6 math CST scale score	74	74	71	67	61
2	Grade 7 MDTP (number of topics mastered)	76	74	72	68	62
3	Grade 7 MDTP (seven topic scores)	77	77	75	69	61
4	Grade 6 math CST scale score and grade 7 MDTP (seven topic scores)	78	77	76	71	65
5	Grade 7 math CST scale score	78	77	73	70	64

CST is California Standards Test; MDTP is Mathematics Diagnostic Testing Project.

**Source:** Authors' analysis of primary data collected for the study.

**Table B3. All models being compared performed equally well in terms of model accuracy**

Model	Predictor	Probability cutoff				
		0.5	0.6	0.7	0.8	0.9
1	Grade 6 math CST scale score	75	80	85	92	97
2	Grade 7 MDTP (number of topics mastered)	77	81	84	88	93
3	Grade 7 MDTP (seven topic scores)	76	81	86	90	94
4	Grade 6 math CST scale score and grade 7 MDTP (seven topic scores)	77	81	87	90	97
5	Grade 7 math CST scale score	78	83	84	92	96

CST is California Standards Test; MDTP is Mathematics Diagnostic Testing Project.

**Source:** Authors' analysis of primary data collected for the study.

## Notes

1. They are Alum Rock K–8 School District, Berryessa Union Elementary School District, Franklin-McKinley Elementary School District, Milpitas Unified School District, Mt. Pleasant Elementary School District, Oak Grove School District, San Jose Unified School District, and Sunnyvale School District. The first five school districts are among seven feeder school districts (the other two districts are Evergreen and Orchard) to East Side Union High School District.
2. Students who are placed in a regular algebra course are expected to take the algebra I CST at the end of grade 8; students who are placed into a slower paced algebra course typically take the general math CST, which assesses achievement of California standards in grades 6 and 7.
3. Along with teacher recommendations, grades, and the other criteria applied across the districts.
4. According to the developer’s website (<http://mdtp.ucsd.edu>, retrieved September 5, 2013), the MDTP is currently field-testing new readiness test forms for the following CCSS courses: grade 7 math, grade 8 math, and algebra I.
5. A sample report can be downloaded from <http://mdtp.ucsd.edu/TestResults.shtml>.
6. Detailed test blueprints can be found on the California Department of Education website (<http://www.cde.ca.gov/ta/tg/sr/blueprints.asp>).
7. Because the student–school relationship was not clearly identified in the longitudinal data received from the participating districts, the research team used district identifiers (instead of school identifiers) to take into account the nested nature of the data (students nested in districts).

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