Making an Impact

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# The effects of the Elevate Math summer program on math achievement and algebra readiness

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## Key findings

Can summer math programs improve math achievement and readiness for algebra content? This randomized controlled trial, conducted in collaboration with the Silicon Valley Research Alliance, shows that a 19-day summer math intervention for students entering grade 8 improved their scores on the Mathematics Diagnostic Testing Project's Algebra Readiness test by 4 points (0.7 standard deviation) and increased estimated algebra readiness rates from 12 percent to 29 percent. The program did not significantly improve students' interest in math or their sense of competence in math.

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## Summary

Success in middle school math is a key predictor of students' success in high school and beyond—and is therefore an important issue for policy and practice in California and throughout the country. Middle school math coursetaking and success have clear consequences for the extent to which students reach advanced math courses—such as precalculus, calculus, trigonometry, or Advanced Placement math—before graduating from high school. Completing these advanced math courses can predict how well students are prepared for postsecondary-level math and whether they will be able to participate and succeed in regular college math courses without remediation or participation in developmental math courses.

Mastering algebra is a critical step to enabling students to succeed in a college preparatory math sequence. But many students are unprepared to succeed in algebra, and they fail the course the first time they take it (Balfanz, McPartland, & Shaw, 2002; Finkelstein, Fong, Tiffany-Morales, Shields, & Huang, 2012; Huang, Snipes, & Finkelstein, 2014). The consequences of failing algebra can be considerable: only one in five students who fail algebra in grade 8 and repeat it in grade 9 achieves proficiency by the end of grade 9 (Finkelstein et al., 2012). Students not achieving algebra proficiency by the end of grade 9 have little chance of reaching and succeeding in advanced college preparatory math courses by the end of high school (Schiller & Muller, 2003; Spielhagen, 2006; Schiller, Schmidt, Muller, & Houang, 2010).

To raise math success rates in middle school, many schools and districts have implemented summer math programs designed to improve student preparation for algebra content in grade 8. However, little is known about the effectiveness of these programs. While students who participate typically experience learning gains, there is little rigorous evidence evaluating the effects of the programs on math achievement or readiness for algebra content. This study fills that void by rigorously examining the effects of one such summer program on student achievement.

Elevate Math is a math support program designed by the Silicon Valley Education Foundation as part of its ongoing effort to help students succeed in middle school math and to master important math and science skills that are needed to succeed in college and the labor market. Though the program is a year-round effort, its core is an intensive 75-hour (19 days over four weeks) summer preparatory course. In summer 2014 the foundation, Regional Educational Laboratory West, and several Silicon Valley school districts collaborated on a randomized controlled trial to assess the effects of the Elevate Math summer program on math achievement, algebra readiness, and attitudes toward math. Students were randomly assigned to a treatment group that received access to the program at the beginning of the summer or to a control group that received access to the program later in the summer. End-of-program test scores and survey responses of students in the treatment group were compared with those of students in the control group prior to their exposure to the program.

The two main findings were:

- The Elevate Math summer program significantly improved math achievement and algebra readiness. Compared with students in the control group, students in the treatment group scored significantly higher (4 points, or 0.7 standard deviation) on

a test of algebra readiness. Students in the treatment group were also significantly more likely (29 percent versus 12 percent) to reach achievement thresholds associated with success in algebra I.

- Despite significant positive effects from the program, most students were still not ready for algebra I content. On average, students in the treatment group still answered most items incorrectly on a test of algebra readiness (scoring 21 out of a possible 45). And only 29 percent of students in the treatment group reached an achievement level that would predict a better than 50 percent chance of succeeding in an algebra I course.

These findings suggest that the Elevate Math summer program improves student math achievement and mitigates some summer learning loss. The program's substantial effect on students' math achievement appears to be driven both by achievement gains over the course of the program and by avoiding a decrease in achievement due to inactivity and a lack of participation in math instruction over the summer. This suggests that programs such as the Elevate Math summer program can be effective in preparing students for grade 8 math content. But the fact that on average participants still answered nearly half the test items incorrectly suggests that most targeted students will need more support than the Elevate Math summer program provides in order to ensure success in algebra.

Nevertheless, math achievement can be improved and algebra readiness rates can be more than doubled over the course of a relatively short period of time. Based on this result, an important question is whether additional support during the school year or greater amounts of instruction during the summer might further help students reach the levels of preparation required to succeed in grade 8 math.

# Contents

## Why this study?

Over the last decade there has been a dramatic increase in the proportion of students enrolled in algebra I. This enrollment rise has been due mostly to an interest in having students complete key courses like algebra I early enough that they can take advanced courses such as precalculus, calculus, trigonometry, or Advanced Placement math before graduating from high school.

### Importance of learning algebra in grade 8

Math courses in U.S. high schools are generally organized in a hierarchical sequence (Riegle-Crumb, 2006; Riegle-Crumb & Grodsky, 2010). Research has documented that differences in ability to meet course prerequisites are among the major sources of disparities in students' math progress (Schiller et al., 2010). The sequential nature of math means that the timing of key prerequisites (for example, some courses must be taken early in middle school) has clear consequences for how far students can progress in the subject during high school (Schiller & Muller, 2003; Spielhagen, 2006). Many students who finish middle school are not prepared to succeed in a rigorous sequence of college-preparatory math courses in high school (Balfanz et al., 2002). Students who do not take algebra I or geometry early enough will have little chance of reaching advanced math courses by grade 12.

***While the dramatic increase in algebra I enrollment in grade 8 has resulted in greater percentages of grade 8 students scoring proficient or advanced on the Algebra I California Standards Test, it has also led to larger numbers of grade 8 students scoring far below basic or below basic***

For over a decade accountability policies in California increased the pressure for schools and districts to ensure that as many students as possible pass algebra I by the end of grade 8 (Williams, Haertel, & Kirst, 2011; Finkelstein et al., 2012). Until recently, schools were penalized on their Academic Performance Index calculation by one performance level each time a grade 8 student took the General Mathematics California Standards Test (CST) instead of the Algebra I CST. For instance, if a grade 8 student scored proficient on the General Mathematics CST, a school would get credit for a score of basic in the calculation of its Academic Performance Index (California Department of Education, 2011, pp. 38–39).

### The challenge of succeeding in algebra I in grade 8

While the dramatic increase in algebra I enrollment in grade 8 has resulted in greater percentages of grade 8 students scoring proficient or advanced on the Algebra I CST, it has also led to larger numbers of grade 8 students scoring far below basic or below basic (Williams et al., 2011).

The consequences of failing algebra I can be considerable. Success in advanced math courses in high school predicts postsecondary success and careers in science, technology, engineering, and math (Adelman, 1999). There is also a close connection between success in middle school academic experiences and subsequent performance in high school (see, for example, Oakes, Gamoran, & Page, 1992; Stevenson, Schiller, & Schneider, 1994; Wang & Goldschmidt, 2003). In particular, only one in five students who fail algebra I in grade 8 and repeat it in grade 9 achieves proficiency by the end of grade 9 (Finkelstein et al., 2012). And only 16 percent of students that receive a C or below in algebra I in grade 8 enroll in geometry in grade 9 (Finkelstein et al., 2012). In short, few students recover from failing algebra I, and failing the subject in grade 8 or 9 disrupts their progress, substantially reducing the likelihood that they will enroll and succeed in the higher level courses required for college success.

A central objective of the Common Core State Standards, in which California participates, is to greatly increase math proficiency among students graduating high school in order to greatly decrease the need for remediation in postsecondary education. Changes resulting from the standards mean that for many California districts algebra I courses have been replaced with integrated math courses that include algebra and other content. Key questions will be how to ensure that students are prepared for algebra content and how to maximize the proportion of students who pass middle school math courses that include algebra content the first time students take them.

The desire to increase the number of students succeeding in algebra has led schools and districts to implement summer programs for students at risk of failing. In the past three years the San Diego Unified School District has enrolled at-risk students who will start algebra I in the fall into Pre-Algebra Upgrade, a learning module, for summer school (Learning Upgrade, 2012). In 2013 Virginia Beach City Public Schools offered two summer programs to strengthen students' pre-algebra skills and help them gain confidence for algebra I: Algebra Readiness Academy for rising grade 9 students and Alge-Prep program for rising grade 7 and 8 students (Virginia Beach City Public Schools, 2014). In Silicon Valley several districts participated in Stepping Up to Algebra (a precursor to the Elevate Math summer program that is the subject of this study), which was designed to improve student preparation and success in algebra I.

***Some evidence from nonexperimental comparison group studies indicates that students who participate in summer math programs experience gains in math achievement, but there is little rigorous experimental evidence assessing the programs' effects on math achievement or success in subsequent algebra I courses***

Little is known about the effects of these programs. Some evidence from nonexperimental comparison group studies indicates that students who participate experience gains in math achievement, but there is little rigorous experimental evidence assessing the programs' effects on math achievement or success in subsequent algebra I courses.

### The Elevate Math summer program

Elevate Math is an intervention program that helps incoming grade 8 students succeed in algebra and related content that aligns with the Common Core State Standards in math (see box 1 for more details about the program). Designed by the Silicon Valley Education Foundation as part of its ongoing effort to help students master important math and science skills needed to succeed in college and career, the program is a year-round effort that includes support for math performance. The core of the program is an intensive 75-hour (19 days over four weeks) summer preparatory course taught by a certified teacher, along with support from a college-educated teaching assistant (see figure 1 for the logic model underlying the Elevate Math summer program). In 2012/13 more than 800 students in 18 districts in Santa Clara County, California, participated in the Elevate Math summer program.

The Silicon Valley Education Foundation works with participating school districts to identify grade 7 students from each district who, based on their prior CST scores, may need additional support to succeed in grade 8 math. The foundation then reaches out to these students and their parents (through parent information events, emails, and teachers and counselors) to explain the program and its benefits and encourage students to participate.

Elevate Math targets grade 7 students who scored at the high basic level or the low proficient level on the grade 6 math CST.[1] In the past, students with these scores were placed into algebra I in grade 8,[2] but they were unlikely to succeed (that is, to score at or above

### Box 1. About the Elevate Math summer program

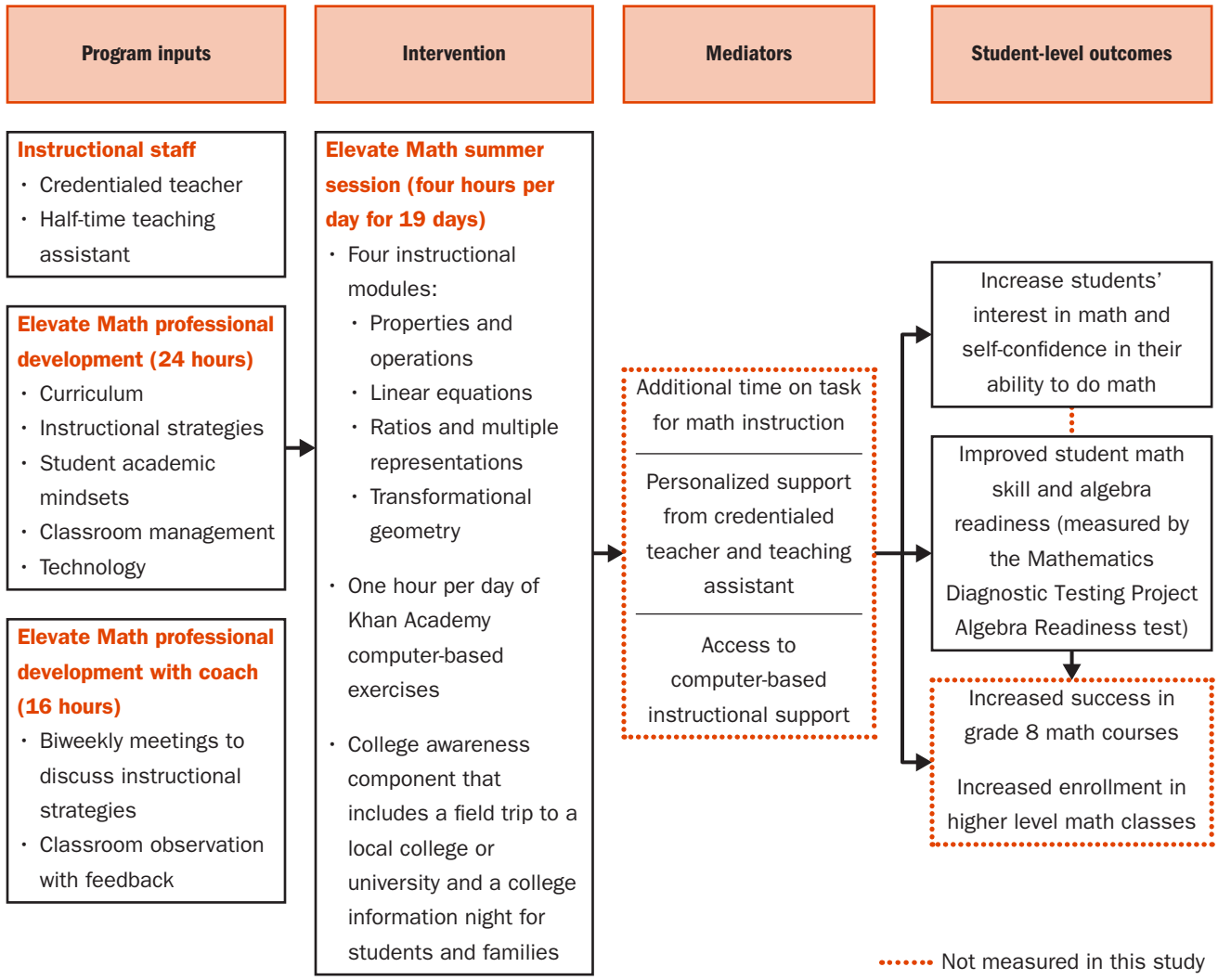
The Elevate Math summer program consists of four main components:

- A Common Core State Standards–based curriculum that covers four math content modules: properties and operations, linear equations, ratios and multiple representations, and transformational geometry.
- Approximately 19 days of four hours of blended learning classroom instruction, with one hour each day spent on Khan Academy (a free online learning system with thousands of educational resources). Each Khan Academy session includes a set of computer-based exercises that reflect the topics covered in the classroom that day. Students also have access to Khan Academy web-based videos to review any math topics covered during their class time.
- A field trip to a local college or university, as well as a college information night for families and students to encourage college awareness. During the study period, most students (74 percent) attended the college field trip.
- Credentialed teachers and their college-level teacher assistants receive 40 hours of Common Core State Standards–based professional development provided by the Santa Clara County Office of Education and the Krause Center for Innovation. The first 24 hours (which occur prior to the summer instruction) include training on curriculum understanding and implementation, instructional strategies aligned with the standards, math practices, technology integration in the classroom, and student engagement. The next 16 hours (which occur over the summer after instruction has begun) are spent in a professional learning community setting, where a coach facilitates the meeting to provide a better understanding of specific Common Core State Standards instructional strategies and math practices that are useful to teach the Elevate Math curriculum.

The Silicon Valley Education Foundation partners with other nonprofits and works closely with 18 school districts and the Santa Clara County Office of Education to offer Elevate Math, which consists of the Elevate Math summer program as well as year-round math supports. Technology-based firms in the area also provide resources to the foundation to support these student programs. According to estimates from the foundation, the Elevate Math summer program costs $500 per student (based on an average class size of 30); this estimate includes the costs of a credentialed teacher, a college-level teaching assistant, a college field trip, and Common Core State Standards–based curriculum and professional development for teachers and the college-level teacher assistants. Schools provide the classroom and a site principal. In addition to these costs, laptop computers are provided to every student through a donation from Dell Wyse. See http://svefoundation.org/programs/elevate-math for more information on Elevate Math.

proficient on the Algebra I CST in grade 8) without additional support: in 2013 only 50 percent of students who took algebra I in grade 8 scored at the proficient level (California Department of Education, 2013). Silicon Valley students who scored at the low proficient level on the grade 6 math CST had a 50 percent chance or less of succeeding in algebra I in grade 8 (Huang et al., 2014). Students had a 50 percent chance or less of succeeding in algebra I in grade 8 unless they scored at least 17 points (.27 standard deviation) above the threshold for proficiency on the grade 6 math CST (Huang et al., 2014). With the changes in courses associated with the Common Core State Standards, students who score at the high basic or low proficient level are now likely to be placed into Common Core math 8 courses, which integrate algebra and other topics. Some have argued that math 8 courses contain more advanced content than existing algebra I courses in grade 8.

**Figure 1. Elevate Math summer program logic model**




**Source:** Authors' compilation.

To the extent that the math 8 courses contain content similar to and at least as challenging as that in algebra I courses, students scoring at the high basic or low proficient level may be unlikely to succeed in the new math 8 courses without additional support.

In addition to prior preparation, student success in grade 8 math may be affected by summer learning loss. Summer learning loss in math has been well documented. Previous studies have shown that students experience summer learning loss, that it is more pronounced for math than for reading, and that it is more pronounced among lower income students (Cooper, Nye, Charlton, Lindsay, & Greathouse, 1996). Summer enrichment programs can ameliorate summer learning loss (Chaplin & Capizzano, 2006). In general, previous research indicates that the majority of rising grade 8 students do not participate in summer school (U.S. Department of Education, National Center for Education Statistics, 1999; Terzian, Anderson, & Hamilton, 2009). To fill all available slots in the Elevate Math summer program, the Silicon Valley Education Foundation has had to continue recruitment efforts through the first day of the summer program. Thus, the study team hypothesized that the Elevate Math summer program serves students who would otherwise be unlikely to continue

formal study in math over the summer. This is substantiated by survey data indicating that 87 percent of students randomly assigned to a control group that did not have access to the Elevate Math summer program for the first half of the summer did not participate in other summer learning while waiting for their four-week Elevate Math summer program session to begin. As these students are typically not participating in math academic enrichment, they are susceptible to summer learning loss during the first four weeks of the summer.

The summer program provides these students a bridge into the beginning of the fall semester of grade 8. A key question then is whether the Elevate Math summer program and others like it can improve student math achievement and algebra readiness over the summer before grade 8. This report presents the results of a randomized controlled trial that addresses this question.

## What the study examined

*This report presents the results of a randomized controlled trial that addresses whether the Elevate Math summer program and others like it can improve student math achievement and algebra readiness over the summer before grade 8*

Though previous research on the Elevate Math summer program has found positive pre- and post-program gains in math proficiency, as well as positive attitudinal changes toward math, the Elevate Math summer program has not been subjected to a rigorous test of its effects on math achievement, algebra readiness, or student attitudes toward and engagement in math learning. Without comparing a set of Elevate Math summer participants and a set of equivalent students who did not take part in the program, it is difficult to ascertain whether the gains are indeed caused by the Elevate Math summer program. Thus the Silicon Valley Research Alliance and Regional Educational Laboratory (REL) West collaborated to mount this rigorous randomized controlled trial to answer three research questions:

1. What is the impact of the Elevate Math summer program on the math achievement and algebra readiness of rising grade 8 students?

2. What is the impact of the Elevate Math summer program on math achievement in the math topic areas most closely aligned with the program's curriculum?

3. What is the impact of the Elevate Math summer program on the math interest and math self-efficacy of rising grade 8 students?

See box 2 for a summary of the data and methodology used in the study and appendix A for more details.

To contextualize the analysis of program effects, REL West also assessed the implementation of the Elevate Math summer program. The assessment focused on five program components: students' attendance at the summer program, student participation in the college field trip, instructional time spent on Khan Academy, teachers' attendance at professional development sessions, and teachers' completion of each module of the program curriculum. The goal of the analysis was to assess the extent to which the core program components were implemented as designed, so that readers can assess whether the evaluation presents a fair test of the program.

The findings of this study will help the Silicon Valley Education Foundation refine its Elevate Math summer program to better serve participating districts and their students as

## Box 2. Data, outcomes, and methodology

### Data

The randomized controlled trial was conducted in summer 2014 at eight schools in six districts in California's Silicon Valley (the Morgan Hill Unified School District and five of the seven feeder districts to East Side Union High School in San Jose). Participating districts identified eligible students based on existing grade 6 California Standards Test (CST) data. Though the Elevate Math summer program targeted students who scored at the high basic level or the low proficient level on the grade 6 math CST, all 496 grade 7 applicants from participating districts were accepted, regardless of prior math skills. More than half of participating students fell into the target range for the intervention based on their grade 6 math CST scores (see table).

**Grade 6 math California Standards Test performance levels of study participants**

| | Far below basic (scale score of 150–252) | Below basic (scale score of 253–299) | Basic | | Proficient | | Advanced (scale score of 415–600) | Unknown |
|---|---|---|---|---|---|---|---|---|
| | | | Low (scale score of 300–324) | High (scale score of 325–349) | Low (scale score of 350–360) | High (scale score of 361–414) | | |
| Percent | 0.84 | 8.60 | 19.92 | 34.80 | 17.82 | 14.05 | 2.52 | 1.47 |
| Number ($n$ = 477) | 4 | 41 | 95 | 166 | 85 | 67 | 12 | 7 |

**Note:** Percentages may not sum to 100 because of rounding.

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

### Outcomes

The study examines the Elevate Math summer program's effects on three sets of outcomes: math achievement and algebra readiness, achievement in specific math topic areas that appear to be aligned with the Elevate Math summer program's curriculum, and math interest and math self-efficacy.

Math achievement was measured using the Mathematics Diagnostic Testing Project (MDTP) Algebra Readiness test, which was administered to the treatment and control groups on the first and last days of their participation in the summer program. The test consists of 45 multiple-choice items in seven topic areas (see table A6 in appendix A). Previous research has shown that this test is highly predictive of success in algebra I in grade 8 (that is, scoring proficient or higher on the Algebra I CST in grade 8) and that grade 7 students had to pass three or more MDTP topic areas to have a greater than 50 percent chance of success in algebra I in grade 8 (Huang et al., 2014). Therefore, for this study, math achievement was defined as the MDTP Algebra Readiness total score, and algebra readiness was defined according to whether students passed three or more MDTP topic areas.

Of the seven topic areas assessed by the MDTP Algebra Readiness Test, the three that most closely aligned with the Elevate Math summer program's curriculum were decimals, their operations and applications, and percent; literals and equations; and geometric measurement and coordinate geometry.

Math interest and math self-efficacy were assessed using measures drawn primarily from a student perception survey developed by Gilbert (2008) and administered by the Silicon Valley Education Foundation as part of its previous and ongoing program monitoring efforts. The math interest scale consisted of five items related to students' interest in math (for example, how exciting math is to the students, how much the students like doing math). Each item

*(continued)*

**Box 2. Data, outcomes, and methodology** *(continued)*

asked students to rate their responses on a five-interval scale ranging from 1 (not at all true for me) to 5 (very true for me), with the midpoint (3) indicating somewhat true for me. The math self-efficacy scale consisted of seven items related to students' confidence in their ability to do math. For example, one item asks, "Even if a new topic in math is hard, how confident are you that you can learn it?" The response options are on a scale from 1 (not at all confident) to 5 (very confident), with the midpoint (3) indicating somewhat confident.

#### Methodology

Participating students were randomly assigned either to a treatment group that was scheduled to enroll during Elevate Math's first four-week summer session or to a control group that did not enroll in the first four-week session but was allowed to enroll in the second four-week summer session. Random assignment was conducted separately for students in each program site. Control group outcomes at the beginning of the second session are valid estimates of the outcomes that would have been observed among students in the treatment group, had they not had access to the program.

Baseline equivalence was assessed by comparing performance on the grade 6 math CST between the treatment and control groups. Program effects were calculated by comparing treatment group outcomes at the end of the first summer session to control group outcomes at the beginning of the second summer session. Program effects were estimated using a single-level regression model comparing average outcomes in the treatment and control groups. The regression model controlled for grade 6 CST scores in order to improve the precision of the estimates and adjust for any differences in pre-program achievement. Research questions 1 and 3 were the primary confirmatory research questions, and the estimates used to address them were adjusted for multiple comparisons using the Benjamini-Hochberg (1995) approach. The analysis provided in response to research question 2 is considered exploratory, and the associated statistical tests are considered less definitive, so tests for statistical significance for these research questions were not adjusted for multiple comparisons. The estimated program effects represent a combination of two factors: the learning gains experienced by the treatment group during the program and the learning loss experienced by the control group during the first part of the summer.

Appendix A provides more detail regarding the analytic models used to estimate program effects, as well as information regarding the extent of student attrition and the characteristics of students in the final analytic sample.

well as districts and students that participate in future years. The findings will also inform the efforts of other local education agencies, state education agencies, and private stakeholders who are considering strategies for improving middle school students' math achievement and algebra readiness. Moreover, this study serves as an example of how school districts and educational support providers can collaborate to conduct rigorous evaluations of educational interventions in the course of their normal operations.

## What the study found

This section presents the study's findings of the Elevate Math summer program's effects on three sets of outcomes: math achievement and algebra readiness, achievement in specific math topic areas, and math interest and math self-efficacy. Information on program implementation, which may help contextualize these findings, is in box 3.

### Box 3. Implementation analysis

To contextualize the estimated program effects, the study assessed the extent to which the Elevate Math summer program components were implemented according to the basic program design. The assessment focused on five program components: students' attendance of the summer program, student participation in the college field trip, instructional time spent on Khan Academy, teachers' attendance at professional development sessions, and teachers' completion of each module of the program curriculum.

The Silicon Valley Education Foundation collected attendance records and records of instruction and professional development and administered a weekly teacher checklist and a student survey on the last day of the summer program. The weekly teacher checklist included items on curriculum and time spent on Khan Academy. The student survey included topics such as math interest, math self-efficacy, and different program components (including the college field trip).

Prior to the study launch, the study team, in consultation with the Silicon Valley Education Foundation, set thresholds for full implementation. The team defined "full implementation" as 80 percent of students attending 80 percent of instruction, 80 percent of students participating in the college field trip, at least 30 minutes of Khan Academy instruction per day, 80 percent of teachers attending 80 percent of the professional development, and teachers covering at least 80 percent of each of the four modules.

Daily attendance data collected by the Silicon Valley Education Foundation indicate that 83 percent of students in the treatment group (196 out of 239) attended at least 15 of the 19 days of instruction and spent an average of 48 minutes on Khan Academy per day. Of the 159 students in the treatment group who responded to the student survey, 74 percent reported attending the college field trip. Eight of the ten teachers (80 percent) attended 80 percent of the professional development. And 5 of the 10 teachers (50 percent) responded to the weekly teacher checklist and covered 100 percent of the first three modules—which included properties and operations, linear equations, and ratios and multiple representations—and over half the transformational geometry module.

***The Elevate Math summer program increased the percentage of students who passed at least three MDTP Algebra Readiness topic areas from 12 percent in the control group to 29 percent in the treatment group***

## The Elevate Math summer program significantly improved math achievement and algebra readiness among participating grade 7 students

The Elevate Math summer program improved the math achievement of the treatment group compared with the control group across several metrics (table 1). The treatment group's performance on the grade 7 MDTP Algebra Readiness test exceeded that of the control group. Out of 45 possible points, the average MDTP score for the treatment group was 21 points, compared with 17 points for the control group. This statistically significant difference of 4 points is the equivalent of 0.7 standard deviation.

The Elevate Math summer program also had a positive, statistically significant effect on algebra readiness, as measured by whether students mastered at least three of seven MDTP topic areas. The program increased the percentage of students who passed at least three MDTP Algebra Readiness topic areas from 12 percent in the control group to 29 percent in the treatment group (see table 1). This 17 percentage point difference is statistically significant and amounts to an improvement of 42 percent, compared to the control group (17 minus 12, then divided by 12).

**Table 1. The Elevate Math summer program had a positive effect on grade 7 students' Mathematics Diagnostic Testing Project Algebra Readiness test scores**

| Outcome measure | Adjusted mean: Treatment group (standard deviation) | Adjusted mean: Control group (standard deviation) | Difference (standard error[a]) | *p*-value (adjusted *p*-value[b]) | Effect size[c] | Unweighted student sample size |
|---|---|---|---|---|---|---|
| Mathematics Diagnostic Testing Project Algebra Readiness test total scale score (points) | 20.81 (6.63) | 16.80 (5.92) | 4.01*** (0.56) | <.001 (<.001) | 0.68 | 349 |
| Algebra readiness[d] (percent passing at least three of seven topic areas) | 29 (46) | 12 (32) | 17*** (4) | <.001 (<.001) | 0.53 | 349 |

*** Significantly different from zero at the .001 level, two-tailed test.

**Note:** A regression model with a dichotomous indicator for treatment status was used to estimate average differences between the treatment and control group outcomes. The model included prior achievement, as measured by grade 6 math California Standards Test scores, and dichotomous indicators representing each school site. The missing-indicator method (White & Thompson, 2005) was used to account for missing values on the grade 6 math CST.

**a.** Estimated using the Huber-White procedure (Greene, 2003).

**b.** Calculated using the Benjamini-Hochberg (1995) procedure.

**c.** Calculated by dividing impact estimates by the control group standard deviation of the outcome variable.

**d.** Because the outcome is dichotomous, a logistic regression analysis was also conducted to assess the findings' sensitivity to specification (see table B2 in appendix B).

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

The Elevate Math summer program also showed positive effects on the specific topics the program targeted: decimals, their operations and applications, and percent; literals and equations; and geometric measurement and coordinate geometry (table 2).

**Table 2. The Elevate Math summer program had positive effects on grade 7 student achievement in three topic areas of the Mathematics Diagnostic Testing Project Algebra Readiness test**

| Topic area of the Mathematics Diagnostic Testing Project Algebra Readiness test | Adjusted mean: Treatment group (standard deviation) | Adjusted mean: Control group (standard deviation) | Difference (standard error[a]) | *p*-value[b] | 95 percent confidence interval | Effect size[c] | Unweighted student sample size |
|---|---|---|---|---|---|---|---|
| Decimals, their operations and applications, and percent score (points) | 3.91 (1.70) | 3.05 (1.69) | 0.86*** (0.17) | <.001 | 0.52 to 1.20 | 0.51 | 349 |
| Literals and equations score (points) | 3.65 (1.51) | 3.13 (1.49) | 0.52*** (0.14) | <.001 | 0.23 to 0.80 | 0.35 | 349 |
| Geometric measurement and coordinate geometry score (points) | 2.50 (1.44) | 1.90 (1.29) | 0.59*** (0.14) | <.001 | 0.32 to 0.87 | 0.46 | 349 |

*** Significantly different from zero at the .001 level, two-tailed test.

**Note:** A regression model with a dichotomous indicator for treatment status was used to estimate average differences between the treatment and control group outcomes. The model included prior achievement, as measured by grade 6 California Standards Test math scores, and dichotomous indicators representing each school site. The missing-indicator method (White & Thompson, 2005) was used to account for missing values on the grade 6 math CST.

**a.** Estimated using the Huber-White procedure (Greene, 2003).

**b.** Not adjusted to account for multiple hypothesis tests because the estimates were part of the exploratory impacts.

**c.** Calculated by dividing impact estimates by the control group standard deviation of the outcome variable.

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

### Math scores at the end of the Elevate Math summer program suggested that most students were still not ready for algebra I content

Despite the Elevate Math summer program's effects, students' math achievement at the end of the program suggested that many students were still not ready for the algebra content in grade 8 math courses. The treatment group's math achievement, as measured by the MDTP Algebra Readiness test, exceeded that of the control group. At the end of the program, the average student in the treatment group correctly answered 21 out of 45 items (or 47 percent), and most students in the treatment group (nearly 70 percent) had not reached achievement benchmarks associated with having a 50 percent or better chance of passing algebra I in grade 8 (that is, achieving mastery in three out of seven MDTP Algebra Readiness topic areas; see table 1).

These findings suggest that, while the Elevate Math summer program had a positive effect on student achievement and readiness for algebra content, participating students will most likely need more support to succeed in grade 8 math courses with algebra content.

***While the Elevate Math summer program had a positive effect on student achievement and readiness for algebra content, participating students will most likely need more support to succeed in grade 8 math courses with algebra content***

### More than a third of the estimated program effect on Mathematics Diagnostic Testing Project Algebra Readiness scores can be attributed to summer learning loss among the control group

Because students in the treatment group began the Elevate Math summer program earlier in the summer than students in the control group, comparing the two groups' performance on a baseline test on their first day of class amounts to a randomized controlled trial of the effects of summer learning loss. Because students were randomly assigned to the two groups, the baseline scores of the control group represent an experimental estimate of what the baseline scores of the treatment group would have been at that same point in the summer, had the students in the treatment group delayed beginning the summer program for approximately four weeks.

The delay in starting the summer program resulted in a significant reduction in math achievement. In particular, the treatment group, assessed in the beginning of the summer, had an average MDTP Algebra Readiness test score of 18.28, while the control group, assessed approximately four weeks later, had an average score of 16.81, 1.47 points lower than the treatment group (these estimates control for differences in grade 6 math CST scores between the two groups; table 3). This is approximately 37 percent of the total effect of the Elevate Math summer program on MTDP scores. This suggests that, without the program the students targeted for the Elevate Math summer program would experience deterioration in math performance over the first part of the summer. It also suggests that approximately 37 percent of the effect of the Elevate Math summer program can be attributed to avoiding summer learning loss among the treatment group.

### The estimated level of interest in math for the treatment group was higher than that of the control group, but the difference was not statistically significant; there was no evidence of positive effects on math self-efficacy

In addition to improving math achievement and preparation for algebra, the Elevate Math summer program aims to increase students' interest in math and to improve their sense of competence in the subject. The findings on the effectiveness of these efforts are mixed and inconclusive.

**Table 3. Baseline scores on the Mathematics Diagnostic Testing Project Algebra Readiness test were about 1.5 points lower for grade 7 students in the control group than for students in the treatment group**

| Outcome measure | Adjusted mean: Treatment group (standard deviation) | Adjusted mean: Control group (standard deviation) | Difference (standard error[a]) | *p*-value | Effect size[b] | Unweighted student sample size |
|---|---|---|---|---|---|---|
| Mathematics Diagnostic Testing Project Algebra Readiness test total scale score (points) | 18.28 (6.62) | 16.81 (5.92) | 1.47* (0.59) | 0.013 | 0.25 | 342 |

* Significantly different from zero at the .05 level, two-tailed test.

**Note:** A regression model with a dichotomous indicator for treatment status was used to estimate average differences between the treatment and control group outcomes. The model included prior achievement, as measured by grade 6 California Standards Test math scores, and dichotomous indicators representing each school site. The missing-indicator method (White & Thompson, 2005) was used to account for missing values on the grade 6 math CST.

**a.** Estimated using the Huber-White procedure (Greene, 2003).

**b.** Calculated by dividing impact estimates by the control group standard deviation of the outcome variable.

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

Level of math interest, measured on a five-point scale (1, low, to 5, high) using an online survey, averaged 2.83 for students in the treatment group and 2.63 for students in the control group (table 4). The difference is equivalent to approximately 0.2 standard deviation and is not statistically significant at the .05 level.

With respect to students' sense of math self-efficacy, the estimated difference between students in the treatment and control groups is closer to zero (approximately 0.03 standard deviation) and is not statistically significant at the .05 level (see table 4).

**Table 4. The Elevate Math summer program's effect on grade 7 students' math interest and math self-efficacy was not statistically significant**

| Outcome measure (1, low, to 5, high) | Adjusted mean: Treatment group (standard deviation) | Adjusted mean: Control group (standard deviation) | Difference (standard error[a]) | *p*-value (adjusted *p*-value[b]) | Effect size[c] | Unweighted student sample size |
|---|---|---|---|---|---|---|
| Math interest | 2.83 (1.12) | 2.63 (1.12) | 0.20 (0.12) | 0.10 (0.20) | 0.18 | 329 |
| Math self-efficacy | 3.21 (0.90) | 3.19 (0.86) | 0.02 (0.09) | 0.80 (0.80) | 0.03 | 329 |

**Note:** A regression model with a dichotomous indicator for treatment status was used to estimate average differences between the treatment and control group outcomes. The model included prior achievement, as measured by grade 6 California Standards Test math scores, and dichotomous indicators representing each school site. The missing-indicator method (White & Thompson, 2005) was used to account for missing values on the grade 6 math CST.

**a.** Estimated using the Huber-White procedure (Greene, 2003).

**b.** Calculated using the Benjamini-Hochberg (1995) procedure.

**c.** Calculated by dividing impact estimates by the control group standard deviation of the outcome variable.

**Source:** Authors' analysis of survey data collected by the Silicon Valley Education Foundation for the study; see appendix A for details.

## Implications of the study findings

This study affirms that the Elevate Math summer program improves math skills for students as they approach grade 8. The findings show that the program significantly improves math achievement as measured by the MDTP total scale score and that it significantly improves the percentage of students that can be classified as "algebra ready." The findings also show that the Elevate Math summer program works both by increasing students' math skills and by helping students avoid summer learning loss through the first half of the summer. In fact, 37 percent of the program effect is due to the avoidance of summer learning loss among the treatment group. Unfortunately, the design of the study does not allow for examining whether the positive effects persist into the fall or beyond. By contrast, the findings suggest that the Elevate Math summer program has no effect on students' sense of efficacy in math or their interest in the subject.

The achievement effects of the Elevate Math summer program are larger than the impact estimates from other evaluations. The score differences between the treatment and control groups amounted to 4 points, or 0.7 standard deviation. Compared with evidence from a large meta-analysis of randomized controlled trials in education, the effect of the Elevate Math summer program appears to be twice as large as the typical (median) effect found among middle school education interventions (Lipsey et al., 2012, p. 34).

One concern in interpreting the effect is that it may be easier to improve on diagnostic tests than on norm-referenced or criterion-referenced state tests. Therefore, to get a sense for how the effect might translate into changes on the types of tests more typically used for accountability purposes, the study team examined the correlation between the MDTP Algebra Readiness test and the grade 7 math CST in a sample of students from districts in the Silicon Valley.[3] For the control group the average MDTP score translates into a CST score of 326, 1 point above the threshold for high basic. For the treatment group the average MDTP score translates into a CST score of 349, 1 point below the threshold for proficiency. This is equivalent to moving students from the 22nd to the 37th percentile in the distribution of the grade 7 math CST scores among students in the Silicon Valley.

***While student achievement is significantly better among students who participated in the Elevate Math summer program than among students who did not, it is still below typical achievement for students in the surrounding districts***

While student achievement is significantly better among students who participated in the Elevate Math summer program than among students who did not, it is still below typical achievement for students in the surrounding districts. Moreover, the average performance of students who participated in the program suggests that most students would not be prepared to succeed in algebra I. On average, students in the treatment group failed to correctly answer most items on the MDTP assessment. In addition, 70 percent of students in the treatment group did not meet the criteria for algebra readiness at the end of the program. Huang et al. (2014) suggest that students have to score at least 0.3 standard deviation above proficiency to have better than 50–50 chance of succeeding in algebra I in grade 8. The fact that the treatment group reached a point equivalent to 1 point below proficiency suggests that, while the Elevate Math summer program had a meaningful effect on student math skills, more improvement would be necessary before students are prepared for the higher level math content they will face in grade 8 and beyond. To be fully prepared for math courses in grade 8 and beyond, students targeted for the Elevate Math program need to combine summer supports with other, longer term, supports for accelerating their progress in math.

This pattern of findings suggests that summer programs such as Elevate Math may be important tools for improving math achievement among students entering grade 8 but that they are not sufficient by themselves for ensuring that students are ready for challenging middle school math courses. For students in the high basic to low proficient range (who were targeted for the intervention) and other students who are motivated to participate, the evidence presented in this report indicates that participating in the Elevate Math summer program would likely improve their math skills. At the same time, students like those in this study, 82 percent of whom scored in the low proficient category or below on the grade 6 math CST, would likely not be sufficiently prepared for algebra and would need additional support to succeed. This evaluation assessed the effects of the Elevate Math summer program only, so further research is recommended to examine the effects of the additional year-round math support provided as part of Elevate Math.

Furthermore, though the implementation of Common Core State Standards is creating changes in course sequences and content, to the extent that the courses students take in grade 8 still contain substantial algebra content, the pattern of findings described here may apply to the new Common Core–aligned courses. The underlying ambition for many students who participate in Elevate Math (and their parents) is to reach a level of math proficiency that enables them to take a high school course sequence that includes calculus in their senior year. The findings of this study suggest that some students emerging from the Elevate Math summer program will do well in grade 8 courses with substantial algebra content. This in turn bodes well for their success in an accelerated math sequence that includes calculus. For the students who still struggle with math achievement after the Elevate Math summer program, it may make sense to design a course pathway that enables ongoing support for these students while maintaining a clear view of the entire high school math sequence.

***Summer programs such as Elevate Math may be important tools for improving math achievement among students entering grade 8, but they are not sufficient by themselves for ensuring that students are ready for challenging middle school math courses***

## Limitations of the study

This study has five main limitations.

First, the study sample is limited to students from the participating Silicon Valley Research Alliance districts. Therefore, the findings may be generalizable only to students and districts that are similar to the study sample.

Second, given the change in curriculum and the lack of existing evidence connecting the MDTP Algebra Readiness test to achievement on the (yet to be implemented) Common Core math assessments, it is unclear whether a positive effect on MDTP achievement will translate into positive effects on achievement in Common Core grade 8 math courses.

Third, student attrition from the analytic sample does not appear to have occurred at random (see appendix A). Students with lower grade 6 CST scores were more likely to be absent from the final analytic sample, and this pattern may have been more pronounced in the control group than in the treatment group. Though the differences are not significant, the baseline grade 6 CST scores in the treatment group were somewhat higher than those in the control group. While the analysis controlled for these differences, the possibility that unmeasured differences could have affected these estimates remains. In addition to the fact that attrition was nonrandom, it occurred for about 27 percent of the sample. To the extent that those who left the sample were different from those who remained, the

generalizability of the findings from this study might be limited. But if students who left the sample are not systematically different from those who remained (or if the differences do not go beyond the grade 6 CST scores, which are controlled for), the estimates presented would accurately represent the effect observed among students who participated in the intervention. Nevertheless, replicating this study in another sample may be the best way to assess the validity of these initial results.

Fourth, because the treatment group took the MDTP Algebra Readiness test at the beginning and end of the program, the treatment group's post-test could have been affected by exposure to the assessment four weeks prior to the post-test. Familiarity with the MDTP Algebra Readiness assessment might have increased performance and post-program outcomes among the treatment group, meaning that the estimated effects of the Elevate Math summer program could be overstated. However, previous research on MDTP Algebra Readiness test-retest reliability (estimated to be .87) suggests that students who re-take the tests after two weeks and up to six months do not improve their scores without intervening instruction (California State University/University of California Mathematics Diagnostic Testing Project, 1995). As such, improvements due to increased familiarity with the test over a four-week span seem to be an unlikely explanation for the improvement in test scores. Moreover, a test-retest effect would not explain the 37 percent of the program effect that was due to the avoidance of summer learning loss in the program group.

***Whether the gains that were seen in the Elevate Math summer program persist into the fall or have broader effects on student math learning in subsequent years is not yet known***

Fifth, the estimates show that the Elevate Math summer program helped reduce summer learning loss and increase achievement through the first half of the summer. However, whether the gains that were seen in the Elevate Math summer program persist into the fall or have broader effects on student math learning in subsequent years is not yet known. Further research involving longer follow-up and a control group with no access to the Elevate Math summer program would help answer that question.

## Appendix A. Data, outcomes, and methodology

This appendix provides details on the study data, outcomes, and methodology.

### Data

The study's randomized controlled trial was conducted at eight middle school sites in six districts in California's Silicon Valley: Alum Rock Union Elementary School District, Berryessa Union Elementary School District, Evergreen School District, Morgan Hill Unified School District, Mount Pleasant School District, and Oak Grove School District. Students typically attended the Elevate Math summer program on the same campus they attended during the school year, though a subset of students attended at nearby campuses. The districts are in suburban communities near San Jose, California. The districts' enrollments range from 2,487 to 13,162, with an average of 9,426. The percentage of English learner students in each district ranges from 19 percent to 53 percent, with an average of 38 percent. The average percentage of students eligible for free or reduced-price lunch is 57 percent. And, on average, 52 percent of the students are Hispanic, 34 percent are Asian, 9 percent are White (non-Hispanic), and 2 percent are Black (non-Hispanic).

Recruitment efforts by the Silicon Valley Education Foundation yielded 496 students to participate in the study. Some 19 students opted out of data collection and were removed from the sample, leaving 477 students (figure A1).

Because the Silicon Valley Education Foundation places a high priority on serving every student that is eligible and interested in participating in the program, randomly assigning students to a control group that would never receive access to the program was undesirable. Therefore, instead of randomly assigning students to a treatment group that was given access to the program and a control group that was not, students who were eligible and willing to participate were randomly assigned either to a treatment group that was scheduled to enroll in the Elevate Math summer program for the first four-week session or to a control group that did not enroll in the first four-week session but was allowed to enroll for the second four-week session. Random assignment was conducted separately for students in each of the school sites by Regional Educational Laboratory West staff, based on anonymized student-level data provided by the Silicon Valley Research Alliance. The random assignment process used Microsoft Excel and consisted of five steps:

1. Establish the number of expected students in each of eight study sites.

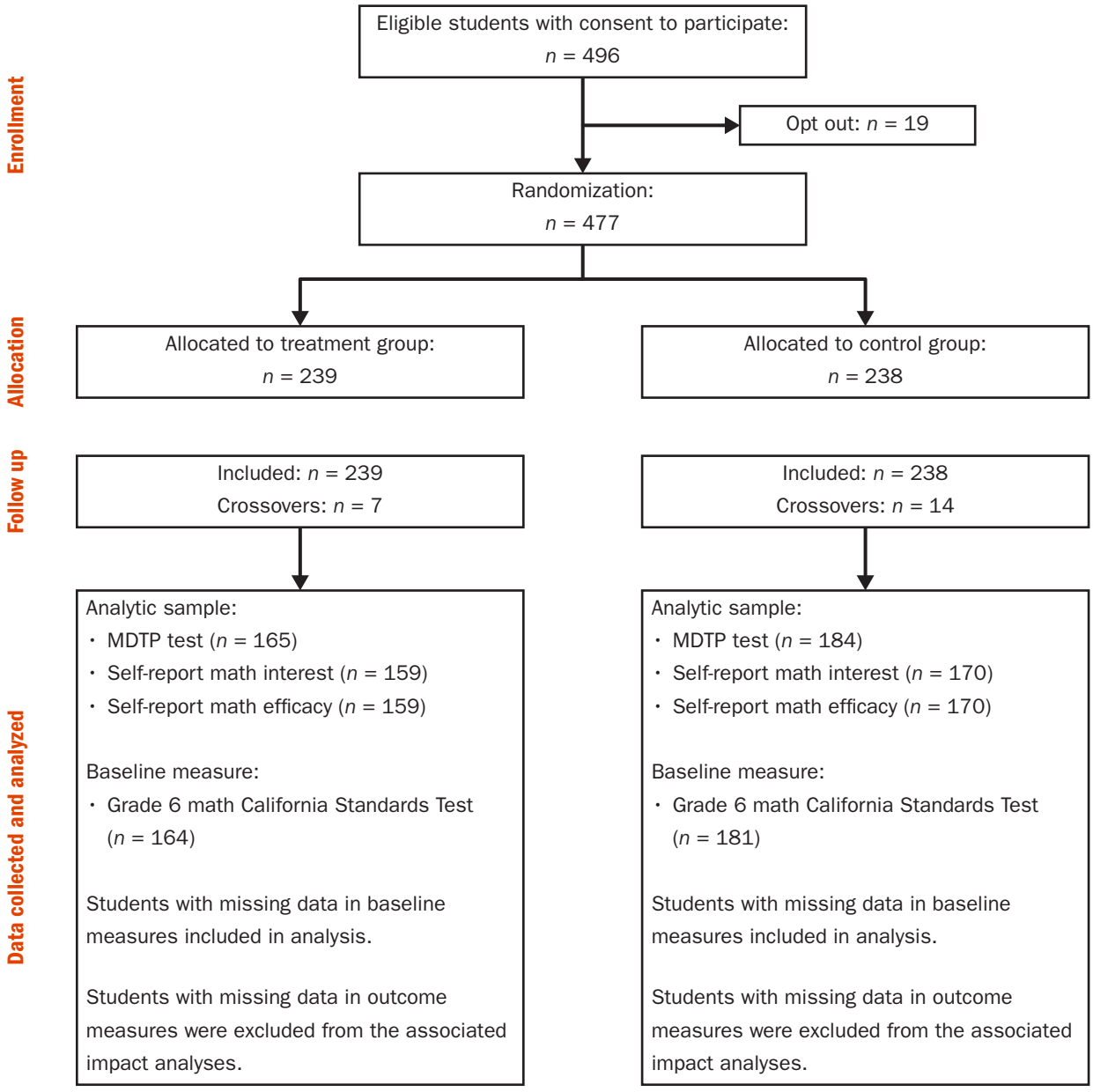
2. For each site, create a set of unique "slots" equal to the number of expected students plus 10.

3. Create a random number variable and assign a random number to each of the slots.

4. Determine the median of the random number variable and assign "session 1" status (for the treatment group) to all slots with values below the median and "session 2" status (for the control group) to all slots with values at or above the median.

5. As students apply, place them in the next available slot and assign treatment status to the student based on the assigned status of the slot into which he or she is placed.

**Figure A1. Student consolidated standards of reporting trials diagram**




MDTP is Mathematics Diagnostic Testing Project.

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

Of the 477 students in the sample, 239 students were randomly assigned to the treatment group, and 238 students were randomly assigned to the control group. Seven students were assigned to attend the first session (treatment group) of the Elevate Math summer program but attended the second session, and fourteen students were assigned to the second session (control group) but attended the first session. These crossovers were kept in the study and were analyzed in the group to which they were originally assigned in the impact analyses. Of the 461 students who indicated their gender, 56 percent ($n$ = 256) were male and 44 percent ($n$ = 205) were female. Based on their grade 6 math California Standards Test (CST) scores, more than half the students fell into the target range of the intervention: 35 percent scored at the high basic level, and 18 percent scored at the low proficient level

(table A1). In addition, 29 percent scored below the target range for the intervention, and 17 percent scored above the range.

On the first day of each session, students took the Mathematics Diagnostic Testing Project (MDTP) test and then a perceptions survey.[4] They had 45 minutes to complete the test. There was no time limit for the survey, and most students spent 15 minutes or less on it. Teachers were instructed by the study team to provide a chance for a makeup test and survey for students who did not show up on the first day but came on the second day. The same test and survey administration was employed on the last day of the program. Teachers contacted students who were not present on the last day to offer a makeup test and survey the next day.

Students for whom outcome data were obtained constituted the analytic samples for those outcomes. MDTP data were obtained for 349 students: 165 students in the treatment group and 184 in the control group. Survey measures of math interest and math self-efficacy were obtained from 159 students in the treatment group and 170 students from the control group. Baseline grade 6 math CST scores were obtained for 164 members of the treatment group follow-up sample and 181 members of the control group follow-up sample.

Before conducting any formal analyses, a series of descriptive analyses were conducted to ensure the quality and accuracy of the data. These analyses examined whether the sample size (overall and by study site) was consistent with expectations, whether the MDTP test scores (overall and by topic area) were outside the range of expected values, whether the survey responses were aligned with the response scales, and whether the score distribution was reasonable by comparing the study data to existing data collected previously for another purpose. Corrections were made during this data cleaning and examination process. The score distribution seemed to be similar to previously collected data.

Overall data attrition was 27 percent, as data were collected from 73 percent of students (349 out of 477). The differential attrition between the treatment group and the control group was 8 percentage points (31 percent for the treatment group and 23 percent for the control group).

To examine how data attrition might have affected the baseline equivalence between the treatment and control groups, the study team conducted the baseline equivalence test using grade 6 math CST scores (table A2). Though the differences were not statistically

**Table A1. Grade 6 math California Standards Test performance levels of study participants**

| | | | Basic | | Proficient | | | |
|---|---|---|---|---|---|---|---|---|
| **Study participants** | **Far below basic** (scale score of 150–252) | **Below basic** (scale score of 253–299) | **Low** (scale score of 300–324) | **High** (scale score of 325–349) | **Low** (scale score of 350–360) | **High** (scale score of 361–414) | **Advanced** (scale score of 415–600) | **Unknown** |
| Percent | 0.84 | 8.60 | 19.92 | 34.80 | 17.82 | 14.05 | 2.52 | 1.47 |
| Number ($n$ = 477) | 4 | 41 | 95 | 166 | 85 | 67 | 12 | 7 |

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

**Table A2. Baseline differences in grade 6 math California Standards Test scores were not statistically significant, regardless of which sample was used**

| Study sample | Adjusted mean: Treatment group (standard deviation) | Adjusted mean: Control group (standard deviation) | Difference (standard error[a]) | *p*-value | 95 percent confidence interval | Unweighted student sample size[b] |
|---|---|---|---|---|---|---|
| Final analytic sample | 339.94 (38.09) | 333.20 (29.60) | 6.74 (3.76) | 0.073 | –0.64 to 14.13 | 345 |
| Original sample for random assignment | 340.42 (39.07) | 336.72 (32.11) | 3.71 (3.23) | 0.252 | –2.64 to 10.05 | 470 |

**Note:** A regression model that accounted for study design characteristics (school site) was used to test the baseline equivalence between the treatment group and control group.

**a.** Estimated using the Huber-White procedure (Greene, 2003).

**b.** The final analytic sample that was used for the impact analyses and with nonmissing grade 6 math California Standards Test scores.

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

significant, in the final analytic sample the point estimate for the treatment group average was 6.74 points above that for the control group. Examining the differences in the full random assignment sample shows that, while again the differences were not statistically significant, prior to any attrition the point estimate of average achievement for the treatment group is 3.71 points above that for the control group. Thus, 55 percent of the observed difference in the analytic sample was present at random assignment. In other words, most of the differences in the analytic sample were due to random variation produced by the random assignment process. The rest of the differences are due to nonrandom patterns in attrition: students with higher baseline CST scores were more likely to drop out of the control group sample than out of the treatment group sample. While this has the potential to introduce bias into the estimated effects, the impact estimates in this study control for baseline levels of achievement, so differences in outcomes would have to be due to factors that were correlated with attrition and math outcomes but not with baseline CST scores.

Other study data that are required by the What Works Clearinghouse reporting guides regarding sample equivalency at the baseline are reported in tables A3 and A4 and data on the impact analyses on all outcome measures is reported in table A5.

## Outcomes

The study examined the Elevate Math summer program's effects on three sets of outcomes: math achievement and algebra readiness, achievement in specific math topic areas that appear to be aligned with the program's described curriculum, and math interest and math self-efficacy.

Math achievement was measured using the MDTP Algebra Readiness test, which consists of 45 multiple-choice items in seven topic areas (table A6). For each topic, the developer of the MDTP Algebra Readiness test has designated a "critical level," which is the minimum number of correct responses required for a student to show adequate preparation in the topic. Previous research (Huang et al., 2014) has shown the MDTP Algebra Readiness test to be highly predictive of success in algebra in grade 8. In particular, seven MDTP Algebra

**Table A3. Pre-intervention sample sizes and characteristics for the baseline sample**

| | Treatment group | | | | Control group | | | |
|---|---|---|---|---|---|---|---|---|
| | Sample size | | Sample characteristics | | Sample size | | Sample characteristics | |
| Baseline measure | Unit of assignment | Unit of analysis | Mean (adjusted mean) | Standard deviation | Unit of assignment | Unit of analysis | Mean (adjusted mean) | Standard deviation |
| Grade 6 math California Standards Test | 239 | 236 | 340.46 (340.42) | 39.07 | 238 | 234 | 336.68 (336.72) | 32.11 |

**Note:** A regression model with a dichotomous indicator for treatment status was used in the study to test for baseline equivalence between the treatment and control groups. Because random assignment was conducted separately within each school site, the model also included dichotomous indicators representing each school site. The standard error was estimated using the Huber-White procedure (Greene, 2003). The study sample (470 students) is the baseline sample with nonmissing grade 6 math California Standards Test scores.

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

**Table A4. Pre-intervention sample sizes and characteristics for the analytic sample**

| | Treatment group | | | | Control group | | | |
|---|---|---|---|---|---|---|---|---|
| | Sample size | | Sample characteristics | | Sample size | | Sample characteristics | |
| Baseline measure | Unit of assignment | Unit of analysis | Mean (adjusted mean) | Standard deviation | Unit of assignment | Unit of analysis | Mean (adjusted mean) | Standard deviation |
| Grade 6 math California Standards Test | 239 | 164 | 339.93 (339.94) | 38.09 | 238 | 181 | 333.20 (333.20) | 29.60 |

**Note:** A regression model with a dichotomous indicator for treatment status was used in the study to test for baseline equivalence between the treatment and control groups. Because random assignment was conducted separately within each school site, the model also included dichotomous indicators representing each school site. The study sample (345 students) is the final analytic sample that was used for the impact analyses and with nonmissing grade 6 math California Standards Test scores.

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

Readiness topic area scores alone can predict Algebra I CST proficiency with 77 percent accuracy.[5] In addition, the higher the MDTP Algebra Readiness topic area score and the more MDTP Algebra Readiness topic areas a student has mastered, the higher the probability that the student scores proficient or higher on the Algebra I CST in grade 8. A student who masters five or more topic areas has a 75 percent chance of scoring proficient or higher on the Algebra I CST in grade 8.

Math achievement was defined as the MDTP Algebra Readiness total score. Algebra readiness was defined according to whether students passed three or more topic areas on the MDTP Algebra Readiness test (based on findings by Huang et al., 2014, that grade 7 students who do so have a greater than 50 percent chance of succeeding in algebra I—that is, scoring proficient or higher on the Algebra I CST in grade 8.

The three topic areas of the MDTP Algebra Readiness test that most closely aligned with the Elevate Math summer program's curriculum were decimals, their operations and applications, and percent; literals and equations; and geometric measurement and coordinate geometry.

The math interest and math self-efficacy measures were intended to capture two specific outcomes, respectively: students' interest in math and students' self-confidence in their ability to do math. These dimensions were assessed using measures drawn primarily from

## Table A5. Post-intervention outcomes for the analytic sample and estimated effects

| Outcome measures | Treatment group | | Control group | | Estimated effect | |
|---|---|---|---|---|---|---|
| | Adjusted mean | Standard deviation | Adjusted mean | Standard deviation | Mean difference | *p*-value (adjusted *p*-value)[a] |
| Research question 1 | | | | | | |
| MDTP Algebra Readiness total scale score (points) | 20.81 | 6.63 | 16.80 | 5.92 | 4.01*** | <.001 (<.001) |
| Algebra readiness (percent passing at least three of seven topic areas) | 29 | 46 | 12 | 32 | 0.17*** | <.001 (<.001) |
| Research question 2 | | | | | | |
| MDTP score for decimals, their operations and applications, and percent | 3.91 | 1.70 | 3.05 | 1.69 | 0.86*** | <.001 (<.001) |
| MDTP score for literals and equations | 3.65 | 1.51 | 3.13 | 1.49 | 0.52*** | <.001 (<.001) |
| MDTP score for geometric measurement and coordinate geometry | 2.50 | 1.44 | 1.90 | 1.29 | 0.59*** | <.001 (<.001) |
| Research question 3 | | | | | | |
| Math interest (1, low, to 5, high) | 2.83 | 1.12 | 2.63 | 1.12 | 0.20 | 0.10 (0.20) |
| Math self-efficacy (1, low, to 5, high) | 3.21 | 0.90 | 3.19 | 0.86 | 0.02 | 0.80 (0.80) |

MDTP is Mathematics Diagnostic Testing Project.

*** Significantly different from zero at the .001 level, two-tailed test.

**Note:** A regression model with a dichotomous indicator for treatment status was used to estimate average differences between the treatment and control group outcomes. The model included prior achievement, as measured by grade 6 California Standards Test math scores, and dichotomous indicators representing each school site. The missing-indicator method (White & Thompson, 2005) was used to account for missing values on the grade 6 math CST. The standard errors used as the basis for statistical significance calculations were estimated using the Huber-White procedure (Greene, 2003).

**a.** For the confirmatory research questions (1 and 3), the Benjamini-Hochberg (1995) procedure was used to calculate adjusted *p*-values across the two outcome measures.

**Source:** Authors' analysis of survey data collected by the Silicon Valley Education Foundation for the study.

## Table A6. Number of items and critical level by topic area on the Mathematics Diagnostic Testing Project Algebra Readiness test

| Topic area | Number of items | Critical level |
|---|---|---|
| Integers | 6 | 4 |
| Fractions and their applications | 8 | 6 |
| Decimals, their operations and applications, and percent | 8 | 6 |
| Exponents and square roots and scientific notation | 4 | 3 |
| Literals and equations | 7 | 5 |
| Geometric measurement and coordinate geometry | 6 | 4 |
| Data analysis, probability, and statistics | 6 | 4 |

**Source:** California State University/University of California Mathematics Diagnostic Testing Project, 1995.

a student perception survey developed by Gilbert (2008) and administered by the Silicon Valley Education Foundation as part of its previous and ongoing program monitoring efforts.

The math interest scale consisted of five items related to students' interest in math (for example, how exciting math is to the students, how much the students like doing math). Each item asked students to rate their responses on a five-interval scale ranging from 1 (not at all true for me) to 5 (very true for me), with the midpoint (3) indicating somewhat true for me.

The math self-efficacy scale consisted of seven items related to students' confidence in their ability to do math. For example, one item asks, "Even if a new topic in math is hard, how confident are you that you can learn it?" The response options are on a scale from 1 (not at all confident) to 5 (very confident), with the midpoint (3) indicating somewhat confident.

Previous research indicates that these survey scales are valid, reliable measures of student math interest and math self-efficacy, each with a Cronbach's alpha that exceeds .7 (Gilbert, 2008). In the study sample the Cronbach's alpha for each survey scale (measured either in the pre-test or in the post-test) exceeded .9.

### Methodology

***Analytic approach and statistical adjustments.*** For all three research questions, analysis of covariance, a single-level regression model, was used to estimate program effects. A baseline measure (grade 6 math CST scores) was included as a covariate in the model to increase the precision of the estimate. Those CST scores were also used to examine baseline equivalence between the treatment and control groups. The model takes the following form:

$$DV_{ij} = \alpha_0 + \beta_1 CST6_i + \beta_2 Tx_{ij} + \Sigma \nu_S Stratum_j + \varepsilon_{ij}$$

where $i$ denotes a student, $j$ denotes a school site, $DV$ is the outcome variable being studied, $CST6$ is the baseline measure and serves as a covariate, $Tx$ is a dichotomous variable indicating students' intervention condition (treatment or control), $Stratum$ is a vector of fixed effects for $j$–1 strata, and $\varepsilon$ is an error term for individual student members. The program effect is represented by $\beta_2$, which captures differences between the treatment and control groups on the outcome variable after controlling for baseline difference and study design factors. Because observations $i$ are clustered within schools, the effect estimates account for the effects of clustering by estimating Huber-White standard errors (Greene, 2003), which avoid the downward bias on the standard errors that clustering can otherwise cause. Effect sizes were calculated by dividing effect estimates by the control group standard deviation of the outcome variable.

***Treatment of missing data.*** The missing-indicator method (White & Thompson, 2005) was used to account for missing values on the covariate (not the outcome variables) in the impact analysis models. With the missing-indicator method, all observations with missing values on covariates are retained in the analysis. Indicator variables are created for missing values on each variable (0 = observed, 1 = missing), and missing values on the

covariates are coded to a constant. Both the recoded covariates and the missing value indicator variables are included in the regression model. In a randomized controlled trial, in which randomization helps ensure that the baseline covariates are balanced, the use of the missing-indicator method appears to refine the precision of impact estimates and standard errors (White & Thompson, 2005).

Observations with missing values on outcome variables were excluded from the impact analyses. Deletion of observations with missing outcome variables has been shown to result in accurate impact estimates and standard errors when outcomes are missing at random, conditional on the covariates (Allison, 2002; von Hippel, 2007).

To examine how robust the findings are with respect to procedures for handling missing data, sensitivity analyses were conducted based on the sample with nonmissing post-test data and nonmissing data on the covariate. These findings are presented in appendix B.

For the MDTP Algebra Readiness test, missing item responses were treated as incorrect responses. For the survey scales, scores were obtained from nonmissing item responses (that is, the scale score for each student was obtained by computing the average score over nonmissing item responses in that scale). For the math interest scale, fewer than 5 students had one or more missing item responses; for the math self-efficacy scale, fewer than 13 students had one or more missing item responses.

***Multiple hypothesis testing.*** The confirmatory research questions were research questions 1 and 3. The questions address two domains: content knowledge in math and attitudes toward math and math learning. The impact analysis in the content knowledge domain focuses on two outcomes: math achievement and algebra readiness. As such, multiple comparison procedures were applied to reduce the probability of finding statistically significant program effects within that domain due to chance factors alone. Similarly, the math attitudes domain has two outcomes (math interest and math self-efficacy), and multiple comparison procedures were used to make adjustments to the statistical significance tests within that domain as well. No across-domain adjustment was made.

Benjamini and Hochberg's (1995) stepwise multiple hypothesis testing procedure was used to test impact estimates for cognition domain. This procedure involves ordering *p*-values obtained for each outcome variable from largest to smallest, multiplying each unadjusted *p*-value by $N/(N - j + 1)$, where $N$ is the number of outcome variables within a domain and $j$ is the order of the test. The procedure involves rejecting all null hypotheses in which the adjusted *p*-value is less than .05.

***Treatment of crossovers.*** Because this study is based on an intent to treat analysis (Bloom, 2006), crossover students were analyzed with their original random assignment group, irrespective of whether they participated in the first or second session of the program. The study team conducted a sensitivity analysis to examine the effects of crossovers on the estimated program effects. In particular, the data were reanalyzed, treating treatment-to-control crossovers as control students and control-to-treatment crossovers as treatment students. Findings of these sensitivity analyses are in appendix B. The results of this analysis suggest a change in the MDTP impact estimate from 4.0 points to 3.6.

The analysis also included an estimate of the local average treatment effect to assess the effect of the treatment on those who actually participated (Bloom, 2006). In particular, the estimated effect on MDTP achievement was divided by the difference in participation rates between the treatment and control groups. In this case, participation was defined by participation in the first session. Based on the analytic sample, 158 out of 165 students from the treatment group (96 percent) participated in the treatment (session 1), while 14 out of 184 (8 percent) students from the control group also participated in the treatment (session 1). Dividing the effect on MDTP achievement of 4 points by the difference in these rates (88 percentage points), suggests a local average treatment effect of 4.5 points. Together, these analyses suggest that the presence of crossovers did not materially change the pattern of effects.

## Appendix B. Sensitivity analyses

For research question 1 (program effect on math achievement), the study team conducted several sensitivity analyses to study the robustness of program impact estimate shown in table 1 in the main report. The reported program impact estimate using the MDTP total score is based on model 2b in table B1; the reported program impact estimate of algebra readiness is based on model 2b1 in table B2. Findings of these sensitivity analyses indicate that the reported estimate was stable and not moving around by model specification.

Similar sensitivity analyses were conducted for program effects on math interest and math self-efficacy (tables B3 and B4). Findings of these sensitivity analyses suggest that the reported program impact estimates as shown in table 4 in the main text are robust, regardless of how the impact model is specified.

**Table B1. Elevate Math summer program effect on grade 7 students' math Mathematics Diagnostic Testing Project total scale score, by model specification**

| Model | Adjusted mean | | Difference (standard error[a]) | *p*-value (adjusted *p*-value[b]) | 95 percent confidence interval | Effect size[c] | Unweighted student sample size |
|---|---|---|---|---|---|---|---|
| | Treatment group (standard deviation) | Control group (standard deviation) | | | | | |
| 1 | 21.14 (6.63) | 16.50 (5.92) | 4.64*** (0.68) | <.001 (<.001) | 3.30 to 5.97 | 0.78 | 349 |
| 2a | 20.76 (6.64) | 16.77 (5.90) | 3.99*** (0.57) | <.001 (<.001) | 2.88 to 5.11 | 0.68 | 345 |
| 2b | 20.81 (6.63) | 16.80 (5.92) | 4.01*** (0.56) | <.001 (<.001) | 2.90 to 5.12 | 0.68 | 349 |
| 2c | 20.56 (6.50) | 16.92 (6.16) | 3.64*** (0.57) | <.001 (<.001) | 2.52 to 4.76 | 0.59 | 349 |
| 3a | 20.78 (6.54) | 16.72 (5.75) | 4.06*** (0.56) | <.001 (<.001) | 2.97 to 5.16 | 0.71 | 340 |
| 3b | 20.78 (6.63) | 16.83 (5.92) | 3.95*** (0.56) | <.001 (<.001) | 2.84 to 5.05 | 0.67 | 349 |

*** Significantly different from zero at the .001 level, two-tailed test.

**Note:** Data were regression-adjusted to account for differences in baseline measures or study design characteristics (strata). Model 1 includes no covariates, only strata. Model 2a includes grade 6 math California Standards Test scores as a covariate using the sample with both nonmissing outcome variable and nonmissing covariate. Model 2b is similar to model 2a, but the missing-indicator method (White & Thompson, 2005) was used to account for missing values on the covariate; this is the model used to report the impact estimate in table 2 in the main text. Model 2c is similar to model 2b, but the treatment status was changed for those crossovers. Model 3a is similar to model 2a but adds gender as another covariate. Model 3b is similar to model 2b but adds gender as another covariate.

**a.** Estimated using the Huber-White procedure (Greene, 2003).

**b.** The Benjamini-Hochberg (1995) procedure was used to calculate adjusted *p*-values across the two outcome measures.

**c.** Calculated by dividing impact estimates by the control group standard deviation of the outcome variable.

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

## Table B2. Elevate Math summer program effect on grade 7 students' algebra readiness, by model specification

| Model | Adjusted mean: Treatment group (standard deviation) | Adjusted mean: Control group (standard deviation) | Difference (standard error[a]) | *p*-value[b] (adjusted *p*-value[c]) | 95 percent confidence interval | Effect size[d] | Unweighted student sample size |
|---|---|---|---|---|---|---|---|
| 1 | 0.31 (0.46) | 0.11 (0.32) | 0.19*** (0.04) | <.001 (<.001) | 0.11 to 0.28 | 0.59 | 349 |
| 2a | 0.29 (0.46) | 0.12 (0.31) | 0.17*** (0.04) | <.001 (<.001) | 0.09 to 0.25 | 0.55 | 345 |
| 2b1 | 0.29 (0.46) | 0.12 (0.32) | 0.17*** (0.04) | <.001 (<.001) | 0.09 to 0.25 | 0.53 | 349 |
| 2b2 | 0.30 (0.46) | 0.11 (0.32) | 0.19*** (0.04) | <.001 (<.001) | 0.10 to 0.27 | .59 | 349 |
| 2c | 0.28 (0.45) | 0.13 (0.33) | 0.14*** (0.04) | <.001 (<.001) | 0.07 to 0.22 | 0.42 | 349 |
| 3a | 0.28 (0.46) | 0.11 (0.30) | 0.17*** (0.04) | <.001 (<.001) | 0.09 to 0.25 | 0.57 | 340 |
| 3b | 0.29 (0.46) | 0.12 (0.32) | 0.17*** (0.04) | <.001 (<.001) | 0.09 to 0.25 | 0.53 | 349 |

*** Significantly different from zero at the .001 level, two-tailed test.

**Note:** Data were regression-adjusted to account for differences in baseline measures or study design characteristics (strata). Model 1 includes no covariates, only strata. Model 2a includes grade 6 math California Standards Test scores as a covariate using the sample with both nonmissing outcome variable and nonmissing covariate. Model 2b1 is similar to model 2a, but the missing-indicator method (White & Thompson, 2005) was used to account for missing values on the covariate; this is the model used to report the impact estimate in table 2 in the main text. Model 2b2 is the same as model 2b1, but a logistic regression analysis was used, treating algebra readiness as a dichotomous variable. Model 2c is similar to model 2b1, but the treatment-to-control crossovers were treated as students in the control group, and control-to-treatment crossovers were treated as students in the treatment group. Model 3a is similar to model 2a but adds gender as another covariate. Model 3b is similar to model 2b1 but adds gender as another covariate.

**a.** Estimated using the Huber-White procedure (Greene, 2003).

**b.** Represents the significance of the test that is associated with the estimated odds ratio for the treatment or control indicator.

**c.** The Benjamini-Hochberg (1995) procedure was used to calculate adjusted *p*-values across the two outcome measures.

**d.** Calculated by dividing impact estimates by the control group standard deviation of the outcome variable.

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

## Table B3. Elevate Math summer program effect on grade 7 students' math interest, by model specification

| Model | Adjusted mean | | Difference (standard error[a]) | *p*-value (adjusted *p*-value[b]) | 95 percent confidence interval | Effect size[c] | Unweighted student sample size |
|---|---|---|---|---|---|---|---|
| | Treatment group (standard deviation) | Control group (standard deviation) | | | | | |
| 1 | 2.84 (1.12) | 2.62 (1.12) | 0.22 (0.12) | 0.07 (0.14) | –0.02 to 0.45 | 0.20 | 329 |
| 2a | 2.81 (1.12) | 2.63 (1.11) | 0.17 (0.12) | 0.14 (0.28) | –0.06 to 0.41 | 0.15 | 324 |
| 2b | 2.83 (1.12) | 2.63 (1.12) | 0.20 (0.12) | 0.10 (0.20) | –0.04 to 0.43 | 0.18 | 329 |
| 2c | 2.82 (1.09) | 2.63 (1.15) | 0.20 (0.12) | 0.09 (0.18) | –0.03 to 0.43 | 0.17 | 329 |
| 3a | 2.81 (1.10) | 2.63 (1.14) | 0.18 (0.12) | 0.14 (0.28) | –0.06 to 0.41 | 0.16 | 319 |
| 3b | 2.82 (1.12) | 2.64 (1.12) | 0.19 (0.12) | 0.11 (0.22) | –0.04 to 0.42 | 0.17 | 329 |

**Note:** Data were regression-adjusted to account for differences in baseline measures or study design characteristics (strata). Model 1 includes no covariates, only strata. Model 2a includes grade 6 math California Standards Test scores as a covariate using the sample with both nonmissing outcome variable and nonmissing covariate. Model 2b is similar to model 2a, but the missing-indicator method (White & Thompson, 2005) was used to account for missing values on the covariate; this is the model used to report the impact estimate in table 5 in the main text. Model 2c is similar to model 2b, but the treatment status was changed for those crossovers. Model 3a is similar to model 2a but gender was added as another covariate. Model 3b is similar to model 2b, but gender was added as another covariate.

**a.** Estimated using the Huber-White procedure (Greene, 2003).

**b.** The Benjamini-Hochberg (1995) procedure was used to calculate adjusted *p*-values across the two outcome measures.

**c.** Calculated by dividing impact estimates by the control group standard deviation of the outcome variable.

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

## Table B4. Elevate Math summer program effect on grade 7 students' math self-efficacy, by model specification

| Model | Adjusted mean | | Difference (standard error[a]) | *p*-value (adjusted *p*-value[b]) | 95 percent confidence interval | Effect size[c] | Unweighted student sample size |
|---|---|---|---|---|---|---|---|
| | Treatment group (standard deviation) | Control group (standard deviation) | | | | | |
| 1 | 3.23 (0.90) | 3.17 (0.86) | 0.05 (0.10) | 0.60 (0.60) | –0.13 to 0.24 | 0.06 | 329 |
| 2a | 3.21 (0.91) | 3.19 (0.84) | 0.01 (0.09) | 0.88 (0.88) | –0.17 to 0.20 | 0.01 | 324 |
| 2b | 3.21 (0.90) | 3.19 (0.86) | 0.02 (0.09) | 0.80 (0.80) | –0.16 to 0.21 | 0.03 | 329 |
| 2c | 3.23 (0.90) | 3.17 (0.86) | 0.06 (0.09) | 0.51 (0.51) | –0.12 to 0.25 | 0.07 | 329 |
| 3a | 3.20 (0.91) | 3.19 (0.84) | 0.01 (0.09) | 0.89 (0.89) | –0.17 to 0.20 | 0.01 | 319 |
| 3b | 3.21 (0.90) | 3.19 (0.86) | 0.02 (0.09) | 0.85 (0.85) | –0.17 to 0.20 | 0.02 | 329 |

**Note:** Data were regression-adjusted to account for differences in baseline measures or study design characteristics (strata). Model 1 includes no covariates, only strata. Model 2a includes grade 6 math California Standards Test scores as a covariate using the sample with both nonmissing outcome variable and nonmissing covariate. Model 2b is similar to model 2a, but the missing-indicator method (White & Thompson, 2005) was used to account for missing values on the covariate; this is the model used to report the impact estimate as shown in table 5 in the main text. Model 2c is similar to model 2b, but the treatment status was changed for those crossovers. Model 3a is similar to model 2a but adds gender as another covariate. Model 3b is similar to model 2b but adds gender as another covariate.

**a.** Estimated using the Huber-White procedure (Greene, 2003).

**b.** The Benjamini-Hochberg (1995) procedure was used to calculate adjusted *p*-values across the two outcome measures.

**c.** Calculated by dividing impact estimates by the control group standard deviation of the outcome variable.

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

## Notes

1. The CST has five performance levels, which are based on scale scores: far below basic, below basic, basic, proficient, and advanced. High basic is defined as a scale score of 325–349, and low proficient is defined as a scale score of 350–360.
2. Initial algebra I course placement is typically based on grade 6 math CST score because grade 7 math CST scores are not available until late August or early September.
3. This includes the Alum Rock, Berryessa, Franklin-McKlinley, Oak Grove, and San Jose school districts.
4. The correlation between the test scores and the survey scale scores is low: less than 0.2 (for both the interest scale and the self-efficacy scale) for students in the treatment group who took the post-test and 0.14 (with the interest scale) and 0.27 (with the self-efficacy scale) for students in the control group who took the pre-test. This indicates that the effect on the survey scales after taking the test is minimal and is about the same between treatment and control groups.
5. Accuracy is defined with respect to the students who were placed into algebra I in grade 8. It refers to the percentage of these students who are predicted to succeed in algebra I in grade 8 who actually score proficient or higher on the Algebra I CST in the following school year. This percentage is also called the positive predictive value.

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