Opening a Gateway to College Access

Algebra at the Right Time

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Overview

Mastering algebra is a fundamental step toward gaining access to and preparing for the higher level math courses that high school students must complete in order to be prepared for college. Three recent REL West studies shed important light on policies and practices that affect student success in algebra and preparation for higher level math courses.

Algebra matters. Students who struggle with math in middle school and high school have a lower chance of meeting eligibility requirements in California's public universities; four years of math in high school, with a strong foundation in algebra that builds from middle school, is key to higher education access. Ensuring that students succeed in middle school math — and in algebra in particular — is an important issue for policy and practice.

Evidence over many years strongly suggests that success in middle school math is a key determinant of students' success in high school and beyond (Oakes, Gamoran, & Page, 1992; Stevenson, Schiller, & Schneider, 1994; Wang & Goldschmidt, 2003; Finkelstein et al., 2012). Mastery of algebra in particular is a critical step to enrollment and success in a college preparatory math sequence that can include trigonometry, pre-calculus, and calculus. Completion of these courses in high school strongly predicts how well students are prepared for postsecondary-level math. Whether students take and pass these advanced high school math courses will determine not only their eligibility for college, but also whether they will be able to participate and succeed in regular college math courses without remediation once they are in college. For community college students in particular, where remediation in math is far more common than in four-year institutions, adequate preparation in math enables students to earn course credits they do not accrue in the remedial course sequence.

Three recently completed REL West studies shed light on a set of key issues relating to algebra success (see sidebar: Recent REL West Research on Algebra Success). One report (Study 1) addresses the frequency of algebra repetition and the extent to which algebra repeaters succeed in algebra and appear to be prepared for the higher-level courses (Fong, Jaquet, & Finkelstein, 2014). Another report (Study 2) addresses the initial placement of students in algebra and the relationship between algebra success and the skills that students bring to these courses (Huang, Snipes, & Finkelstein, 2014). This study addressed several important questions: Which students are likely to succeed in algebra? What are the consequences of struggling in algebra, and what level of success is achieved by students who repeat it? A third study (Study 3) examines the effectiveness of a summer school supplementary algebra program that prepares students for their upcoming 8th grade algebra courses (Snipes et al., 2015). The evidence produced by these studies provide relevant and useful information for several important dimensions of policy and practice. In this research brief, we discuss the implications of the findings these from these three studies for decisions that may be made at the state, local, and school level, and for the development of effective strategies for support-

ing students' progress in middle school math. (See back page for details and links to studies.)

Findings

Repeating middle school math courses is problematic. Large numbers of students repeat algebra courses every year. Middle school students who repeat algebra after initially failing the course have relatively low chances for becoming proficient in algebra.

Over the last decade there has been a dramatic increase in the number and proportion of California grade 8 students enrolled in Algebra I. While this has resulted in greater percentages of grade 8 students scoring proficient or advanced on the Algebra I California Standards Test (CST),[1] it has also led to larger numbers of grade 8 students scoring far below basic or below basic on this same test (Williams et al., 2011). In 2008, an estimated 212,000 California students in grades 8–11 repeated algebra (EdSource, 2009, fig. 4).[2]

The consequences of failing algebra 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 who receive a C or below in algebra in grade 8 enroll in geometry in grade 9 (Finkelstein et al., 2012). In short, few students recover from failing algebra, 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.

1 The California Standards Test (CST) was aligned to the 1997 standards and was the anchor for the state's accountability system for nearly 20 years. The CST is no longer administered in California. It has been replaced by the Smarter Balanced Assessment Consortia tests that were administered for the first time in spring 2015. We refer to research that used the CST because that was the basis for assessing math proficiency at the time.

2 EdSource identified as test repeaters 2 percent of grade 8 test takers, 38 percent of grade 9 test takers, 52 percent of grade 10 test takers, and 52 percent of grade 11 test takers.

Policy Context: Algebra 1 and Common Core Math

The introduction of the Common Core State Standards in math (CCSS-M) over the past two years has provided grade-specific standards that have reorganized course content in school districts across California. Course content, and course names, are often specific to districts and are likely to change as instructional materials continue to be developed that align with grade-specific standards. For example, a course named "Algebra I" may currently be offered in some districts in 9th grade, but formally that course is aligned with the "Common Core State Standards grade 9" content; other districts that have opted for an "integrated" math course sequence in grades 9-11 may refer to the course as "Course 1." Because the CCSS-M are purposefully designed to reinforce content within and across grades, pre-algebra content is introduced early in middle school and algebra readiness builds through 9th grade. We acknowledge that students historically have taken a wide range of course paths, and may continue to do so. In this brief, we refer to "Algebra 1" as the course that historically, under the 1997 California state content standards, had been offered to 9th graders but was frequently taken by 8th graders. Most content specialists would agree that the content required for the current CCSS-M grade 8 is more demanding than the previous "Algebra 1" course under the 1997 standards that was suggested for grade 9.

The proportions of students who fail algebra and have to repeat the course are even higher among vulnerable populations, including poor students, Hispanic students, and English language learners.

A recent REL West study (Study 1) examined algebra repeating patterns in a large high school district in California's Silicon Valley. This study showed that 44 percent of students repeat algebra, and that the proportion of students who must repeat these courses because they fail them on the first attempt is even higher among poor and minority students (Fong, Jaquet, & Finkelstein, 2014). For example, 51 percent of students qualifying for free or reduced-price lunch failed algebra and repeated the course, compared to a rate of only 32 percent among non-economically disadvantaged students. Student classified as English language learners failed and repeated Algebra I at a rate of 57 percent, and Hispanic students did so at a rate of 61 percent. On the other hand, only 36 percent of White students and 26 percent of Asian students failed Algebra and repeated the course.

Unfortunately, repeating algebra has not been shown to be a particularly effective strategy for achieving algebra proficiency and preparing students for success in future math courses.

This same REL West study shows that students who initially fail algebra the first time they take it tend to improve when they take the course a second time. However, the improvements are modest, and the outcomes are not sufficient to position students for completion of advanced math courses before they finish high school. For example, the average Algebra I grade among students who repeated algebra was a C-, compared to an average of D+ when they first took the course. In fact, 68 percent of students who earned below a C when they initially took Algebra I, earned below a C when they repeated the course. Moreover, among students who scored below proficient when they initially took the course, 89 percent of students still scored below proficient after taking it a second time (Fong, Jaquet, & Finkelstein, 2014). Based on these numbers, it is difficult to argue that students who have to repeat algebra because of poor performance have a good chance of succeeding in the course when they take it a second time. As a result, it seems unlikely that these students will master the material required to succeed and progress through a sequence of higher level math courses. This suggests that policymakers and practitioners may want to consider using placement decisions and all available instructional supports to minimize the chances that students fail algebra on their initial attempt.

Students must score well above the thresholds for proficiency in prior math courses in order to have even a 50-50 chance of success when placed into algebra.

Beginning in the mid-1990s, with the push to increase the number of students who pass algebra and eventually take calculus in high school, some districts opted for "algebra for all" policies in the 8th grade. Similarly, with the implementation of the Common Core State Standards-Mathematics (CCSS-M), many districts are implementing accelerated course sequences in which students are scheduled into CCSS Course 1 (considered by some to be a grade 9 course) in the 8th grade. However, evidence from another REL West study (Study 2) on algebra placement in several school districts in Silicon Valley, CA, casts doubt on the effectiveness of placing students in accelerated algebra sequences without assessing their readiness based on prior math performance (Huang, Snipes, & Finkelstein, 2014). In particular, the study suggests that students who take challenging middle school math courses before they are ready do not fare well.

The study shows that existing assessment data enables one to predict who will succeed in grade 8 algebra courses as early as the end of the 6th grade. It employs grade 6 CST data to predict the extent to which students

who took algebra in the 8th grade "succeeded," that is, achieved proficiency on the grade 8 Algebra I CST.[3]

The evidence from this analysis strongly indicates that reaching proficiency is not enough to support success in grade 8 algebra. In particular, students who scored exactly at the threshold for proficiency in the courses taken prior to taking Algebra I were actually more likely than not to fail to reach proficiency when placed in Algebra I in the 8th grade. The data show that students must score at least .27 standard deviations above the proficiency threshold on the grade 6 CST before they have even a 50-50 chance of succeeding (that is, achieving proficiency on the Algebra I CST) when placed in Algebra I in grade 8 (Huang, Snipes, & Finkelstein, 2014). This is the equivalent of moving from the 44th to the 55th percentile in the local distribution of achievement.[4]

Importantly, this level of performance only gave students a 50-50 chance of success in Algebra I. In an era of high-stakes accountability, there are many cases in which a 50 percent success rate for a course such as algebra would not be considered satisfactory. To the extent that policymakers and practitioners are interested in ensuring that students have a substantially better than 50-50 chance of succeeding in algebra, students would have to reach even higher levels of achievement in the previous courses. For example, in order to have a three in four chance (75 percent) of succeeding in Algebra I, grade 6 students would have to score at least .91 standard deviations above proficiency. This is the equivalent of reaching what is currently the 76th percentile of achievement in these districts.[5]

At the current time, school districts are redesigning math courses — and math course sequences — to meet the new standards. Two of the most common approaches in grades 9-11 are to maintain a "traditional" sequence of algebra, geometry, and advanced algebra or to *integrate* the content over three successive years (for example, Course 1, 2, 3). The implication is that rather than having an "Algebra I" course, *integrated* courses are designed in such a way that algebra content is distributed, enriched, and regularly reinforced throughout high school. However, the existing evidence suggests that regardless of the traditional or integrated sequence, math courses aligned with the new standards are even more challenging than the courses they replaced. An example is the way in which transformational geometry is taught. Typically, this content was taught in geometry courses in 10th grade with limited coverage and application. Under CCSS-M in 9th grade, the content is algebra-rich, and includes far more complex ways for understanding and applying transformations. To the extent that these new courses are striving to enact higher standards, students will have to reach even higher levels of achievement in the context of grade 6 and 7 math courses in order to have a reasonable chance of success in grade 8 and grade 9. This suggests that policymakers and practitioners may want to consider conservative approaches to the placement of students into challenging middle school math courses, and consider acceleration decisions carefully. At a minimum, it suggests that placing students who are below or close to the proficiency thresholds in previous courses into challenging math courses in the following school year will not result in high passing rates.

The available evidence shows that providing students with additional intensive academic supports improves their chances of success in algebra. At the same time, it also shows that there are important limitations to what can be accomplished with short-term interventions.

One strategy districts have used to increase students' chances of success in algebra is to take students who score near the proficiency threshold (for example, between the thresholds for "high basic" and "low pro-

3 Predictions were based on grade 6 CST data, because in most cases (in the districts under study) grade 7 CST data were not available in time for districts to use them for initial placement decisions. Therefore, grade 8 math placements were typically based on grade 6 CST data. These decisions were sometimes altered when grade 7 math CST scores became available. However, in 78 percent of cases, the predicted chances of success based on grade 7 CST data were consistent with the predicted chances of success based on grade 6 CST data (Huang, Snipes, & Finkelstein, 2014).

4 Calculations based on WestEd analysis of the distribution of achievement within the sample of students from the participating districts from Huang, Snipes, & Finkelstein, 2014.

5 Calculations based on WestEd analysis of the distribution of achievement within the sample of students from the participating districts from Huang, Snipes, & Finkelstein, 2014.

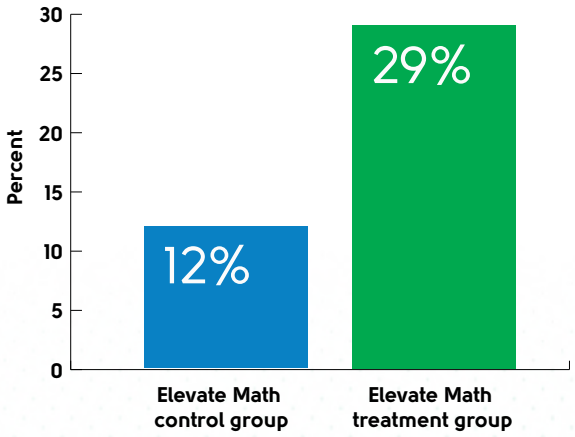
ficient") and provide them with additional instruction to improve their preparation for challenging content. With this in mind, REL West conducted a rigorous study (Study 3) of a summer math intervention designed to improve Algebra I success among students performing at or near the threshold for proficiency in the courses preceding Algebra I (Snipes et al., 2015). The evidence from this study shows that providing students with such support significantly improves their math outcomes and increases the percentage of students who qualify as "algebra ready."

The study (Study 3) examined the effects of Elevate Math (see box, page 6), a program providing approximately 4 weeks of daily algebra instruction for rising 8th graders who had scored between "high basic" and "low proficient" on the grade 6 CST. Eligible students from six districts in Silicon Valley, CA[6] were randomly assigned to a treatment group that was provided access to the Elevate Math summer program over the first 4 weeks of the summer, and a control group that was not.

The study showed that the program had a significant, positive effect on achievement. Evidence from the Elevate Math impact study indicates that the Elevate Math summer program improved student performance by 4 points (21 for program group versus 17 for control group), or .7 standard deviations, on the Math Diagnostic Testing Projects' Algebra Readiness (MDTP-AR) test (Snipes et al., 2015). The MDTP has been shown to be highly predictive of success in grade 8 Algebra (Huang, Snipes, & Finkelstein, 2014). The intervention also increased the percentage of students who reached the threshold for algebra readiness from 12 percent in the control group to 29 percent in the treatment group (see Figure 1).[7]

In order to get some sense of the magnitude of this impact, it can be compared to the effects found in other randomized studies of education interventions. When compared to evidence from a large meta-analyses of randomized controlled trials (RCTs) in education, the effect of Elevate appears to be twice as large as the typical (median) effect found among middle school education interventions (Lipsey et al., 2012). In terms of the California Standards test, the average control group MDTP score translates into a CST score of 326, 1 point above the threshold for "high basic." The treatment group 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 Silicon Valley.[8]

Figure 1: Algebra readiness, rising eighth graders



Students exceeding the median threshold on the Math Diagnostic Testing Projects' Algebra Readiness test

So, while student achievement among the students who were provided access to the Elevate program is significantly better than students who were not, it is still below typical achievement for students in the surrounding districts. Moreover, as mentioned above, the available evidence suggests that students have to score well above proficiency to have better than a 50-50 chance of succeeding in grade 8 Algebra I (Huang, Snipes, & Finkelstein, 2014). The program group reached a point on the MDTP AR test equivalent to 1 point below CST proficiency. This suggests that, while the Elevate program had a meaningful effect on student math skills, these students still have a long way to go before they are prepared for the higher level math content they will face in 8th grade and

6 The participating districts included Alum Rock Union Elementary School District, Berryessa Union School District, Evergreen School District, Morgan Hill Unified School District, Mount Pleasant School District, and Oak Grove School District.

7 Algebra readiness was defined as exceeding the MDTP (AR) threshold associated with a 50 percent or greater chance of success in Algebra I (Huang, Snipes, & Finkelstein, 2014).

8 Calculations based on REL West analysis of the distribution of achievement within the sample of students from the participating districts from Snipes et al., 2015.

beyond. It may be that, in order to be fully prepared for the math courses they will face in subsequent grades, students targeted for the Elevate program need to combine summer supports with other, longer term supports for accelerating their progress in math.

Implications for Policy and Practice

Every year, large numbers of students fail algebra. For students who fail algebra, repeating the course is not associated with success. Therefore, policymakers may consider working to devise strategies that minimize the extent to which students experience algebra failure in the first place.

Changes in policy have been shown to drive changes in the number of students taking algebra at earlier points in their education. Though the mechanics of this appears to result in larger numbers of students who have passed algebra courses by the eighth grade, it also has been shown to result in larger numbers of students who struggle with algebra (Williams et al., 2011). Moreover, it is clear that students who take algebra early and struggle have very little chance of succeeding on the second attempt (Fong, Jaquet, & Finkelstein, 2014). Failing to master algebra can thwart students' chances of accessing and succeeding in the higher level math courses that are associated with college readiness. Moreover, as various on-track studies have shown, course failure in the 8th and 9th grades is strongly associated with substantially reduced chances of graduating from high school (Allensworth & Easton, 2005, Balfanz, Herzog, & MacIver, 2007). These failures occur at a point in students' academic development in which the consequences of failure can be significant — or at least very difficult to

The Elevate Math Summer Math Program

Elevate Math (Elevate) is an intervention program aimed at helping incoming grade 8 students succeed in algebra and related content that aligns with the CCSS in math. It was designed by the Silicon Valley Education Foundation (SVEF) as part of its ongoing effort to help students master important math and science skills that are needed to succeed in college and careers. The program is a year-round effort that includes supports for math performance in the summer and school year. However, the core of the program is an intensive 75-hour (19 days over 4 weeks) summer preparatory course.

The Elevate Math summer program consists of four main components:

- Approximately 19 days of four hours of blended learning classroom instruction, with one of these hours spent on Khan Academy (a free online learning system with thousands of educational resources) each day. 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.
- Credentialed teachers and their college-level teacher assistants receive 40 hours of Common Core State Standards (CCSS)-based professional development provided by the Santa Clara County Office of Education and the Krause Center for Innovation. The first 24 hours include training on curriculum understanding and implementation, instructional strategies aligned with the CCSS, math practices, technology integration in the classroom, and student engagement. The next 16 hours are spent in a Professional Learning Community setting, where a coach facilitates the meeting to provide a better understanding of specific CCSS instructional strategies and math practices that are useful to teach the Elevate curriculum.
- A CCSS-based curriculum that covers four math content modules: (1) properties and operations, (2) linear equations, (3) ratios and multiple representations, and (4) transformational geometry.

recover from. With this in mind, policymakers and practitioners may wish to consider balancing the desire to accelerate students' math progression with the need to avoid increasing course failure during middle school.

Diagnostic tests can be effective tools for placement and targeting support. Policymakers and practitioners can make use of diagnostic tests to identify students who need additional support.

The diagnostic tests referred to in this research brief are short. They can be administered in less than a single class period, and the results accurately predict student success in future math courses up to 78 percent of the time (Huang, Snipes, & Finkelstein, 2014). Combined with standardized test scores from previous years, teachers, principals, and district personnel are in a position to have a great deal of information regarding students' particular strengths and weaknesses, as well as their chances of success in challenging courses with substantial algebra content.[9] These tests can be administered as early as the 6th grade, and provide detailed information on students' level of performance as well as their performance in particular math content areas (Huang, Snipes, & Finkelstein, 2014). The evidence summarized in this brief suggests that policymakers and practitioners could make use of these assessments early and often in order to target supports and supplemental instruction to students' particular areas of weakness. Students for whom the assessment results suggest borderline chances of success in challenging math courses could be targeted for additional support.

9 Though the analyses relating these tests to future academic performance was done using CST data, these analyses can be easily repeated once the Common Core assessment data become available. In the mean time, the fact the Common Core assessments are believed to be more challenging than their CST predecessors reinforces the notion that placement decisions should be made with caution, and that — if avoiding course failure is an important goal — the standards for placement into challenging math courses should be high.

Summer math supports can improve students' preparation for challenging courses such as algebra, but by themselves they are not enough to ensure that students are ready.

The evidence presented in this brief suggests that policymakers and practitioners can consider supplemental supports as a means of improving students' preparation for challenging middle school math courses. The evidence indicates that students can get a substantial boost in math skills and an increase in their chances of being "algebra ready" from participating in intensive summer support programs such as Elevate Math (Snipes et al., 2015). However, the evidence also suggests that practitioners may need to consider (and evaluate) much higher dosages of support, both over the summer and throughout the school year. For example, though Elevate Math substantially increases students' math skills and algebra readiness, most students participating in the program still test below the threshold associated with algebra readiness. With this in mind, policymakers and practitioners might explore whether longer-term supports further improve the odds of student success in algebra. These longer-term supports could take the form of supports that last beyond the summer into the years in which students encounter these challenging courses. They might also take the form of supplementary instructional supports that begin earlier in students' academic lives. As students with an increased risk of algebra failure can be identified as early as the end of 6th grade (Huang, Snipes, & Finkelstein, 2014), one viable strategy may be to begin providing supplementary supports to students over the summer after 6th grade or in the fall as they move into the 7th grade.

Policymakers and practitioners may wish to exercise caution with respect to placing students in courses for which they are not prepared. Proficiency on the previous year's end-of-course test may not be enough to indicate a good chance of success in the subsequent course.

As policymakers and practitioners use assessment data and to inform decisions regarding when to place students into challenging middle school math courses, they may want to be mindful of an important pattern: most students who score at the threshold for proficiency in previous math courses did NOT succeed when placed into grade 8 Algebra I. The only students who did have a better than 50-50 chance of success were those who scored substantially above the passing threshold (Huang, Snipes, & Finkelstein, 2014). This suggests that, when making placement decisions, district administrators, math teachers, and other education professionals may need to look beyond "proficiency" to assess the particular strengths and weaknesses of each student, and whether that student has reached a point in their skill development where they are more likely than not to succeed if placed in a challenging math course. Moreover, early placement of these students into challenging courses should be weighed against their increased chances of failure and the negative consequences associated with that outcome.

Additional research is needed to confirm the relationship between these assessments and success in new CCSS math courses and tests, and to establish benchmarks that can be used for placement.

The advent of the CCSS in math is likely to generate meaningful changes in the content and sequence of math courses across the middle grades. Though it is unlikely that the fundamental patterns summarized in this research brief will change, additional research will be useful in refining our understanding of these patterns and the manner in which they manifest themselves in a new curricular environment. For example, the relationship between students' math skills and their chances of success in challenging academic courses is unlikely to go away. As such, the need to assess students' skills and their readiness for success in these courses is likely to remain. However, the specific nature of the relationships between specific types of math skills and success in challenging middle school math courses, as well as the overall thresholds associated with success, may change as the content of the courses evolves. Further research will be useful in order to maximize our understanding of the skills that support math success as students move through the middle grades, as well as to refine the specific thresholds and strategies for targeting students for additional support.

The portfolio of work on algebra readiness that is reported in this research brief has been made possible with support from the U.S. Department of Education's Regional Educational Laboratory (REL) program. One of the 10 laboratories, REL West, serving the western states of California, Nevada, Utah, and Arizona, and based at WestEd in San Francisco, has developed a long-standing research alliance with a group of nine school districts in Silicon Valley, along with the Silicon Valley Education Foundation, who have made math preparation a cornerstone of their reform strategy. Over several years, the research program has developed to answer the very questions that have been generated through the alliance; the results from the study are used to directly inform the districts' practices around math placement and instruction. The alliance has demonstrated the utility of a research-practice partnership by enabling rigorous research to move forward in a timely manner, with applicable findings reported to the partnering school districts in Silicon Valley, and others across the state that are currently working on similar issues in algebra preparation.

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Recent REL West Research on Algebra Success

Study 1: Who Repeats Algebra I, and How Does Initial Performance Relate to Improvement When the Course is Repeated?

November 2014

This report addresses the frequency of algebra repetition and the extent to which algebra repeaters succeed in algebra and appear to be prepared for the higher-level courses.

https://relwest.wested.org/resources/91

Study 2: Using Assessment Data to Guide Math Course Placement of California Middle School Students

September 2014

A study that addresses the initial placement of students in algebra and the relationship between algebra success and the skills that students bring to these courses. Which students are likely to succeed in algebra? What are the consequences of struggling in algebra, and what level of success is achieved by students who repeat it?

https://relwest.wested.org/resources/41

Study 3: The effects of the Elevate Math summer program on math achievement and algebra readiness

July 2015

This study examines the effectiveness of a summer school supplementary algebra program that prepares students for their upcoming eighth-grade algebra courses.

https://relwest.wested.org/resources/195

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The Regional Educational Laboratory West (REL West) at WestEd provides scientifically valid research findings that help meet the education needs in Arizona, California, Nevada, and Utah. Our staff draw from existing high-quality research, as well as conduct research and development projects and experimental studies. We also help stakeholders interpret evidence and build their own research capacity.

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Snipes, J. & Finklestein, N. (2015). *Opening a gateway to college access: Algebra at the right time.* San Francisco: REL West @ WestEd.

This report is available online at http://relwest.wested.org/