California Collaborative on District Reform

Policy and Practice Brief

Raising Expectations for Mathematics Instruction in California: Algebra and Beyond

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Authors

Catherine Bitter
cbitter@air.org

Jennifer O'Day
joday@air.org

About the California Collaborative on District Reform

The California Collaborative on District Reform, an initiative of the American Institutes for Research, was formed in 2006 to join researchers, practitioners, policymakers, and funders in ongoing, evidence-based dialogue to improve instruction and student learning for all students in California's urban school systems.

Introduction: Opening the Gateway

As expectations for students to meet high academic standards have risen over the past two decades, so have the expectations for students to complete, and excel in, more rigorous mathematics courses. Once a course reserved only for the college-bound, algebra is now a graduation requirement for all California students as well as an early "gateway" into a college preparatory program. In recent years, pressure has mounted for students to clear this gateway earlier and earlier; while most districts now require algebra in ninth grade, some do so in grade 8 and some offer it as early as seventh grade for some of their students. Meanwhile, data in most districts reveal large discrepancies among student groups in both their enrollment in and their successful completion of Algebra I.

Given algebra's pivotal role in a college preparatory program, such enrollment and performance gaps raise fundamental questions about equity in our schools. How do we ensure that all students have the opportunity to succeed in the advanced mathematics courses they will need to matriculate and be successful in college? At what point in their school careers must they enroll in algebra in order to gain access to those advanced courses before graduation? What kinds of supports are needed to ensure that students who have access to those courses have the skills to succeed in them?

These are among the questions that state policy makers and educators have been debating since the July 2008 motion of the California Board of Education requiring all eighth grade students to take the state Algebra 1 end-of-course exam. Though the state Superior Court subsequently overturned the Board's decision based on process, the questions surrounding this issue remain an important topic for districts across the state.

Ensuring success in algebra for all students involves several key areas of attention and action for districts. These include the creation of a strong K-12 mathematics curriculum, appropriate placement of students in mathematics courses, enhancement of current instructional capacity in mathematics, and provision of additional supports for struggling students. In today's fiscal climate, finding funds to address these issues is perhaps the greatest challenge of all, but the recent infusion of one-time funds from the American Recovery and Reinvestment Act of 2009 (ARRA) may provide new opportunities.

This brief draws on dialogue and investigation among the district practitioners, researchers, and policymakers participating in the California Collaborative on District Reform. In this brief we discuss ways in which districts can approach these issues given the current fiscal and political context in California. We also provide recommendations for strategies the state can use to support districts in these efforts.

Goal: Appropriate Curriculum and Instruction K-12 to Prepare All Students for Success in Rigorous Mathematics

The recent statewide debate focused primarily on *whether algebra should be required in the eighth grade.* For members of the California Collaborative on District Reform, the more fundamental question is: how can we best ensure success for all students in algebra and higher mathematics?

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From this perspective, the heart of a strong algebra program is effective mathematics curriculum and instruction across *all* grade levels, K through 12. A robust foundation in early algebraic concepts can help students succeed when they enroll in Algebra I. In addition, for students to have equitable opportunities to master algebra, the algebra curriculum itself must be conceptual, and rigorous. Students should have the opportunity to enroll in algebra in time to complete other graduation and college preparation mathematics requirements. Finally, districts should consider whether courses *after* Algebra I build on and reinforce the concepts introduced in that course.

Clarify Goals for Mathematics Instruction

District decisions about when students should take and complete Algebra I must take into account the full range and sequence of curricular offerings in mathematics. The starting point for these determinations should be the district's goals regarding mathematics course completion and performance for all students graduating from high school. For example, is the goal for all students to complete the California graduation requirements? For all students to complete the A-G requirements for entrance into the University of California? Once they have set an overall goal for what students should know and be able to do by high school graduation, districts can more appropriately consider what content should be covered in each course and how algebra fits into and supports the district's long-range goal for each student.

Focus and Deepen K-12 Mathematics Instruction

Across grade levels, California's standards and textbooks require teachers to teach an extensive amount and range of content each year. This phenomenon is not specific to California and becomes clear when comparing a common U.S. curriculum map to those of other countries (Schmidt, 2008). The mathematics curriculum in the United States is often repetitive across grades, emphasizing similar concepts with little depth. Topics typically do not build well on one another from year to year, and students may be introduced to a new set of concepts without the necessary prerequisite knowledge. According to Schmidt (2008), this disconnected K-12 curriculum is limited in focus, rigor, and coherence. Teachers struggle to cover all topics, and students are expected to master many concepts in very constrained periods of time.

In addition, the federal and state accountability systems place pressure on teachers to cover all standards in order to prepare students for state assessments. These pressures may force a teacher to move on to a new topic rather than reinforce (or re-teach in a new way) a concept with which students are struggling.

Though districts have little short-term control over the content of the textbooks or the number/type of state standards, they can consider ways to focus instruction and build coherence within the K-12 curriculum by developing *key standards* for each grade.[1] These standards would form the core of the curriculum and would build well on each other

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[1] This is also a key area of action for the state. See recommendations on page 14.

from year to year. Algebraic concepts would be emphasized in these key standards starting in early grades so that students build a foundation in preparation for Algebra I. Textbooks that cover a broad range of topics can be used as resources for more in-depth instruction.

In addition to addressing too many disparate and often incoherent topics, mathematics instruction in early grades (e.g., K-5) often focuses on helping students to get the right answer (e.g., on state assessments) rather than on a conceptual and intuitive understanding of mathematics (Daro, 2008). One reason for this is that conceptual instruction is often difficult for elementary teachers, who are themselves not well trained in mathematics. Inadequate knowledge of mathematics content can lead teachers to rely on calculation processes and mnemonics, which can foster misconceptions among students. For example, students may think they always need to line up numbers "on the right" when adding them together, one above the other (e.g., 32 + 7). However, when a student is then asked to add two numbers with decimals (e.g., 2.1 + 3.32), this strategy can lead to the wrong answer. A conceptual understanding of place value would help students determine that in this latter case they need to line up the decimal points instead of the integers.

Such misconceptions and inability to think through a problem will work against rather than ensure students' ability to produce or even recognize the appropriate answer on state tests or in real life situations. Indeed, the items included on the assessments often involve more flexible problem solving that is not supported by mnemonics. For example, students may have learned the "butterfly" process[2] to add two fractions together, which will not work on a test question that asks for the addition of *three* fractions. Or they may have seen simple questions such as "3+6=X" in class, but not questions where the "answer" is to the left of the equal sign, e.g., "3+X=9" – a very typical standardized test question (Daro, 2008).

[2] This is a mnemonic used when fractions are written side by side. Students first multiply diagonal numbers, writing the answers above the fractions. They then multiply across those two answers for the numerator and add the bottom two numbers for the denominator.

Districts can consider strategies to address misconceptions throughout the K-12 curriculum and to focus instruction on conceptual understanding. Having teachers who are well prepared to teach mathematics is crucial, so building capacity through professional development and recruitment is essential. Focusing instruction on key standards can also allow teachers to spend more time on students' understanding of each concept.

Develop Systems and Criteria for More Effective and Equitable Placement into Algebra and Advanced Mathematics Courses

Once students develop a strong base in mathematics concepts in grades K-7, appropriate placement in challenging courses is critical in providing access to and ensuring success in rigorous, higher-level mathematics. Placement in Algebra I is an essential first step. As discussed earlier, *when* to place students in Algebra I has been the subject of considerable debate in California and nationwide, with an overall push to place more and more eighth grade students in algebra.

Both advocates and critics of universal eighth grade algebra focus their arguments on a desire to equalize opportunity for all students. Those advocating 100% enrollment in eighth grade point out that algebra is a gatekeeper for students to be prepared for and enroll in college. They argue that all students should be given the same opportunities to be well prepared for college. If some students take algebra in eighth grade and others have to wait until grade 9, those who take it early will be advantaged, and achievement and attainment gaps will persist. In addition, if all students are to be tested in algebra in eighth grade, as the State Board's decision mandated, then all students should have the opportunity to be prepared for the test.

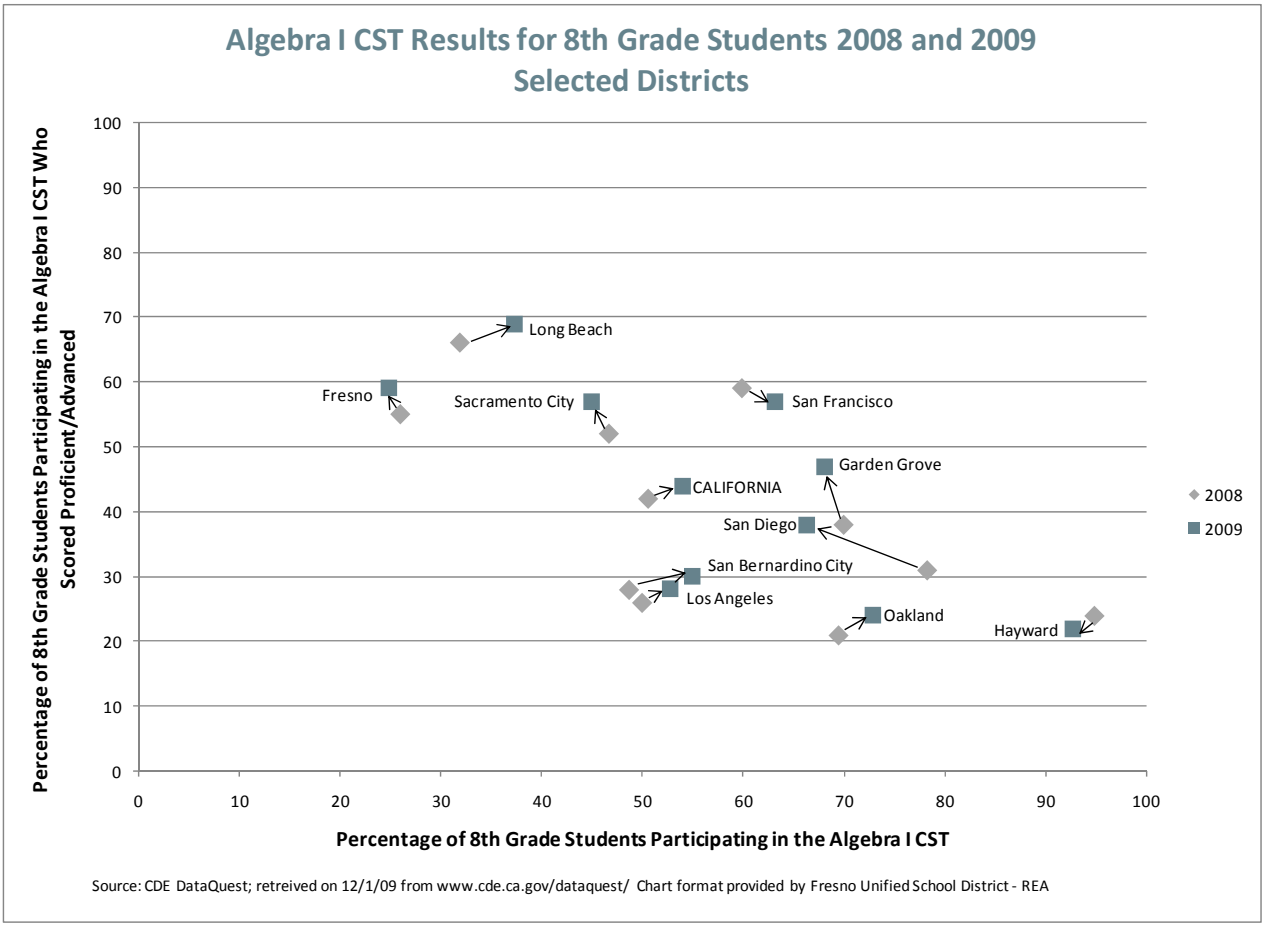
Critics of universal eighth grade algebra, however, argue that enrolling students who are *not* well prepared for algebra does little to foster equity if those students end up experiencing failure and have to repeat the course later on. These students might be better served by strong seventh and eighth grade instruction in algebraic concepts, followed by Algebra I in ninth grade when they can be more successful in the course.

Additionally, mandated algebra for eighth graders could result in fewer students taking math in their junior and senior years of high school, increasing the need for math remediation among graduates (EdSource, 2009). Finally, while algebra is indeed a gateway course for college and career readiness, students do not necessarily need to pass this course in eighth grade to fulfill entrance requirements for the UC system and for other paths.

Districts should consider the impact of increasing eighth grade enrollment in algebra on students' success and proficiency in the course.

To navigate the decision-making process, districts might first consider the impact of increasing eighth grade enrollment in algebra on students' success and proficiency in the course. Statewide trends provide some information on this. According to a report released by EdSource (2009), the percentage of eighth graders taking the Algebra I CST rose from 32% in 2003 to 51% in 2008. The percentage of eighth graders taking the test who scored proficient or advanced *also* increased during this time period, though only slightly (from 39% to 42%). The good news is that in total, 1.8 times as many eighth graders reached proficiency on this exam in 2008 as in 2003. On the flip side, the bad news is that 1.5 times as many eighth graders scored *below or far below basic* in 2008 as in 2003 (EdSource, 2009). While these data suggest that more students are learning algebra successfully in eighth grade, they also indicate that many students may have been placed in Algebra I without the preparation or support for them to succeed. These students will need to repeat the course.

Data from the major urban school districts in California support these conflicting results. The figure below displays algebra performance and enrollment percentages for eighth graders in several urban districts in California, from 2008 to 2009. Ideally, we would like to see districts



Source: CDE DataQuest; retreived on 12/1/09 from www.cde.ca.gov/dataquest/ Chart format provided by Fresno Unified School District - REA

increase both *enrollment* and the percentage of those enrolled students who are *proficient,* to minimize an increase in students who take the course but do not perform well on the test. However, as shown in the figure, many districts struggle to do so. In some cases, districts that *increased* participation in eighth grade algebra experienced a *decrease* in the percentage of test takers who scored proficient/advanced.

Finally, two recent studies raise questions about the benefit of placing underprepared students in eighth grade algebra. Loveless (2008) found that the percentage of low-achieving students in advanced eighth grade mathematics courses (Algebra I or higher) increased from 3.0% in 2000 to 7.8% in 2005. Loveless defined the group of "low-achieving students" as those scoring in the 10th percentile on the NAEP mathematics test and estimated that these students had roughly a second-grade level of mathematics knowledge. With such a low level of mathematics understanding, these "misplaced" students would likely struggle in an algebra course. In addition, teachers trying to teach a rigorous algebra curriculum may struggle to provide additional instruction in basic mathematics to these students.

In another study, Allensworth and Nomi (2009) explored the implications of mandatory Algebra I enrollment for eighth grade students in Chicago Public Schools. Although more students enrolled in Algebra I, as expected, this did not lead to any observable benefits. In fact, failure rates and absenteeism increased among low- and average-ability students.

If *requiring* algebra in eighth grade may not be appropriate for all districts, then how can a district best determine *who* should take algebra in eighth grade? Even districts that are aiming for 100% enrollment in eighth grade algebra will need to identify those students who are ready or not ready for this course as they transition toward higher enrollment rates. They will also need to identify students who need additional support before or during algebra. Several considerations can help districts determine the best placements.

Student Mathematics Pathways

Analyzing the various pathways that students (both struggling and strong) actually take in mathematics before and after they enroll in algebra can help districts determine at what point students must enroll in the course to gain access to advanced courses before graduation. For example, determining which courses eighth grade algebra students pursue in high school can help districts understand how increasing algebra enrollment among eighth graders might affect students' enrollment in more advanced college-preparatory courses. Are students progressing on to more advanced courses? Or are many repeating algebra?[3] Alternatively, for students who do not take algebra in eighth grade, is there another appropriate trajectory that will allow them to reach the overall targets for high school graduation, and college or career readiness? For example, if students enroll in a rigorous algebra course in 9th grade, they could supposedly move on to geometry, pre-calculus, and possibly calculus in the remaining high school years. Is this what actually happens? Finally, for those eighth graders who take but struggle in algebra, districts can consider what pathways through high school will provide other opportunities to succeed in algebra and more rigorous courses. For example, do more advanced courses reinforce basic algebra skills? Are there opportunities for students to build these skills through summer courses or other forms of supplemental instruction?

Equity and Access

Placement questions should be considered within the context of equity and access. A major concern with having some students enroll in algebra earlier than others is that traditionally underserved students will have fewer opportunities. Currently, large discrepancies exist in the enrollment and achievement of students in this course. For example, statewide, 44% of eighth graders who took the Algebra I CST in 2008-09 scored

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[3] According to EdSource (2009), 38% of ninth graders were taking the Algebra I CST for a second time, although some of these students may have taken the test twice because they were in a two-year Algebra sequence.

proficient or above. However, only 26% of African American students and 33% of Hispanic students taking the Algebra I CST reached that level. For students learning English, the gap is even greater: only 18% of English learners who took the Algebra I CST in eighth grade reached proficiency (California Department of Education, n.d.).

One strategy that Fresno Unified School District is exploring to address these discrepancies is the development of a set of indicators to determine which students are prepared for algebra at each grade. Traditionally most districts rely on teacher recommendations and/or grades in previous mathematics courses. While these indicators certainly provide some information on student preparedness, additional data, such as proficiency on the CST, language proficiency levels, and scores on a placement exam, can help inform placement decisions and ensure that the decisions are equitable (Aguilar, 2009).

Examining Data

Developing a system for effective and equitable placement of students into algebra and advanced mathematics courses can involve extensive data analysis. Such an analysis would include not only an examination of student mathematics achievement for various subgroups of students, but also analyses of student enrollment and language proficiency as well as current instructional capacity. In addition, closely analyzing other types of data, including student schedules and course-taking trajectories, can provide valuable information on the implications of increasing algebra enrollment in eighth grade for long-term student success in mathematics. In the box on the next page ("Quantifying the Challenge…"), we outline some of the critical data that districts can examine to determine an approach to mathematics instruction, including the extent to which algebra should be required in eighth grade.

Goal: Instructional Capacity to Support Student Success

Increasing student enrollment in eighth grade algebra and in other higher-level mathematics courses may require a significant investment in or reallocation of resources to ensure the district has the capacity to support student success. To understand the impact on resources, districts can examine what capacity they currently have, such as the number of qualified teachers at each grade level and the number of school- and district-level support staff, and what capacity they will need to implement various approaches.

One place to start is with a review of the qualifications of teachers currently teaching algebra in the district. According to a report by the Center for the Future of Teaching & Learning (2008), the number of middle school students taking Algebra I with an underprepared or "out of field" teacher increased from 73,000 in 2004 to more than 74,000 in 2007. In addition, in California, approximately 32% of teachers assigned to teach Algebra I in middle school do not have a subject matter credential in mathematics (CFTL, 2008). The capacity needs are particularly critical in schools with a large population of traditionally underserved students – students in poor, high-minority schools are more likely to have an underprepared teacher for mathematics (Gaston, 2008). The capacity needs across the state are exacerbated by growing algebra enrollments in middle grades, current shortages of prepared teachers even at the high school level, and the expected retirement of approximately one in five teachers within the next five years (CFTL, 2008). Finally, the California Commission on Teacher Credentialing (CTC) has raised concerns about the assignment of teachers with multiple subjects credentials (earned on the basis of K-7 mathematics standards rather than algebra) to teach middle school algebra, a policy that is allowed in certain circumstances (EdSource, 2009). In 2008, the National Council on Teacher Quality found that multiple-subject elementary teachers differ substantially in their mathematics preparation due to disparate math content requirements in teacher preparation programs across the country. The only commonality in these programs was "widespread inattention to algebra" (Greenberg & Walsh, 2008).

Quantifying the Challenge: Examining Data to Inform a Districtwide Approach to Mathematics

A close examination of student data can inform the approach to algebra enrollment:

- **Mathematics Proficiency:** The level of student math proficiency shows how well the curriculum meets the needs of students. Key data include:
  - Numbers of students passing Algebra I at each grade level.
  - Percentages of students scoring proficient on the mathematics CST at each grade level.
    - Percentage of students passing algebra in each grade level who are also scoring proficient. (These data can help monitor the *rigor* of algebra courses.)
    - Percentage of students who take algebra in eighth grade but do not score proficient on the algebra CST, but then score proficient in ninth and tenth grade. (Measures whether subsequent courses let students succeed.)

  Districts can also consider data **beyond the CST.** Many districts track benchmark assessments across grade levels and have other achievement data available, including teacher-made assessments and chapter tests.

- **Mathematics "Artifacts":** "Artifacts" (Crawford & Dougherty, 2003) include non-achievement data, such as master schedules, transcripts, and student course-taking patterns. These data can help identify the **mathematics pathways** of students before and beyond eighth grade, and inequities in these pathways. They can also shed light on the nature of math curriculum and instruction. Key issues include:
  - Courses students take after passing algebra. (To determine whether eighth grade algebra is providing opportunities for all students to take college-preparatory courses.)
  - Courses students take after struggling in algebra. (To help determine whether there are additional opportunities for students to learn algebra.)
  - Course pathways for students of various subgroups.
  - Student course loads and class sizes to determine whether students receive equitable time and attention from teachers.
  - Quality of algebra courses: Are some students receiving more rigorous algebra instruction than others?

- **Language Proficiency:** Students who are learning English must master algebraic concepts and language simultaneously. Assessing English proficiency prior to algebra can help determine whether students are prepared linguistically. In addition, tracking specific data on students' background, including native language, formal educational experiences, and time in the United States, can provide valuable information about student needs.

- **Student Enrollment:** Determining the total number of students at each grade level, the number of additional students expected to enroll in eighth grade algebra, and the number of students who would enroll in more advanced courses can help districts identify the level of capacity-building required for various approaches. Estimating these data for several years into the future allows districts to develop a long-term strategy for building capacity.

- **Instructional Capacity:** Increasing algebra enrollment for eighth graders, or improving mathematics instruction districtwide, will require that districts hire additional staff or reallocate mathematics staff and support personnel. Key data for districts to consider include:
  - Number of eighth grade mathematics teachers qualified to teach algebra.
  - Number of ninth grade mathematics teachers who could (and would) move to eighth grade.
  - Of the eighth grade mathematics teachers who are not prepared to teach algebra, the number that could be moved to other grade levels or prepared through additional professional development.
  - Number of teachers who will be leaving or retiring in the next 5 years.

The need for instructional capacity to support student success in algebra extends well beyond algebra teachers themselves, however. Teachers of grades K-7 must be prepared to support algebraic thinking and introduce a strong foundation in algebraic content; today too few teachers have such preparation. It will thus be important for districts to know and address the mathematics capacity needs of their pre-eighth grade teachers. In addition, more high school teachers must be prepared to teach advanced classes (e.g., calculus) to the growing numbers of students ready for them. And finally, districts will also need to assess their capacity to provide additional supports for less-well prepared students as they transition toward greater proportions of their students taking higher level mathematics courses. Underneath all these capacity needs may also be a requisite shift in teachers' expectations about who can master these skills at an earlier age – professional development and the development of professional communities can aid in this transition.

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To increase capacity, districts can consider strategies and systems to grow teacher knowledge as well as to recruit more qualified teachers. However, in tight fiscal times, districts also need to think creatively about how to accomplish these tasks. Taking advantage of the federal stimulus funds could allow districts to implement short-term strategies to build capacity, such as providing intensive professional development or incentives for reassigning teachers. In addition, districts may also want to consider alternative ways to increase their instructional capacity in mathematics; for example, the use of technology or incorporation of community college course-taking may be necessary and effective strategies to boost instructional capacity in the short term.

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Build Capacity through Recruitment, Retention, and Reassignment

A close examination of student enrollment and teacher data for several years into the future can inform the district's strategies for recruitment and retention (see box above, "Quantifying the Challenge…"). After considering their capacity strengths and needs, districts might consider the following options for recruitment and retention.

Structuring Incentives

Increasing enrollment in more rigorous mathematics courses may require teacher reassignment. For example, to increase algebra enrollment in eighth grade, districts may need to shift algebra teachers from ninth to eighth grade. Transitioning to middle school is not always a desirable prospect for high school teachers, and therefore districts may consider incentives for reassignment, including financial incentives and opportunities for improved working conditions (e.g., more opportunities for professional learning, modified course loads). Examples of incentive opportunities for recruitment and retention of mathematics teachers include California Senate Bill 1660, which created financial incentives for math, science, and Special Education teachers to work in struggling schools (defined as those in the lowest 30% of the Academic Performance Index (API)) by enabling districts to redirect professional development funds for this purpose. The California Student Aid Commission also offers financial incentives by paying up to $11,000 in student loans for every year spent teaching hard-to-staff subjects—like middle school mathematics (EdSource, 2009). Finally, funds from ARRA could support such incentives.

Partnering with Teacher Preparation Programs

Many districts struggle to find well-qualified teachers who are familiar with their student population and aligned with district goals, strategies, and culture. Finding teachers prepared to teach rigorous mathematics can pose even greater challenges, particularly for elementary schools. Partnering with a local teacher preparation program is a promising strategy to increase the supply of teachers who meet the district's needs. For example, Long Beach Unified School District (LBUSD) has developed a long-term relationship with California State University Long Beach, helping the university to align its teacher preparation program with the needs of the district. Teacher candidates intern in LBUSD and become familiar with the context and students. In exchange LBUSD has been able to influence the standards and expectations for teacher skills within the teacher preparation program.

Integrating Human Resources and Academic Leadership

Human resources (HR) departments within districts often work in isolation. Building tighter connections between HR and the district's academic departments can facilitate communication about the types of skills and background needed in incoming teachers. HR can better understand the needs of the student population and the extent to which teaching candidates are prepared to meet those needs.

Empowering School-Level Mathematics Departments

At the secondary level, mathematics departments can take on more ownership of mathematics outcomes and the improvement of mathematics instruction. Too often mathematics departments serve simply as organizational structures (Daro, 2008). However, leveraging this structure to form a team of educators focused on mathematics pathways and student success could help bridge district-level goals and the school sites. For example, mathematics departments could work more closely with district HR departments to share responsibility for recruiting strong candidates. Or they could take the lead in ensuring their mathematics teachers are well prepared to teach English learners by working with the department of language acquisition or providing support and training for sheltered English instructional strategies.

Provide Effective, High-Quality Professional Development in Mathematics

A strong professional development program can target the skill areas necessary to prepare more students for rigorous courses, including strategies for teaching conceptual understanding of algebra and introducing algebraic concepts in earlier grades. Such a program would target both pedagogical strategies and mathematics content, particularly at the elementary grades, where teachers typically have not been trained in mathematics. In addition, in light of the curriculum considerations discussed above, professional development could help teachers better navigate the curriculum, standards, and textbooks to refine and focus their instruction and make the most of these tools. To be effective, the teacher development would need to be sufficiently intensive, and might require a significant investment in resources. The California Mathematics Project estimates it would cost California $8.5 million to provide professional development programs for 1,500 middle school algebra teachers, 2,000 elementary school teachers, and 2,000 non-algebra middle school teachers – not including teacher stipends or project monitoring and administration expenses (EdSource, 2009).

A strong professional development program would target both pedagogical strategies and mathematics content.

Considerations for providing strong professional development include:

Building Professional Learning Communities

Strong professional learning communities can create ongoing learning opportunities for teachers and provide time for teachers to identify and develop key standards essential for algebra learning. Developing an effective professional learning community can be challenging, however, and ineffective communities are quite common. According to the Collaborative districts, several aligned factors can help professional learning communities develop effectively. These include:

- *A shared vision of the goals of the work*. Co-developing a vision among teachers and administrators can foster buy-in from those participating in the learning community.
- *A system for gathering data and feedback.* A strong data system allows the community to develop relevant goals and to measure the extent to which goals are met.
- *Time for reflection.* Participants need time to revisit goals, develop new courses of action to address issues, and determine what is working and what is not working.
- *Accountability for implementation.* Without a system of accountability, the work of the community can easily drop off as a priority for the teachers.
- *Consistency over time.* For a community to work effectively toward meeting goals, consistency in participation, vision, and strategies is important.
- *Tie work to the classroom.* Classroom visitations, co-teaching, or in-class coaching provide opportunities to break down barriers between teachers and tie goals directly to classroom work.

Such a community could allow teachers to work better together to identify misconceptions among students, articulate content across grade levels, develop assessments to measure algebraic understanding, and develop classroom strategies to increase the focus, rigor, and coherence of their teaching.

Content-Focused Professional Development

Most elementary school teachers have not been formally trained in mathematics (e.g., with a college degree in math). Thus, a strong professional development program in mathematics pedagogical content knowledge could help teachers in these earlier grades understand algebraic concepts and learn ways to introduce them to their students in a focused and coherent way. Such a program could focus on the identification of common misconceptions and ways to address them. Additionally, the CTC is considering reviving the mathematics specialist credential. Such specialists could be comprised of veteran teachers, and could provide support for multiple-subject teachers in elementary and middle school, demonstrate lessons, and provide professional development (EdSource, 2009).

Goal: Effective Support for Struggling Students

Increasing student achievement in algebra will require a long-term process of capacity building and refinement of curriculum to ensure that students enter algebra with a strong foundation in algebraic concepts. Until this foundation is in place, it is likely that many students will reach algebra without the sufficient background and skills to be successful. In addition, these students are likely to be from traditionally underserved backgrounds and attending large, urban schools with many students from poverty (Loveless, 2008). Districts must consider strategies to provide intensive support to these students to address misconceptions and boost pre-algebra knowledge and skills. Though additional supports may serve as a short-term strategy to address gaps in knowledge until reforms take hold, it is likely that there will always be students who need additional support. Thus, districts may want to consider both short- and long-term plans for such supports.

Until a strong foundation in algebraic concepts is in place, it is likely that many students will reach algebra without the sufficient background and skills to be successful.

Tiered/ Differentiated Support for Students

Student supports can range from in-class assistance and feedback to out-of-class interventions at various levels of intensity, depending on student need. The cost, of course, increases for more individualized and intensive formats, so districts should consider how schools can best target the appropriate level of support to the students who need it, given funds available. Teachers who have formed a strong professional community could work together to identify students in need of additional assistance and target appropriate support strategies for them. In addition, districts may need higher-intensity supports for more students in the short term, and lower-intensity supports for more students once strategies to improve the K-7 program have been established. Options for support include these (Daro, 2008):

- *In-class supports* – These could include additional one-on-one teacher feedback, small group instruction, or partner work. These strategies can target students who are struggling with some concepts but have a generally firm base in algebraic concepts.

- *Lower-intensity outside-of-class support* – For students who are not keeping pace, supports such as homework clinics, tutoring, and teacher support outside of class (e.g., during lunch, after school) can help provide the additional instructional time necessary for these students to catch up on algebra preparation skills and for teachers to address students' misconceptions that have developed over time.

- *Higher-intensity outside-of-class support* – Students who are far behind and/or have severe misconceptions will need higher intensity support. This could include remedial courses and extended day or summer programs. A goal would be to reduce the numbers of students needing such high-intensity support over time as the mathematics program increasingly addresses the skills students need to be successful in algebra and beyond.

Targeted Support for Subpopulations

Additional supports for subpopulations, such as English learners, can target areas of need, including language acquisition, to help these students keep pace and on track to algebra. See the text box on the next page regarding special considerations for English learners.

Considerations for ELs

Approximately 25% of California's students are designated as English learners (ELs). This population continues to grow in size and diversity, but EL achievement in mathematics continues to lag behind that of other student subpopulations. More resources and better-prepared teachers are needed to provide these students with appropriate opportunities to learn and succeed.

Algebra is a particularly challenging course for ELs in English-only classrooms since it transitions from concrete number manipulations to abstract thinking (Lager, 2004), requiring a much higher level of language. Students are not only learning the mathematics itself, but simultaneously learning common English and academic mathematical English (Cummins, 2003). Common EL struggles include unknown or misunderstood vocabulary and misunderstood syntax (e.g., unusual sentence or question constructions) (Lager, 2004). Students do not necessarily realize they are misinterpreting a question (e.g., if they recognize all the words) and therefore do not always ask for clarification. In addition, students often do not have the language to properly explain or justify an answer, and therefore teachers get only a limited understanding of students' comprehension and learning.

To better address these needs, teachers of advanced mathematics courses, including algebra, can consider themselves teachers of language as well as mathematics. Strategies include building on students' current knowledge of language (both their native language and English) and previous mathematics knowledge; scaffolding new learning with techniques such as modeling, small-group work, use of visuals, and language clarification; and actively developing students' general academic and mathematics vocabulary (Cummins, 2003). Particular attention should be paid to assessing student learning in ways that access students' knowledge of mathematics and language. Districts should provide opportunities for mathematics teachers to learn about ELs' language needs and ways to assess and address these needs within the context of mathematics instruction. In addition, districts should allocate resources to supporting the learning needs of ELs in mathematics, including instructional materials to aid in mathematical language acquisition, additional student supports, and, where appropriate, native language instruction.

Leveraging Federal Stimulus Funds for a Focus on Mathematics

Addressing the issues outlined in this brief may require a significant investment in resources. In a time of fiscal retrenchment, such an investment may seem impossible for many districts. However, we recommend districts consider ways to use federal stimulus money efficiently to start addressing their mathematics program. Many of these issues require a significant *initial* investment in resources with longer-term funding to sustain a program. The federal stimulus funds could provide the initial investment for the first few years, and allow time for districts to reallocate and obtain additional funding for longer-term sustainability.

Use American Recovery and Reinvestment Act Funds for Short-Term Strategies to Increase Student Success in Rigorous Higher-Level Mathematics Courses

Possible allocations for resources include:

Data Analysis

As discussed above, a thorough examination of data enables districts to determine their current

needs in terms of students' success in mathematics. The data can also help districts better understand how many and which students are prepared for algebra at various grade levels, and whether these students are on a solid trajectory to advanced mathematics courses. These analyses can help inform an approach to mathematics. However, data analysis can be time consuming and resource intensive, requiring significant investments in data collection, analysis, and infrastructure for ongoing data monitoring. Federal stimulus funds could support such an investment.

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Capacity Building

While the short-term nature of the funds prevents districts from using the money for long-term additional staff, the funds can be used for initial capacity-building efforts to develop current staff, such as intensive professional development for current teachers or incentives for high school teachers to move to middle schools. In particular, the development of professional learning communities requires a significant initial investment in time for teachers to meet together, develop common goals, plan together, and learn from each other to set the foundation for ongoing partnerships and cross-learning. Creating time for teachers to meet together and develop such relationships could be an ideal area in which to target federal stimulus dollars.

Student Supports

In the short term, federal stimulus money may be an excellent source of funds for providing an intensive level of support to students as they transition to a more rigorous course of study. For example, funds could be used for tutoring, homework clinics, additional instructional materials, or extended day or summer programs in the short term.

Conclusion

The current debate in California over eighth grade algebra enrollment has presented districts with an opportunity to think critically about their algebra programs and capacities. We reiterate, however, that the eighth grade algebra question is just a piece of what districts must consider in their overall efforts to help students meet high standards in mathematics. An informed approach will take into account students' current achievement in mathematics (both for all students and for subgroups of students), the district's curriculum and goals for student course completion, and the district's current capacity with respect to teachers, instructional support staff, and funds available for student support. A strong curriculum in K-12, appropriate student placement strategies, high-quality teacher recruitment and professional development, and an effective differentiated student support program are all essential to district efforts to improve their mathematics programs and outcomes. Districts that can move forward at this time to examine their program and address challenges in these areas will be better prepared to meet the rising expectations for more students to succeed in algebra and beyond.

Implications/Recommendations for the State

Given the court's hold on the eighth grade algebra testing mandate, now is a good time for the state to consider the overall goals for K-12 mathematics proficiency and to closely examine the supports and resources available statewide to improve students' success in rigorous mathematics courses.

- **We recommend that enrolling all eighth graders in algebra be a district-level decision and not be mandated by the state.** Districts can best determine whether requiring algebra in eighth grade is an appropriate strategy for improving students' performance in advanced mathematics courses. Nonetheless, the state still needs to address the compliance issues with NCLB testing, which require that the CST match the standards for each grade level. To satisfy this requirement, **we recommend the state develop eighth grade mathematics standards**, which include early algebraic concepts, on which to base an eighth grade mathematics CST.
- **The state should reexamine the state-adopted standards and textbooks**. The California standards have been in place for 12 years (California State Board of Education, 1997). Now is the time to revisit these standards to ensure that instruction is focused on conceptual understanding, that algebraic concepts are built into the curriculum at earlier grades, that misconceptions are addressed, that the material covered each year builds in a coherent way from previous years, and that all students are expected to receive rigorous instruction. The common core standards developed by the National Governors Association and the Council of Chief State School Officers provide an excellent opportunity for this review and for identifying a core set of clearer, fewer standards in algebra that allow teachers to teach essential topics in depth to ensure that all students understand each concept thoroughly. Technology-based instructional tools present a potential supplemental approach for students to access mathematics material. However, all standards and instructional materials should be reviewed with English learners' needs in mind.
- **The state should provide more diagnostic data on student performance – e.g., performance of subgroups on pre-algebra and algebra exams**. These additional data will enable districts to diagnose weaknesses in their instructional program, and allow teachers to use the data to address individual student needs in future courses and provide sufficient support for students who struggled on the exam.
- **Teacher credentialing requirements should include the mathematics knowledge necessary to teach algebraic concepts in early grades.** This includes both relevant content knowledge and *pedagogical content* knowledge. Teachers should be expected to demonstrate that they can prepare students well for algebra and more challenging material.
- California faces a shortage of qualified mathematics teachers. **The state should consider alternative strategies to build the pool of qualified mathematics teachers in the state.** Such strategies could include additional incentives for mathematics majors to become teachers, and incentives for districts to build mathematics teacher pipelines, or strategies to recruit mathematics teachers from related fields outside education.
- **The state should consider how accountability programs like the District Assistance and Intervention Team (DAIT) program can better support students' success in rigorous mathematics courses at the secondary level.** Requirements for districts and schools in improvement or corrective action should allow for supports and time for students to master their mathematics skills. Alternative support strategies should be considered (e.g., the partnership between Fresno and Long Beach Unified School Districts).
- **The state should allocate resources, e.g., federal stimulus funds, toward addressing issues of English learners in algebra.** Such actions could include investigations of academic language requirements, provision of materials and guidance for professional development of teachers of ELs, and review and/or development of assessments to better gauge students' language preparation for advanced mathematics courses.

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California Collaborative on District Reform

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The California Collaborative on District Reform, an initiative of the American Institutes for Research, was formed in 2006 to join researchers, practitioners, policymakers, and funders in ongoing, evidence-based dialogue to improve instruction and student learning for all students in California's urban school systems.

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