# REL Appalachia Ask A REL Response 

Math

January 2020

## Question:

What are the outcomes for students who take Algebra I in grades 5, 6, 7, or 8 compared with students who take Algebra I in grade 9 or later?

## Response:

Thank you for your request to our REL Reference Desk regarding evidence-based information about outcomes for students who take Algebra I in middle school. Ask A REL is a collaborative reference desk service provided by the 10 Regional Educational Laboratories (RELs) that, by design, functions much in the same way as a technical reference library. Ask A REL provides references, referrals, and brief responses in the form of citations in response to questions about available education research.

Following an established REL Appalachia research protocol, we searched for peer-reviewed articles and other research reports on outcomes for students who take Algebra I in middle school. We focused on identifying resources that specifically addressed the outcomes for students who take Algebra I in grades 5, 6, 7, or 8, although there was limited research on outcomes for students who take algebra before grade 8. The sources included ERIC and other federally funded databases and organizations, research institutions, academic research databases, and general Internet search engines. For more details, please see the methods section at the end of this document.

The research team did not evaluate the quality of the resources provided in this response; we offer them only for your reference. Also, the search included the most commonly used research databases and search engines to produce the references presented here, but the references are not necessarily comprehensive, and other relevant references and resources may exist. References are listed in alphabetical order, not necessarily in order of relevance.

## References

Cirino, P. T., Tolar, T. D., \& Fuchs, L. S. (in press). Longitudinal algebra prediction for early versus later takers. The Journal of Educational Research, 1-13. Retrieved from https://eric.ed.gov/?id=ED589565

From the abstract: "Algebra I is a crucial course for middle and high school students for successful STEM related coursework. A key issue is whether students should take Algebra I in 8th versus 9 th grade. Large-scale policy studies show conflicting results, and there are few (particularly longitudinal) individual difference studies. Here, 53 students were assessed in 6th grade on cognitive, numerosity, and mathematical skills, and then followed; 26 students took Algebra I in 8th grade, and the other 27 in 9th grade. Comparisons between groups at grade 6 revealed gaps in some (but not all) cognitive skills and on mathematical competencies, but not on numerosity. By Algebra I, gaps in cognitive skills diminished, but gaps in mathematical skills remained constant. Gaps in algebra skills were also apparent, despite the age difference between groups. Results suggest that the additional year of instruction was not optimally tuned to pave the way for strong Algebra I performance."

Clotfelter, C., Ladd, H., \& Vigdor, J. (2012). The aftermath of accelerating algebra: Evidence from district level policy initiatives (NBER Working Paper No. 18161). Cambridge, MA: National Bureau of Economic Research. Abstract retrieved from https://eric.ed.gov/?id=ED566129; full text available at https://www.nber.org/papers/w18161.pdf

From the abstract: "In 2002/03, the Charlotte-Mecklenburg Schools in North Carolina initiated a broad program of accelerating entry into algebra coursework. The proportion of moderately performing students taking Algebra in 8th grade increased from half to 85\%, then reverted to baseline levels, in the span of just five years. We use this policy-induced variation to infer the impact of accelerated entry into algebra on student performance in math courses as students progress through high school. Students affected by the acceleration initiative scored significantly lower on end-of-course tests in Algebra I, and were either significantly less likely or no more likely to pass standard follow-up courses, Geometry and Algebra II, on a college-preparatory timetable. Although we also find that the district assigned teachers with weaker qualifications to Algebra I classes in the first year of the acceleration, this reduction in teacher quality accounts for only a small portion of the overall effect."

Domina, T., McEachin, A., Penner, A., \& Penner, E. (2015). Aiming high and falling short: California's eighth-grade algebra-for-all effort. Educational Evaluation and Policy Analysis, 37(3), 275-295. Abstract retrieved from https://eric.ed.gov/?id=EJ1072750; full text available at
https://pdfs.semanticscholar.org/8cf4/9e9b2a67dd4f0086a6d375a5944beee62c41.pdf
From the abstract: "The United States is in the midst of an effort to intensify middle school mathematics curricula by enrolling more 8th graders in Algebra. California is at the forefront of this effort, and in 2008, the state moved to make Algebra the accountability benchmark test for 8th-grade mathematics. This article takes advantage of this unevenly implemented policy to understand the effects of curricular intensification in middle school mathematics. Using district-level panel data from all California K-12 public school districts, we estimate
the effects of increasing 8th-grade Algebra enrollment rates on a 10th-grade mathematics achievement measure. We find that enrolling more students in advanced courses has negative average effects on students' achievement, driven by negative effects in large districts."

Dougherty, S. M., Goodman, J., Hill, D. V., Litke, E. G., \& Page, L. C. (2014). Updating Algebra for All?: Evidence of a middle-grades math acceleration policy. Paper presented at the Society for Research on Educational Effectiveness. Retrieved from
https://eric.ed.gov/?id=ED562828
From the abstract: "The Wake County Public School System (WCPSS) in North Carolina recently addressed the issue of advancement in and equitable access to advanced mathematics. Under a recent policy, WCPSS uses a SAS-generated predicted probabilities of students' success in obtaining a passing score on the NC Algebra I End-of-Course (EOC) exam, to determine recommended course placement in grades 6 through 8 . The authors examine the question: do students who are just eligible for advancement in mathematics in middle school and who participate in advanced mathematics lead to improved academic outcomes compared to students who just miss being eligible for advancement and who do not enroll in advanced mathematics? By focusing on the students on the margin of eligibility under this policy the authors use a regression-discontinuity design to estimate the causal impact of this mathematics acceleration policy on subsequent test scores, grades, and course-taking behavior of middle-school students in Wake County who were exposed to this policy. The results indicate that students on the margin of eligibility and who participate in advanced mathematics in middle school may experience negative effects as a result of being in a peer group of more advanced ability, on average."

Koon, S., \& Davis, M. (2019). Math course sequences in grades 6-11 and math achievement in Mississippi (REL 2019-007). Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, Regional Educational Laboratory Southeast. Retrieved from:
https://eric.ed.gov/?id=ED597299
From the abstract: "Fewer than one in five grade 11 students in Mississippi is ready for college math, even though state high school graduation requirements include Algebra I and three additional math credits. Because the requirements do not specify what math courses must be taken to fulfill the additional three credits, students generally select from a list of approved courses, which raises the need to understand the extent to which math course sequences are related to college ready performance on the ACT. This study examined the sequences of math courses that Mississippi students who started grade 6 in 2011/12 took in grades 6-11; the math achievement and demographic characteristics of students who took similar math sequences; and how math sequences, prior math achievement, and student demographic characteristics relate to college readiness in math. Math sequences became more diverse in later grades, consistent with the increase in course options. Students took 3,404 unique math sequences, which can be grouped into six clusters based on similarities in the courses taken and the order in which they were taken. Average math achievement in grade 11 was highest for students who followed the Algebra I to Geometry to Algebra II to Algebra III sequence beginning in grade 8 ; the sequence was followed by disproportionately more female students than male students and more White students than Black students.

Grade 5 math achievement and race/ethnicity but not math sequence were the most efficient variables with the highest classification accuracy for identifying a student as at risk of failing to meet the ACT college readiness benchmark in math. This suggests that there is no clear relationship between math sequence and the likelihood of being ready for college math, after grade 5 math achievement and race/ethnicity are controlled for."

Liang, J.-H., Heckman, P. E., \& Abedi, J. (2012). What do the California standards test results reveal about the movement toward eighth-grade Algebra for All? Educational Evaluation and Policy Analysis, 34(3), 328-343. Abstract retrieved from https://eric.ed.gov/?id=EJ975445; full text available at https://edsource.org/wp-content/uploads/old/Algebra-CST-UCDavisStudy0812121.pdf

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

Loveless, T. (2013). Part III: Advanced math in eighth grade. In The 2013 Brown Center Report on American Education: How well are American students learning? [Volume 3, Number 2] (pp. 22-32). Washington, DC: The Brookings Institute. Retrieved from https://www.brookings.edu/research/advanced-math-in-eighth-grade/

From the introduction: "As recently as 1990, taking algebra in eighth grade was unique. That has changed dramatically in recent years, and now more eighth graders take algebra than any other math class. Enrollment in eighth-grade algebra-and in other advanced math classes-varies by state. This section of the Brown Center Report exploits that variation to study the relationship of states' enrollment in advanced math classes and scores on NAEP. The research question is whether a relationship exists between changes in advanced math enrollments and changes in 8th grade NAEP scores. Do states that boost advanced enrollments experience a concurrent increase in achievement? A second analysis uses the same technique to look at the potential that advanced courses are being 'watered down.' Are rising enrollments associated with lower mean achievement in advanced classes?"

Penner, A. M., Domina, T., Penner, E. K., \& Conley, A. (2015). Curricular policy as a collective effects problem: A distributional approach. Social Science Research, 52, 627-641. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4457374/pdf/nihms670468.pdf From the abstract: "Current educational policies in the United States attempt to boost student achievement and promote equality by intensifying the curriculum and exposing students to more advanced coursework. This paper investigates the relationship between one such effort-California's push to enroll all 8th grade students in Algebra-and the distribution of student achievement. We suggest that this effort is an instance of a 'collective effects' problem, where the population-level effects of a policy are different from
its effects at the individual level. In such contexts, we argue that it is important to consider broader population effects as well as the difference between 'treated' and 'untreated' individuals. To do so, we present differences in inverse propensity score weighted distributions to investigate how this curricular policy changed the distribution of student achievement more broadly. We find that California's attempt to intensify the curriculum did not raise test scores at the bottom of the distribution, but did lower scores at the top of the distribution. These results highlight the efficacy of inverse propensity score weighting approaches for estimating collective effects, and provide a cautionary tale for curricular intensification efforts and other policies with collective effects."

Simzar, R., Domina, T., \& Tran, C. (2016). Eighth-grade algebra course placement and student motivation for mathematics. AERA Open, 2(1), 1-26. Retrieved from
https://eric.ed.gov/?id=EJ1194596
From the abstract: "This study uses student panel data to examine the association between algebra placement and student motivation for mathematics. Changes in achievement goals, expectancy, and task value for students in eighth-grade algebra are compared with those of peers placed in lower-level mathematics courses ( $N=3,306$ ). In our sample, students placed in algebra reported an increase in performance-avoidance goals as well as decreases in academic self-efficacy and task value. These relations were attenuated for students who had high mathematics achievement prior to algebra placement. Whereas all students reported an overall decline in performance-approach goals over the course of eighth grade, previously high-achieving students reported an increase in these goals. Lastly, previously high-achieving students reported an increase in mastery goals. These findings suggest that while previously high-achieving students may benefit motivationally from eighth-grade algebra placement, placing previously average- and low-performing students in algebra can potentially undermine their motivation for mathematics."

Walston, J., \& McCarroll, J. C. (2010). Eight-grade algebra: Findings from the eight-grade round of the early childhood longitudinal study, kindergarten class of 1998-99 (ECLS-K). Statistics in Brief (NCES-2010-016). Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics. Retrieved from https://eric.ed.gov/?id=ED512148

From the brief: "This Brief is intended to provide descriptive statistics about various aspects of algebra enrollment in the eighth grade. The first analyses describe who is taking algebra in the eighth grade; findings compare eighth-grade course enrollment percentages for students with different demographic, family, geographic, and school characteristics (table 1). The second set of findings looks at eighth-grade algebra enrollment levels in the schools and reports the percentage of students who attend schools with relatively low, medium, and high levels of eighth-grade algebra enrollment by demographic, family, geographic, and school characteristics (table 2). The next set of findings incorporates data collected at the end of fifth grade. Enrollment in algebra or higher is compared by varying levels of fifthgrade mathematics achievement (figure 1), and among students with relatively strong fifthgrade mathematics scores, enrollment is compared by sex and race/ethnicity (figure 2). Enrollment in algebra or higher in eighth grade is also compared for students with varying
views about mathematics as self-reported in the fifth grade (figure 3). The final set of findings describe mathematics achievement scores and other student measures from the end of eighth grade for students not yet in algebra and those in algebra or higher. First, the eighth-grade mathematics scores for those in algebra by the eighth grade and those not yet in algebra are broken down by demographic, family, geographic, and school characteristics (table 3), and by fifth-grade mathematics score quintiles (figure 4). Findings are then presented that look at student-reported enjoyment of mathematics (figure 5) and future educational expectations (figure 6) by course enrollment."

## Additional Ask A REL Responses to Consult

Ask A REL Appalachia at SRI International. (2017). What is the impact of tracking in mathematics in grades 5-8 on students' mathematics achievement and future mathematics pathways? Retrieved from https://ies.ed.gov/ncee/edlabs/regions/appalachia/askarel/aar19.asp

Ask A REL Appalachia at SRI International. (2017). What type of mathematical skills and knowledge predict success in algebra l? What does the research say about strategies or interventions to improve algebra readiness (particularly in middle school)? Retrieved from https://ies.ed.gov/ncee/edlabs/regions/appalachia/askarel/aar05.asp

Ask A REL Northeast \& Islands at Education Development Center. (2017). What recent research is available regarding middle school tracking in mathematics, closing achievement gap in mathematics, and acceleration in middle school math and HS Algebra I in 8th grade? Retrieved from https://ies.ed.gov/ncee/edlabs/regions/northeast/AskAREL/Response/50

Ask A REL Northwest at Education Northwest. (2019). What does the research say about the readiness and placement of eighth grade students in algebra? Retrieved from https://ies.ed.gov/ncee/edlabs/regions/northwest/askarel/algebra.asp

Ask A REL Southeast at Florida State University. (2017). What research has been conducted on a "Grade 8 Algebra for All" policy? Retrieved from https://ies.ed.gov/ncee/edlabs/regions/southeast/aar/m 03-2017.asp

## Additional Organizations to Consult

## National Council of Teachers of Mathematics: https://www.nctm.org/

From the website: "The National Council of Teachers of Mathematics advocates for highquality mathematics teaching and learning for each and every student."

- Algebra: Not ‘If' but 'When': https://www.nctm.org/News-and-Calendar/Messages-from-the-President/Archive/Linda-M -Gojak/Algebra -Not- If -but- When /

From the President's messages: "Algebra has often been referred to as a 'gatekeeper' to higher learning -both in mathematics and in other fields. Research shows that students who complete a mathematics course beyond the level of Algebra 2 are more than twice as likely to pursue and complete a postsecondary degree. Students who don't do well in algebra compromise their career options, especially in STEM fields. The question is no longer if students should take algebra but rather when students should take algebra."

## Methods

## Keywords and Search Strings

The following keywords and search strings were used to search the reference databases and other sources:

- (algebra OR "accelerat* algebra") AND ("middle school" OR "eighth grade") AND (effect* OR impact OR outcome*)
- (algebra OR "accelerat* algebra") AND ("middle school" OR "eighth grade") AND (confid* OR self-efficacy OR persistence)


## Databases and Resources

We searched ERIC, a free online library of more than 1.6 million citations of education research sponsored by the Institute of Education Sciences (IES), for relevant resources. Additionally, we searched the academic database ProQuest, Google Scholar, and the commercial search engine Google.

## Reference Search and Selection Criteria

In reviewing resources, Reference Desk researchers consider-among other things-these four factors:

- Date of the publication: Searches cover information available within the last ten years, except in the case of nationally known seminal resources.
- Reference sources: IES, nationally funded, and certain other vetted sources known for strict attention to research protocols receive highest priority. Applicable resources must be publicly available online and in English.
- Methodology: The following methodological priorities/considerations guide the review and selection of the references: (a) study types—randomized controlled trials, quasi experiments, surveys, descriptive data analyses, literature reviews, policy briefs, etc., generally in this order; (b) target population, samples (representativeness of the target population, sample size, volunteered or randomly selected), study duration, etc.; (c) limitations, generalizability of the findings and conclusions, etc.
- Existing knowledge base: Vetted resources (e.g., peer-reviewed research journals) are the primary focus, but the research base is occasionally slim or nonexistent. In those cases, the best resources available may include, for example, reports, white papers, guides, reviews in non-peer-reviewed journals, newspaper articles, interviews with content specialists, and organization websites.

Resources included in this document were last accessed on January 21, 2020. URLs, descriptions, and content included here were current at that time.

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[^0]:    This memorandum is one in a series of quick-turnaround responses to specific questions posed by education stakeholders in the Appalachia region (Kentucky, Tennessee, Virginia, and West Virginia), which is served by the Regional Educational Laboratory Appalachia (REL AP) at SRI International. This Ask A REL response was developed by REL AP under Contract ED-IES-17-C-0004 from the U.S. Department of Education, Institute of Education Sciences, administered by SRI International. The content does not necessarily reflect the views or policies of IES or the U.S. Department of Education, nor does mention of trade names, commercial products, or organizations imply endorsement by the U.S. government.

