LEADING INDICATOR SPOTLIGHT

Pre-algebra and Algebra Enrollment and Achievement

Lindsey Musen

A Companion Series to
Beyond Test Scores: *Leading Indicators for Education*

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About the Leading Indicator Spotlight series of research briefs

Improving student outcomes and closing achievement gaps takes time – more time than is often allowed in typical big-city political environments. Education leaders and community members need a way to monitor how much – if any – progress is being made in their schools and school systems *before* the results show up in indicators like student test scores, when it is often too late to intervene effectively.

Leading indicators that signal early progress toward academic achievement allow education leaders, especially at the district central office level, to make decisions about supporting student learning that are less reactive and more strategic. The concept of leading indicators builds on existing efforts by school districts to use data to inform systemwide decision making.

The report *Beyond Test Scores: Leading Indicators for Education*, published by the Annenberg Institute in 2008, looks at four school districts that are in the vanguard of data-informed decision making. The report examines how these districts – Hamilton County (Chattanooga, Tennessee), Montgomery County (Maryland), Naperville (Illinois), and Philadelphia (Pennsylvania) – are developing and using leading indicators for education.

The Leading Indicator Spotlight series of research briefs is designed to accompany *Beyond Test Scores*. Each brief examines in detail one leading indicator identified in the study and answers the questions:

- Why is this indicator useful for monitoring academic achievement?
- How do school districts measure this indicator?
- How can districts act on this indicator for intervention and reform?

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Introduction

In *Beyond Test Scores: Leading Indicators for Education*, Foley and colleagues (2008) define *leading indicators* as those that "provide early signals of progress toward academic achievement" (p. 1) and stress that educators "need leading indicators to help them see the direction their efforts are going in and to take corrective action as soon as possible" (p. 3). The authors identify pre-algebra and algebra enrollment as one leading indicator that is commonly used by school districts. This brief in the Leading Indicator Spotlight series will discuss why this indicator is useful, how this indicator is measured by school districts, and how districts can put data about this indicator into action for intervention and reform.

Why use algebra enrollment and achievement as a leading indicator?

Success in algebra opens doors to more advanced math, a college preparatory high school curriculum, higher college going rates, and higher college graduation rates.

> The academic intensity of the student's high school curriculum still counts more than anything else in precollegiate history in providing momentum toward completing a bachelor's degree. . . . The highest level of mathematics reached in high school continues to be a key marker in precollegiate momentum, with the tipping point of momentum toward a bachelor's degree now firmly above Algebra II. (Adelman 2006, pp. xviii–xix)

Success in algebra is also linked to job readiness and higher earnings once the student has entered the workforce (Achieve 2008b). As the global economy grows more quantitative and competitive, the demands of college faculty and employers for advanced math skills are increasing. Many are concerned that our future workforce won't have the skills it needs to succeed in the new economy (Evan, Gray & Olchefske 2006).

Furthermore, there is a gap in both access to and enrollment in advanced math courses between minority and low-income students and their more affluent peers (Evan, Gray & Olchefske 2006).

> Not all high schools present adequate opportunity-to-learn, and some groups of students are excluded more than others. Latino students, for example, are far less likely to attend high schools offering trigonometry (let alone calculus) than White or Asian students. Students from the lowest socio-economic status (SES) quintile attend high schools that are much less likely to offer any math above Algebra II than students in the upper SES quintiles. (Adelman 2006, p. xviii)

In response, many urban school districts are increasing access to rigorous coursework, particularly in math, and encouraging students to take pre-algebra and Algebra I in middle school.

Gateway to advanced math and college success

> Algebra is a foundation and language system on which higher order mathematics, science, technology, and engineering courses are built.
>
> – *Aimee Evan, Tracy Gray, and Joseph Olchefske,* The Gateway to Student Success in Mathematics and Science

Algebra is a prerequisite for many high school math courses: geometry, Algebra II, trigonometry, calculus, and statistics. There is an emphasis on passing algebra in eighth or ninth grade so that students have time to take higher-level math courses before graduating from high school. Evan, Gray, and Olchefske (2006) emphasize the importance of the middle school years in establishing academic pathways:

> Because the trajectory for taking advanced high school coursework is set prior to ninth grade, it is imperative that students begin their academic preparation for advanced mathematics and science coursework in middle school. The middle school years are when students decide which academic path they will take. (p. 3)

Students develop a way of thinking in basic algebra that is then applied in the contexts of advanced courses in a variety of fields (Achieve 2008b). In particular, Algebra II was defined as a key threshold for college access and success, since many colleges and universities begin their credit-bearing math courses above the Algebra II level.

Success in Algebra II in high school is linked to both college enrollment and bachelor's degree attainment. Currently, many four-year institutions of higher education require students to have completed Algebra II to be eligible for admissions (Achieve 2008b). On average, 22 percent of entering college freshmen fail placement tests for college-level math and are placed in non–credit-bearing remedial courses (Evan, Gray & Olchefske 2006). Two-thirds of students who take remedial math courses end up dropping out of college (Achieve 2006). This demonstrates that there is a gap between the math education K–12 schools are providing and the expectations of college coursework.

There is a growing demand for students to graduate from high school college-ready. The importance of a strong high school academic experience is undisputed among scholars. Landmark studies by Clifford Adelman in 1999 and 2006 found that of the students who enrolled in college, "the courses students take in high school are more predictive of [college] success than family income and race" (Adelman 1999, 2006, as cited in Achieve 2004b, p. 3). When White and minority students enter college with similar high school transcripts, the bachelor's degree attainment gap is cut in half. Adelman's key finding was that students who had taken Algebra II in high school were twice as likely to earn a bachelor's degree as students who had not taken this course but had also enrolled in college (Adelman 2006).

Therefore, Algebra I acts as a gateway to a bachelor's degree. Early algebra course taking provides access to more advanced math while students are still in high school, which opens the doors to college enrollment. Enrollment in pre-algebra and algebra serves as an indicator for college-readiness status at graduation.

Gateway to careers

> The Information Age workplace assigns a high premium to the analytic competencies of mathematics and science that are so central to our global digital economy.
>
> – *Aimee Evan, Tracy Gray, and Joseph Olchefske,* The Gateway to Student Success in Mathematics and Science

The global economy is increasingly technical, quantitative, and knowledge-based. In the United States, there has been a significant shift from a manufacturing- and agriculture-based economy to a knowledge- and service-based economy. However, even manufacturing and agriculture are demanding more technical skills, and there is growing concern that we won't have the highly skilled labor supply required to compete. At the core of this issue is math and science education.

There is evidence of a consensus among leaders that these demands are growing (Evan, Gray & Olchefske 2006). This implies a shift in what it means to be "job ready" and what schools can do to prepare students for the workforce. Studies show that workers with higher incomes took more advanced math courses in high school than workers with lower incomes (Achieve 2004b, 2006; NMAP 2008; Murnane, Willet & Levy 1995). Evan, Gray, and Olchefske (2006) suggest a link between the number of eighth-grade algebra students and global competitiveness, urging a dramatic increase in access to eighth-grade algebra. Therefore, enrollment in pre-algebra and algebra serves as an indicator for job-readiness status at graduation.

Disparities in math course taking

> Preparing *all* students for rigorous mathematics and science coursework in middle school and early in high school helps to close the achievement gap among students from differing ethnic and socioeconomic groups.
>
> – *Aimee Evan, Tracy Gray, and Joseph Olchefske,* The Gateway to Student Success in Mathematics and Science

There is wide disparity in math course taking and achievement that segregates students along the lines of race and income. This achievement and opportunity gap has significant economic consequences for families, urban and rural communities, and the national socio-economic landscape (Adelman 2006; Pelavin & Kane 1990, as cited in Evan, Gray & Olchefske 2006; Dalton et al. 2007, as cited in Bozick & Ingels 2008; Gamoran & Hannigan 2000; Schneider et al. 1998, as cited in Bozick & Ingels 2008; Moses & Cobb 2001). Therefore, it is particularly important for urban districts to be aware of both course availability and math enrollment and success rates. Knowing enrollment patterns in pre-algebra and Algebra I helps districts to ensure equitable opportunities for all students.

How can algebra enrollment and achievement be measured?

This indicator is measured by enrollment and achievement data. Districts keep track of the number of students enrolled in pre-algebra and Algebra I in each grade and examine disaggregated enrollment data by gender and racial/ethnic subgroups, course failure, and repetition rates.

Algebra achievement is typically measured by formative assessments, end-of-year exams, and subsections of state standardized tests. Many states, including Texas, North Carolina, and Louisiana, have implemented common statewide end-of-year exams for Algebra I. Achieve (2009) has developed end-of-year exams for Algebra I and Algebra II based on their national standards for math achievement. Algebra aptitude is also measured by the NAEP (National Assessment of Educational Progress) and the TIMSS (Trends of International Mathematics and Science Study). However, the NAEP and TIMSS measure only state- or national-level achievement, not district or student-level achievement.

Intervention and reform: How can districts put data into action?

If students are enrolling late in pre-algebra and Algebra I, repeating these courses, or not reaching advanced math courses before graduation, the primary systems-level reform is to offer or require Algebra I for students in earlier grades.

> Several important studies completed over the last twenty years point to the observation that the achievement gap between students of differing ethnic and socioeconomic groups can be significantly reduced or even eliminated if low-income and minority students increase their success in high school mathematics and science courses. (Evan, Gray & Olchefske 2006, p. 12)

Chicago, Boston, and other large urban districts have begun efforts to improve math achievement by encouraging earlier algebra course taking. However, critics argue that requiring algebra in eighth or ninth grade for all students without the proper supports and structures could increase course failures, grade retentions, and dropout rates (Allensworth & Nomi 2009).

The use of data about algebra enrollment and achievement as a leading indicator can ensure effective policy and practice. Along these lines, the National Mathematics Advisory Panel (NMAP 2008), Achieve (2004a; 2004b; 2008a; 2008b, 2010), and Evan, Gray, and Olchefske (2006) offer a series of recommendations in the categories of academic preparation, teaching quality, assessment and accountability, course quality, and supports and interventions.

Academic preparation for algebra

> Too many students in middle or high school algebra classes are woefully unprepared for learning even the basics of algebra.
>
> *– National Mathematics Advisory Panel, 2008*

Experts acknowledge that readiness to take algebra begins as young as preschool "to develop the mathematical thinking, skills, and conceptual knowledge students will need to tackle higher-level courses" (Achieve 2008b). Achieve has developed an algebra strand beginning in kindergarten to prepare students for advanced math coursework (Achieve 2004a). This is in line with NMAP's (2008) recommendations:

> The mathematics curriculum in grades pre-K–8 should be streamlined and should emphasize a well-defined set of the most critical topics in the early grades. . . . [This] must include (and engage with adequate depth) the most important topics underlying success in school algebra. (pp. xiii, xvii)

If district data show late or low enrollment, high rates of course failure and repetition, or disparities in math course taking, reform designers should reevaluate the district's K–8 algebra strand.

Teaching quality

> Twelve to fourteen percent of variability in math achievement gains for elementary students can be explained by teacher quality.
>
> *– National Mathematics Advisory Panel, 2008*

If evaluators conclude that teaching quality is a district weakness, the following reform efforts are suggested:

- Improve middle school teachers' instructional skills and ensure access to professional

development (Evan, Gray & Olchefske 2006).
- Strengthen teacher content knowledge (NMAP 2008).
- Strengthen connections to the full K–12 math curriculum and K–12 math educators (NMAP 2008).
- Ensure that teachers have the capacity to work with English language learners and students with learning differences (Achieve 2008a).
- Ensure that teachers can deliver positive math experiences to students (Achieve 2008b).

Teachers should be sensitive to student anxiety around math, believe in the potential for success for all students, and provide ongoing encouragement and math strategy instruction. NMAP found that math anxiety is connected with low grades and test scores as well as not enrolling in advanced courses (NMAP 2008). This finding is echoed by Achieve (2008b):

> Many students give up on math and believe it is not for them. All too often even parents believe that higher-level math courses are too hard and are out of reach for their own children. (p. 11)

This stigma around math achievement can be overcome by teachers. Support from teachers and peers, a focus on effort rather than ability, individualized teaching, and building self-confidence in students are shown to improve math outcomes, particularly for minority students (NMAP 2008).

Policy implementation is always challenging, but it can be impossible without teachers who are willing and capable of making the policy effective in the classroom. If students enroll late in algebra, seek to take less challenging courses, or are not achieving success, algebra enrollment and achievement data can be combined with teaching-quality data to set a course for reform.

Assessment and accountability

NMAP (2008) recommends using value-added analyses of student math achievement gains to identify and understand high-quality teaching and hold teachers accountable. Evan, Gray, and Olchefske (2006) recommend regular formative assessments to monitor progress and help address student needs. Finally, Achieve and several states have developed end-of-course exams for Algebra I and Algebra II (see Achieve 2009). Districts can use these data to identify teaching quality, student need, and disparities between racial, ethnic, or gender groups. Data-driven feedback provided with a timely turnaround can help teachers, principals, and district administrators implement effective improvements.

Course quality and availability

The question of a universal mandate puts course quality at risk, as critics fear that teachers will need to water down the curriculum in order for the lowest-ability students to succeed.

> All students need math courses that are genuinely rigorous, not just courses with rigorous-sounding titles. Each year of math instruction needs to do its part to build students' conceptual development and the skills they will need to continue progressing. (Achieve 2008b, p. 11)

Districts whose data show highly positive algebra achievement and enrollment might look closely at the course curriculum and compare assessments with state or national assessments. Finally, low enrollment in algebra courses or more advanced math might simply indicate lack of access to these courses. The research shows that students in urban districts have less access to calculus and trigonometry (Adelman 2006). This may have an effect on algebra enrollment.

Student-level interventions

Analysts recognize that even if system reforms are put into place, some students will need more academic support than others. Both summer algebra preparation programs and afterschool programs that "help students develop academic and self-efficacy skills as well as a stronger foundation in algebra" are recommended (Achieve 2008a, p. 12). According to Achieve (2008b), many states and districts have already implemented these programs, and the results are "promising." Districts with data showing high enrollment but low algebra achievement might identify gaps between the level of teaching and the level of student comprehension and provide extra support in or out of class.

A districtwide transition to earlier algebra will be difficult for many students. Supports should be in place ahead of time to help students make the jump to algebra.

Looking to the future

These recommendations are drawn from nationwide data and a patchwork of excellent studies and meta-analyses. However, there are no in-depth case studies that document a districtwide algebra reform that demonstrates a thorough evaluation, thoughtful reform efforts, and demonstrated success. Most case studies are driven by the promotion of particular products or services. And most quantitative studies contain data on just a small slice of math reform.

The findings from existing research are not always clear-cut. Many studies described in this brief show benefits for students who have taken more rigorous math courses. But in a study of Chicago public schools, Allensworth and Nomi (2009) found that requiring more rigorous courses in high school did not lead to improved outcomes, although they do not conclude that requiring more rigorous coursework was a bad policy.

> Although more students completed ninth grade with credits in algebra and English I, failure rates increased, grades slightly declined, test scores did not improve, and students were no more likely to enter college. In sum, few benefits resulted from universalizing college preparatory course work among freshmen, but dropout rates did not increase. (p. 367)

The field would greatly benefit from case studies of districts that have demonstrated positive outcomes as a result of changes to policy and practice that go beyond the adoption of a particular program. More research is needed to suggest the conditions required to ensure that mandating a more challenging math curriculum will increase student learning.

Algebra enrollment and achievement is potentially a key leading indicator for college and job readiness, college enrollment and success, and career earnings. Districts that can effectively evaluate this leading indicator will be taking an important step toward large-scale reform through data-driven decision making.

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