July 25, 2014
ARISE Literature Review: Benchmarks of High School Math Achievement
Produced by: Lauren Rocco

Overview

As a subject, math can be conceived of as a ladder: most schools offer students a primary progression of Pre-Algebra, Algebra I, Algebra II, Geometry, Trigonometry, Pre-Calculus, and Calculus. (Researchers sometimes omit Geometry from the ladder, because the quality of Geometry instruction varies dramatically and the content is not required to complete later math classes). Often schools offer remedial or elective math classes on the side of this main ladder. Many researchers consider Algebra the most significant gatekeeper of this ladder, not just as the entry point for higher math courses, but also a gateway to honors math and ultimately to college acceptance.

High school mathematics achievement is a very strong predictor of high school success, high school graduation, college acceptance and college graduation. The higher a high school student continues on the math ladder, the more likely the student is to graduate from high school, continue to college and graduate from college. Of all high school indicators (test scores, high school GPA, even socio-economic status (SES)), the strongest predictor of bachelor's degree completion is the highest level of mathematics a student studies in high school (Adelman 1999). In particular, finishing a course beyond the level of Algebra II more than doubles the odds that a student who enters college will complete a bachelor's degree (Adelman 1999, Trusty & Niles 2005). Moreover, the positive impact of a rigorous mathematics curriculum on minority students is greater than the impact of a rigorous mathematics curriculum on white students (Adelman 1999). Although the sample size was small, Trusty and Niles (2003) found that the probability of a American Indian student obtaining a bachelor's degree went from 56% to 70% when the student took intensive math courses.

Although the math track a student is on matters significantly for her ultimate success in high school and college, given the closed nature of the math ladder, students end up on math tracks early in their academic career and have a hard time switching tracks later. Spielhagen (2006) notes that whether or not a student took 8th grade Algebra in one school district was determined by a test taken in 6th grade. Trusty & Niles (2005) suggest that trajectory towards intensive math begins in elementary school and crystalizes in middle school. Tracking tends to be impermeable (Hallinan & Oakes 1994). Once a student enters a lower or slower math track in elementary school or middle school, it is very difficult to get out and even if the student is capable of excelling in intensive math, the stage is set for the student to waste her talent in high school (Trusty & Niles 2005).

In order to progress to classes higher on the math ladder, students need access to the earlier rungs. Timing matters. If a student does not begin high school taking Algebra 1 or Geometry, she has little chance of reaching advanced courses, and these are the courses that predict college attendance (Riegle-Crumb 2006). All students who start high school taking at least Algebra 1 achieve higher levels of math than peers who enter high school taking Pre-Algebra or lower (Riegle-Crumb 2006).

Taking higher levels of math is not enough. In addition to the timing of course-taking, students need to *learn* the content and pass the course for several reasons. Prior achievement levels in mathematics determine subsequent math course-taking (Sciarra 2010). A student who does well on early rungs on the math ladder in middle school and early high school will likely take more math classes and take classes of increasing rigor in high school. A student who does not take or does not do well in early classes on the math ladder is less likely to take many math classes and will likely select for or be put into less rigorous classes. SES is strong predictor of math course-taking, but when students do well academically the predictive power of SES diminishes (Sciarra 2010). Performance during the first year of high school is especially critical, because grades serve as structural prerequisites, influence the student's expectations for herself and inform others' perceptions of the student's potential (Riegle-Crumb 2006). Performance in math classes also matters to close the achievement gap: student achievement in advanced classes has to match that of their white peers in order to close the achievement gap (Riegle-Crumb 2010).

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American Indians are more than 4 times more likely than white students to stop taking math courses at Algebra II (African American students 1.5 times more likely, Latino students 2 times more likely) (Sciarra 2010). Of all student groups, American Indian students are most likely to have misalignment between their course-taking and their aspirations. More American Indian students said that they expected to go to college but did not complete a course in Algebra 2 than the number of American Indian students who said that they wanted to go to college and completed Algebra 2 (Sciarro 2010). Many factors influence Alaska Native and American Indian achievement in mathematics: access to and quality of curricula, access to high-quality math teachers, culturally-relevant pedagogy, access to counselors and mentors who encourage students to take mathematics, accurate self-beliefs about math ability etc.

Regrettably, there is a dearth of literature on the effects of various benchmarks on high school math achievement of Alaska Native and American Indian students, a larger literature exists on how benchmarks influence high school math achievement of African American and Latino students, and a much larger literature exists on how benchmarks influence secondary math achievement of 'all' students. A few studies of comparative math achievement did have Alaska Native and American Indian participants, but often the number of students was too small to yield statistical significance or merely documented the existing achievement gap.

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Possible Benchmarks for ARISE

- **Proficiency on state exam or other high-stakes tests**
  - \+ Readily-accessible data
  - – Linkage to long-term math achievement and long-term academic achievement is weaker than other benchmarks.
  - – Conveys less detail about student content knowledge of than math course achievement.
  - – ARISE response to low scores / high scores is less clear than for other benchmarks.

- **7th Grade Pre-Algebra**
  - \+ Research shows this benchmark has a positive effect on math achievement.
    - Ma (2000) found that students who took Pre-Algebra in 7th grade scored half a standard deviation higher on math achievement in 8th grade than students who did not take math in 7th grade.
  - – Less research documents this benchmark.

- **8th Grade Algebra 1**
  - \+ Research shows a positive effect on long-term math achievement when students take Algebra 1 in 8th grade.
    - Spielhagen (2006) found that taking Algebra 1 in 8th grade led to higher levels of long-term math attainment than students who did not take Algebra 1 in 8th grade. By 11th grade, 77% of students who took Algebra 1 in 8th grade were in an advanced course beyond Algebra 11, and 62% of students who did *not* take Algebra 1 in 8th grade were in Algebra 11 in 11th grade.
    - Ma (2000) found that students who took Algebra 1 in 8th grade scored .28 of a standard deviation higher on math achievement in 9th grade, than students who did not take Algebra 1 in 8th grade.
  - \+ Research documents a decline in student grades and study habits during the 8th to 9th grade transition (Rosenkranz 2014). There may be an advantage to students accessing Algebra content prior to this decline in grades and study habits.

- **9th Grade Algebra 1**
  - \+ Research suggests this benchmark is the minimum threshold for closing the math achievement gap. If students do not take Algebra 1 by 9th grade, their chances of reaching high level math classes is low (Riegle-Crumb 2006).
  - – There is some evidence that this benchmark is weaker than the benchmark of 8th grade Algebra 1.
    - Ma (2000) found that no math class in 9th grade had a statistically significant effect on 10th grade math achievement.

- **Completion of a math course beyond Algebra 11**
  - \+ Research shows that this benchmark has measurable long-term benefits, such that finishing a high school course beyond Algebra 11 more than doubles the odds that a student who enters college will complete a bachelor's degree (Adelman 1999, Trusty & Niles 2003).

+ Research shows that there is a substantial gap in this benchmark. Currently only 21.7% of American Indian students take a course beyond Algebra II (compared to 54.3% of white students) (Sciarra 2010).
– This is a "late" benchmark, potentially after 10th grade, when current students have only two years to address their trajectory and graduate on time.
+ This benchmark may work best for students in conjunction with another "earlier" benchmark.

- **Algebra II by 9th Grade**
  + Research shows that this benchmark has measurable long-term benefits, such that finishing a high school course beyond Algebra II more than doubles the odds that a student who enters college will complete a bachelor's degree (Adelman 1999, Trusty & Niles 2003).
  + This benchmark would be an ambitious, early benchmark that would likely set up students to take several high level math courses in high school.
  – There may be structural constraints to this benchmark within ASD.

- **Algebra II by 10th Grade**
  + Research shows that this benchmark has measurable long-term benefits, such that finishing a high school course beyond Algebra II more than doubles the odds that a student who enters college will complete a bachelor's degree (Adelman 1999, Trusty & Niles 2003).

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Additional Achievement Benchmark to consider:

- **9th Grade "On-Track" Indicator**
  - \+ Chicago Public Schools (CPS) developed an "on-track" indicator to identify students who were at a high risk of dropping out of high school. Students who complete ninth grade with enough credits to move on to 10th grade and who have earned no more than one F in a core subject are considered "on-track." (Roderick 2014)
  - \+ "On-trackness" was more predictive of high school graduation than race / ethnicity, SES and test scores. Students who end freshman year on track are *four times* more likely to graduate from high school than those who end freshman year off-track. (Roderick 2014)
  - \+ Students who pass ninth grade classes are very likely to graduate from high school. Students who earn As and Bs are almost guaranteed to graduate from high school. Students who fail just one or two classes in ninth grade are at a high risk of never graduating. (Rosenkranz 2014).
  - – This is a more complicated benchmark.
  - – This benchmark is not directly related to mathematics achievement.

- **Successful completion of each benchmark.**
  - \+ It may be worth including in the selected benchmark a requirement of successful completion of the benchmark, since understanding the content and progressing to the next rung on the math ladder requires passing the benchmark not just meeting the benchmark.

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