Title: Variation in Student Algebra Achievement Levels by Classroom Instruction and Teacher Backgrounds: Results from a Randomized Trial of Two Algebra Sequences for Underprepared Freshmen

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Abstract

Background/Context:

One of the aims of the education standards movement is to make intellectually demanding course work the norm in high school. In the area of mathematics, a growing number of states and districts now require that students not only earn an Algebra 1 credit to graduate, but that they take Algebra 1 - or a more advanced mathematics course - during their freshman year. In addition, some large school districts have made earning an Algebra 1 credit a requirement for promotion to 10th grade. There are compelling arguments for enrolling most – if not all – freshmen in Algebra 1. Successful completion of Algebra 1 in the first year of high school places all students on an equal footing, credit-wise, to reap the benefits of advanced mathematics courses in high school.

The painful reality associated with such mandates, however, is that Algebra 1 course failure rates among freshman are typically very high. When Los Angeles required all freshmen to take Algebra 1 in Fall 2004, only 39% of the students earned a C or better in the course and 44% failed (Helfand, 2006). Milwaukee’s “algebra for all” policy resulted in about half of the freshmen failing algebra, on average, over a 7 year period (Ham and Walker, 1999). These and other data suggest that mandates alone – without a more effective instructional approach - will not produce substantially higher percentages of disadvantaged students who are “college ready” and may actually accelerate the high school dropout rate as numerous students become discouraged over their prospects of earning the credits needed for graduation.

A large part of the reason for the dismal Algebra 1 results in such cities is that most first-time freshmen in public schools in these districts are seriously under-prepared to succeed in a rigorous Algebra 1 curriculum if additional supports are not provided. The traditional Algebra 1 course assumes that students have mastered basic and intermediate math skills, including multiplication and division of fractions, decimals, and signed numbers. Students who are below grade level in mathematics, however, struggle to perform operations with rational numbers and integers (National Research Council, 2001; National Mathematics Advisory Panel, 2008). A second area in which many students need extra help is with the transition from arithmetic to mathematics. One of the central TIMSS findings is that the mathematics curriculum in U.S. schools is highly repetitive and remains strongly focused on arithmetic between the 4th and 8th grades. Students in the US are taught fewer advanced mathematical topics in 7th and 8th grade than are students in higher achieving nations (Schmidt et al., 1999). As a result, the learning curve in high school mathematics can be very steep. A perusal of the leading algebra textbooks used in the 9th grade, for example, indicates that many of the texts begin with a rapid “review” of probability, proportional reasoning, measurement, data, and geometry - topics that large numbers of students, according to TIMSS data, have had limited opportunity to learn in middle school.

This study compares two of the more common sequences of curriculum offered to help underprepared freshmen pass Algebra 1. Both strategies make use of “double dose” classes which allow for approximately 70-90 minutes of instruction in a subject per day, throughout the school year. However, the additional class time allowed by the double dose opens the question of what to do with that extra time. In the first condition compared in this study, sometimes called “Stretch Algebra” or “Algebra 1A/1B,” students begin to study algebra from the beginning of the course, but proceeding at a slower pace and stopping throughout the course to backfill on intermediate skills as when the teacher observes that review is needed. In the second condition, students take the Transition to Advanced Mathematics (TAM) curriculum, a structured catch-up
course developed by Johns Hopkins University, during the first semester as an opportunity for students to catch up on intermediate skills, followed by Algebra 1 during the second semester.

**Purpose/Focus of Study:**
The effect of the TAM curriculum on students’ Algebra achievement has been established by prior research (Kemple, Herlihy, and Smith, 2005; Balfanz, Legters, and Jordan, 2004) as well as a first set of analyses from this study’s data which were presented at the SREE Spring 2011 conference. Analyses for this paper and presentation will focus on a careful examination of the implementation of both conditions and an assessment of the effect of other moderators (for example, teacher certification and teaching experience) on the outcome. These measures will allow us to assess the varying conditions under which each of these ways of teaching Algebra 1 is likely to succeed or fail. Key research questions are:

1) What were overall implementation levels in the study? Measures of fidelity will include: curriculum coverage; specific content covered; use of best practices; peer coaching; and use of professional development.

2) Are there difference between Stretch and TAM students in terms of the classroom instruction they received, their relationships to their teachers, and their attitudes towards the subject of Algebra? And to what extent did those experiences vary within treatment group by observed levels of implementation?

3) What are the links between implementation, classroom practices, and student attitudes to students’ Algebra achievement and course passing outcomes? Specifically, what are the comparative outcome levels for categorized ‘high’ and ‘low’ implementers?

4) Did levels of implementation (and teacher attitudes) vary by quantity and quality of supports teachers received and by their backgrounds, such as prior experience using the curriculum?

**Setting & Participants:**
A total of 13 school districts from across the Northeast, South, Southwest, Midwest, and West of the United States participated in the study, eight during the 2008-2009 school year and another five during the 2009-2010 school year. Each was a medium to large district located in an urban setting with at least two high schools each serving a minimum of 75 first-time freshmen who are taking Algebra 1 but are underprepared in mathematics. The sample of participants from the 13 school districts includes a total of 46 schools, 131 teachers, and 4,941 students.

**Intervention:**
Each district included either two, four, or six high schools, and within each district half were randomly assigned to either the TAM or Stretch conditions. Within each school all teachers and students then partook in the algebra sequence to which they were assigned. In both conditions, students were taught by the same teacher all year and received one extra 45-50 minute class period of mathematics instructions during the school day. In schools assigned to the Stretch condition, Algebra 1 was taught year-long for 90 minutes per day using an algebra curriculum of the district’s choosing. Teachers in the Stretch condition were then able to use the
extra time to review prior material and catch-up on intermediate math skills where students most struggled with skills gaps. In the TAM condition, students spent the first semester in a structured catch-up course, followed by Algebra in the second semester using a district chosen curriculum.

The TAM curriculum was developed by researchers and teachers, both with experience in teaching Algebra 1 in struggling urban schools that serve largely students from high-minority and high-poverty backgrounds. One of the goals of the curriculum’s development was to help teachers avoid the problem of either having to water down the content of their Algebra 1 course or risk failing the majority of students. The TAM curriculum was originally designed for students entering the 9th grade 1-4 grade levels behind in mathematics achievement, though in this study all students at study schools participated due to the large scale of the study and difficulties at the school and teacher level of rostering the classes throughout the participating study year. The TAM curriculum is tightly organized and as part of it teachers receive detailed lesson plans to five units: Mathematical Reasoning, Data Analysis, and Probability; Numbers and Integers; Rational Numbers; Measurement; and Patterns and Functions & Introduction to Algebra. The 90 minute class period is broken into a consistent series of routines that include segments of teacher directed instruction, partner and small group interaction, and individual work and practice. The lessons and routines help teachers with the additional 45 minutes of class period to be taught each day, but also in recognition that often it is the most inexperienced of teachers who are assigned to teacher 9th grade Algebra 1.

The TAM curriculum also recognizes the shortages in materials that often exist in low-resource schools (such as paper and copiers) and students are provided with consumable workbooks that contain all the materials they will need through the duration of the course while teachers are provided with a complete set of teaching materials, including everything from a teacher manual, to paperclips, string, algebra tiles, and a class set of white boards for students. Since TAM teachers received supplies as part of the curriculum, stretch algebra teachers received gift cards to an educational supply company.

Teachers implementing the TAM/Algebra 1 condition received several days of professional development on the curriculum, prior to the start of school. Teachers also met four additional times each semester to preview the upcoming course sub-units. The study provided a classroom coach for the entire year, whose responsibility was to interact with each TAM/Algebra 1 teacher for the equivalent of two class periods per week. Stretch Algebra teachers also received study-provided professional development (on curriculum mapping) at the beginning of the school year, as well as professional development on instructional strategies throughout the year, as requested by the district. The study did not support a coach for the Stretch Algebra condition.

Research Design:

The overall research design is a multi-site cluster randomized trial. Within districts, schools were randomly assigned to implement either the Stretch Algebra or the TAM condition. Each district participates in the study for a single year, during which relevant data are collected.

Data Collection and Analysis:

There are four key sources of data. First, student achievement data obtained from nationally normed achievement tests in mathematics provide measures of students’ algebra and intermediate mathematics achievement levels. At the beginning of the school year, students took the CTBS Terra Nova test in mathematics (Level 19), as a pre-test of their knowledge of intermediate mathematics. The same test was given again in January, at the end of the first
semester, to assess academic growth in intermediate math. As a covariate control for prior Algebra knowledge, we use students’ scores on the Orleans-Hanna Algebra Prognosis Assessment, given at the beginning of the school year. To assess their end-of-year Algebra knowledge, students take the CTB Algebra 1 assessment at the end of their freshman year.

Second, student and teacher surveys given at the beginning and end of the school year provide important context to understanding any differences in student achievement gains as related to instruction, curriculum, and supports. Student surveys provide information on classroom instruction and student attitudes, while teacher surveys provide data on teachers’ prior backgrounds, their professional development experiences during the year, and perceptions of support from school leadership.

Third, classroom observations conducted for each Stretch Algebra and TAM/Algebra 1 teacher twice during implementation (once during the fall semester and once in the spring). These observations provide quantitative and qualitative information about basic fidelity and instructional quality that allow us to conduct exploratory analysis of the context(s) in which one or the other of the curricula produced strong effects. Measures include student engagement and breakdowns of instruction content and time spent on various areas and activities.

Fourth, student administrative records provide data on student demographics, prior achievement, and grades in ninth grade mathematics courses.

Missing data are imputed using multiple imputation. As a primary method of data analysis we use multi-level models to estimate the impacts of the two conditions and intervening classroom and teacher factors on student achievement outcomes. Exploratory and confirmatory factor analyses are used in constructing summative measures of implementation and classroom instruction based on survey and observation data.

Findings / Results:

At the 2011 SREE Spring conference, we presented the results from analyses of study data that focused on treatment impacts on primary achievement outcomes. TAM students achieved equivalent Algebra 1 test scores despite spending only half as much time on Algebra curriculum, and at the same time TAM students had experienced significantly more growth in their intermediate math skills. At the 2012 SREE Spring conference, results will be presented from a second wave of analyses focusing on variations in implementation levels, classroom practices, teacher backgrounds, and their links to outcomes. Results find that treatment and higher levels of implementation were related to different classroom instruction experiences on the part of students and more frequent use of best practices. These variations in classroom instruction were further related to more positive student attitudes towards algebra. Both classroom practices and student attitudes are linked to Algebra 1 course passing and higher achievement levels on standardized testing. Results of high and low implementing classrooms/teachers will be compared. Further results will also explore the effects of teacher background characteristics on treatment implementation levels effects on algebra outcomes.

Conclusions:

Students in the TAM condition significantly improved their intermediate math skills while reaching equivalent levels in Algebra achievement to those if Stretch students, in only one semester. However, the algebra performance and success of students in both condition was dependent on the classroom, teacher, and school conditions under which implementation occurred.
Appendices

Appendix A. References


