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Title:

Efficacy Study of a Pre-Algebra Supplemental Program in Rural Mississippi: Preliminary Findings

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Background / Context:

Mastering mathematics is important for all students, not only because such success increases college and career options and prospects for future income, but also because mathematics literacy helps citizens and policy leaders to make sound judgments (NMAP, 2008). The National Mathematics Advisory Panel (NMAP) heralded algebra as a “demonstrable gateway to later achievement” (2008, p. xiii). Success in high school mathematics through Algebra II or higher correlates with future success, including improved college access (Horn & Nuñez, 2000; Horowitz, 2005), improved chances of college graduation (Achieve, 2006; Adelman, 1999; Evan, Gray, & Olchefske, 2006), and higher future earnings (Achieve, 2006; Osler, 2007). Yet, at the point when students should be transitioning from learning arithmetic (addition, subtraction, multiplication, and division) to learning mathematics (the study of the relationships among numbers, which traditionally begins with algebra), many are unprepared in fundamental mathematics concepts that strongly predict algebra achievement (Sielger et al., 2012). Ideally a successful transition to learning mathematics occurs in the middle school grades, thereby enabling students to be successful in high school algebra. But this inconsistently occurs, particularly in rural settings—while rural students overall score at a rate equal to the national mean (Provasnik et al., 2007), rural students in several states lag significantly behind their non-rural peers in mathematics achievement. Reeves (2008) reported that the opportunity to learn mathematics in high school was the most salient factor for explaining the rural/nonrural achievement gap—a stronger predictor even than family socioeconomic status. This suggests that the rural achievement gap can be addressed with modifiable school-based strategies that increase students’ opportunity to learn. Therefore, even though rural students lag behind in mathematics, it is likely that their achievement can be increased by providing additional resources. Addressing the needs of rural students—particularly with respect to being successful in algebra—is a policy-relevant, social justice issue.

Purpose / Objective / Research Question / Focus of Study:

Given the assumption that raising mathematics achievement in rural settings might be accomplished through additional resources, we sought to understand whether a low-cost supplemental program could result in increases in student learning (and changes to teacher practices; not reported herein). *Every Day Counts Algebra Readiness (EDC Algebra Readiness)* is a resource developed to improve the mathematics proficiency of middle school students and help prepare them for success in high school algebra. The program is a supplemental curriculum for use in the first 10-15 minutes of class, focusing on the most important pre-algebra concepts. Through the use of an interactive bulletin board and concrete visual representations, the program is designed to foster mathematical discussions as well as build student confidence and fluency in mathematics. Although this program is currently in wide use in several U.S. states, its impact on student algebra readiness has not been rigorously studied. Past research indicates that the mathematics pedagogy supported by this program, including daily exposure to pre-algebra concepts, visual models, and placing mathematics in a real-world context, has a positive impact on students’ mathematics learning (Great Source, 2006). As a supplemental curriculum, the program does not displace other elements of the middle grades mathematics curriculum, therefore increasing its feasibility of use. While *EDC Algebra Readiness* has the potential to increase achievement for students in many types of schools, studying it in rural schools will demonstrate whether increasing opportunity to learn using a cost-effective supplemental

mathematics curriculum can increase achievement among a population struggling with mathematics achievement but often ignored in rigorous research.

Research Questions. This experimental efficacy study examines the impact of *EDC Algebra Readiness* on the algebra readiness of 7th grade students in rural schools in Mississippi. The study also examines the program's impact on the Algebra I achievement of these students, as measured by results on the state's end-of-course test. The main research questions are: Does random assignment to *EDC Algebra Readiness* have a significant impact on rural Mississippi seventh-grade students' algebra readiness? Does random assignment to *EDC Algebra Readiness* have a significant impact on rural Mississippi seventh-grade students' later Algebra I achievement? Exploratory research questions rely on data from teacher implementation logs and classroom observations to examine how using *EDC Algebra Readiness* affected teacher instruction, and how changes in teacher practice mediated student outcomes.

Setting:

The study includes 36 public, rural Mississippi schools offering 7th grade mathematics. We selected Mississippi for several reasons: Mississippi is the fourth-most rural state in the nation, students are required to pass Algebra I to graduate high school, and many rural Mississippi students are underperforming in mathematics—Mississippi has the largest rural state-national score gap in mathematics on the National Assessment of Educational Progress.

Population / Participants / Subjects:

This study involves 7th grade students and their teachers in 36 rural Mississippi schools where the intervention had not previously been implemented. Seventh graders were selected as the primary grade of interest for a study of an intervention aimed at preparing students for success in algebra (the majority of students take Algebra I in eighth or ninth grade). Because of the requirement that students pass Algebra I for graduation and because this is a time at which students are transitioning to learning mathematics, seventh grade is an important year for developing algebra readiness.

Intervention / Program / Practice:

EDC Algebra Readiness is a widely-used supplemental program developed by Clark (2006a) and published by Harcourt Great Source that provides curriculum supports for preparing middle school students for success in high school algebra (Houghton Mifflin Harcourt, 2009). The program consists of an interactive bulletin board containing several visual models around which teachers conduct whole-class activities for 10-15 minutes per day. Teachers use visual models, such as the Calendar (geometry and algebraic relationships), Counting Tape (equivalent fractions and decimals), and Percent Circle (fractions, decimals, and percentages) to lead students in consistent, incremental daily practice designed to help them express conceptual thinking about mathematics and to understand critical algebra readiness concepts and skills. *EDC Algebra Readiness* focuses on key concepts for transitioning students from learning arithmetic to learning mathematics: fractions, decimals, and percents; integers; number patterns; algebraic representation with variables, expressions, equations, and graphing; geometry; measurement; and data and probability with problem solving and discussion (Clark, 2006b; Houghton Mifflin Harcourt, 2009). *EDC Algebra Readiness* was chosen for this study because of its usability (teachers are provided with professional development [PD] and detailed information about its use in the classroom), feasibility (it can be used to supplement any mathematics curriculum, is relatively inexpensive, and does not require specific technology), and promise of efficacy based

on results from an elementary-level version of the program (Great Source, 2006) and its focus on conceptual understanding of a limited number of crucial pre-algebra topics.

Research Design:

The main purpose of the study is to obtain an unbiased estimate of the impact of *EDC Algebra Readiness* on 7th grade rural students' algebra readiness. This is a cluster-randomized trial in which 36 schools were randomly assigned to conduct business as usual or to receive *EDC Algebra Readiness* materials and accompanying teacher PD. Data for the main impact analysis were collected at the end of the implementation year (spring 2013), when students' algebra readiness was assessed using two proximal measures (the *Iowa Algebra Aptitude Test (IAAT), Fifth Edition* and a researcher-developed *Algebra Readiness Assessment*). Students' performance on the Algebra I state test will serve as a delayed post-test, assessing the impact of their participation on Algebra I readiness. The spring 2012 mathematics portion of the 6th grade Mississippi state test, the MCT2 (Mississippi Curriculum Test, Second Ed.; Mississippi Department of Education, 2014), will provide student- and school-level covariates. Even though this MCT2 assessment differs somewhat from the outcome measures, this type of pretest increases precision substantially (Bloom, Richburg-Hayes, & Rebeck Black, 2007) and reduced data burden on participants in comparison to administering a custom pretest for the study. Assignment was not blocked by district because of the small numbers of schools in each rural district.

Treatment group. Teachers in this group were asked to use the *EDC Algebra Readiness* curriculum to provide seventh graders with 10-15 minutes of instruction on integers, fractions, decimals, proportions, and/or percents each day to supplement the typical mathematics curriculum, within the existing mathematics class period. Teachers in these schools received an *EDC Algebra Readiness* kit and PD training in the summer of 2012. They also participated in an online community for monthly PD booster sessions.

Control group. Teachers in this group were asked to use their regular mathematics curriculum in their usual class period. However, control group teachers received the training and materials for the intervention following all implementation and data collection for the impact study (control group teachers received the PD and materials in July 2013).

Data Collection and Analysis:

To address the first research question (Does random assignment to *EDC Algebra Readiness* have a significant impact on rural Mississippi seventh-grade students' algebra readiness?), we are using two proximal student achievement outcomes. In order to have a student outcome measure sensitive to the intervention but not over-aligned to the content of *EDC Algebra Readiness*, researchers and mathematics content analysts developed the *Algebra Readiness Assessment* as a proximal assessment that addresses the knowledge and skills that the program addresses. This outcome measure is presumed to be sensitive to the intervention's effects and able to detect an impact if one is present. The *Iowa Algebra Aptitude Test (IAAT), Fifth Edition* (Schoen & Ansley, 2005) is a standardized test of pre-algebra mathematics achievement with acceptable psychometric properties (high internal consistency; Rogers, 2007). It is recommended to teachers preparing students for algebra, and therefore was chosen as the other proximal measure. Both the *Algebra Readiness Assessment* and the *IAAT* were administered during math class time to 2,818 students of 48 teachers in 36 participating schools toward the end of the implementation year (spring 2013). To address the second main impact question (Does random assignment to *EDC*

Algebra Readiness have a significant impact on rural Mississippi 7th grade students' later Algebra I achievement?), we will collect Algebra I achievement data from the end-of-course *Mississippi Algebra I Subject Area Test* (Pearson, 2007). Depending on whether the students take Algebra I in 8th or 9th grade, those tests will be administered by schools in spring 2014 or spring 2015. For all of these analyses, we will use extant school- or student-level MCT2 data as covariates; this presentation will report on analyses of the proximal variables using school-level MCT2 data.

Analysis. Impacts of *EDC Algebra Readiness* on student achievement on the *IAAT* and *EDC Algebra Readiness* assessments were estimated using two-level HLM models with students nested within school, and impacts estimated at the school level, the level of random assignment. Impact analyses included a school level pretest covariate (grand mean centered) for each respective outcome.

Findings / Results:

Descriptive statistics (adjusted means, standard errors, and effect sizes) for the *IAAT* and *Algebra Readiness Assessment* assessments impact analyses (treatment versus control) are shown in Table 1. (please insert Table 1 here).

Treatment schools' adjusted mean on the *IAAT* test was 145.16 (SE = 1.87), compared to an adjusted mean of the control schools of 144.09 (SE = 1.29) with an adjusted difference of 1.07 that was not statistically significant ($p > .05$). The effect size as calculated using Glass's Δ for multilevel analysis for the *IAAT* is 0.07. On the *Algebra Readiness* assessment, treatment schools' adjusted mean was 150.66 (SE = 1.95), compared to an adjusted mean of the control schools of 149.93 (SE = 1.37) with an adjusted difference of 0.73 that was not statistically significant ($p > .05$). The effect size as calculated using Glass's Δ for multilevel analysis is 0.04.

Conclusions:

Addressing the needs of rural students—particularly with respect to being successful in algebra—is a policy-relevant, social justice issue. Providing a low-cost, supplemental resource to support rural students as they begin to “learn mathematics” may increase students' opportunities to learn mathematics (Reeves, 2008) and to be successful in high school Algebra. *EDC Algebra Readiness* costs under \$300 per teacher; however preliminary analyses suggest that implementing the program results in lower-than-expected effect sizes. Researchers will include student-level covariates in the analyses as these data become available; it is possible that inclusion of these data will result in more promising findings. In addition, issues regarding implementation fidelity and its relationship to impacts of the *EDC Algebra Readiness* on student outcomes will also be discussed. The more important policy-relevant question for Mississippi concerns longer-term outcomes—whether the students who were in schools randomly assigned to the treatment condition outperform their control school counterparts on the measure of student success in Algebra. Because the first round of Algebra assessment data were administered by the state in spring 2014 or will be administered in spring 2015, this study is not yet able to report impacts on this key distal outcome measure.

Appendix A. References

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Appendix B. Tables

Table 1. Adjusted means, standard deviations, and effect sizes for the impact (treatment versus control) of EDC Algebra Readiness on the IAAT and Algebra Readiness Assessments

Assessment	Treatment N	Control N	Treatment Mean (SD)	Control Mean (SD)	Mean Difference	Effect Size
IAAT	1366	1335	145.16 (1.87)	144.09 (1.29)	1.07	0.07
Algebra Readiness	1459	1339	150.66 (1.95)	149.93 (1.37)	0.73	0.04

Notes: Both the *IAAT* and *Algebra Readiness* scores are on a standard scale with a mean of 150 and a standard deviation of 15. Effect sizes were calculated using Glass's Δ for multilevel analysis.