

**Title:**

Testing the Efficacy of a Tier 2 Kindergarten Mathematics Intervention: Findings of Year 1

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## Abstract Body

### Background:

The adoption of the Common Core State Standards for Mathematics (CCSSM, 2010) in 46 states has raised the mathematical proficiency bar for U.S. students. The advent of these new standards is at a time when the body of empirical evidence on the negative consequences of early and persistent difficulties in mathematics is clear, compelling, and growing. In an investigation of mathematics achievement data generated from 7,892 children in the Early Childhood Longitudinal Study-Kindergarten Cohort (ECLS-K), Morgan, Farkus, and Wu (2009), for example, found students with persistent math difficulties in both the fall and spring of kindergarten had a 70% chance of scoring in the same risk category at the end of fifth grade.

The purpose of this 4-year Goal-3 Efficacy Trial, funded by the Institute of Education Sciences (Clarke, Doabler, Smolkowski, & Fien, 2012), is to study the efficacy of ROOTS, a (Tier 2) kindergarten mathematics intervention designed to improve the mathematics achievement of students at risk for MD. This presentation focuses on data generated from the first year of the larger efficacy trial (2012-2013). The study used a randomized control trial (RCT) design (blocking on classrooms) to investigate the ROOTS intervention when implemented under rigorous experimental conditions. Year 1 of the ROOTS efficacy trial took place in 29 kindergarten classrooms from four school districts in Oregon with approximately 10 eligible students per classroom. Eligibility of student participation was based on screening scores from two standardized measures of mathematics achievement. The research team randomly assigned these 10 students to one of three conditions: (1) a ROOTS-large group (5:1 student-teacher ratio), (2) a ROOTS-small group (2:1 student-teacher ratio), and (3) a no-treatment control group. A total of 58 ROOTS groups participated in Year 1.

### Focus of Study:

There are two primary aims of this presentation. **Aim 1: Present impact findings from the first year of the 4-year ROOTS efficacy trial.** For this first aim we will examine the immediate impact of the ROOTS curriculum on student mathematics achievement. During the 2009-2010 school year, we conducted a preliminary investigation of the ROOTS curriculum in 29 kindergarten classrooms and found promising effects on the mathematics achievement of students at risk for MD. We anticipate finding similar results in this efficacy trial.

**Aim 2: Empirically examine the association between instructional intensity, manipulated via instructional group size, and student mathematics achievement.** As part of our theoretical rationale for examining instructional intensity, we use a treatment intensity framework specified by Warren, Yoder and Fey (2007), which centers on specifying the particulars – “active ingredients” – of the intervention that are hypothesized to improve student learning. To our knowledge, few, in any, studies on mathematics interventions have yet to directly examine the effect of manipulating instructional intensity within a single study. Here, we manipulate group size, a proxy of instructional intensity, to examine hypothesized mechanisms of change (i.e., student-teacher instructional interactions) in the ROOTS intervention. We considered ROOTS groups with a 5:1 student-teacher ratio as a “low intensity” treatment groups and ROOTS groups with a 2:1 student-teacher ratio as a “high intensity” treatment groups. Instructional intensity was measured using a low-inference observation instrument.

### Setting:

Year 1 of this 4-year study was conducted in Oregon during the 2012-2013 school year. A total of 29 kindergarten classrooms from 14 schools were recruited to participated. These schools were from four school districts (urban and suburban), which had student enrollments that ranged from 5,000 to 38,000 students. Each of the 29 participating classrooms contained three instructional groups: (1) a *low intensity* ROOTS-large group (5:1 student-teacher ratio), (2) a *high intensity* ROOTS-small group (2:1 student-teacher ratio), and (3) a no-treatment control group. A total of 58 ROOTS groups participated in Year 1 (29 ROOTS-large, 29 ROOTS-small).

### **Participants:**

A total of 31 interventionists taught the 58 ROOTS groups. Interventionists, on average, taught more than one group (i.e., ROOTS-large and ROOTS-small) and consisted of district-employed instructional assistants ( $n = 20$ ) and temporary personnel ( $n = 11$ ) hired by the Center on Teaching and Learning at the University of Oregon for the purposes of the study. Two of the interventionists were kindergarten teachers. Of the interventionists, 28 were female (90%) and the majority identified as Caucasian.

Across the 29 kindergarten classrooms, a total of 794 students were screened for mathematics difficulties and eligibility for the ROOTS intervention. Currently, all student and teacher demographic data have been collected, but the descriptive analyses have yet to be fully completed. Based on the screening scores, 10 students per classroom were selected to be in the study and thus eligible for randomization. A total of 291 students were randomly assigned to the three groups: ROOTS-large ( $n = 146$ ), ROOTS-small ( $n = 58$ ), and no-treatment control group ( $n = 87$ ). The final analytic sample consisted of 252 students: ROOTS-large ( $n = 49$ ), ROOTS-small ( $n = 124$ ), and no-treatment control group ( $n = 79$ ).

### **ROOTS Intervention:**

ROOTS is a Tier 2 kindergarten intervention program that was designed to be delivered by interventionists in small-group instructional formats (i.e., 5:1 or 2:1 student-teacher ratios), 5 times per week for approximately 10 weeks. The goal of ROOTS is to support students' development of procedural fluency with and conceptual understanding of whole number concepts. The specific focus on whole number aligns with the heightened expectations of the CCSSM (2010) and calls from expert panels for more focused and coherent Tier 1 curricula (NMAP, 2008). ROOTS provides in-depth instruction in whole number concepts by linking the informal mathematical knowledge developed prior to school entry with the formal mathematical knowledge developed in kindergarten. The program includes 50 lessons, approximately 20 minutes in duration. Each lesson consists of 4 to 5 brief math activities that center on three key areas of whole number understanding: (a) Counting and Cardinality (b) Number Operations and (c) Base 10/Place Value. Curricular objectives advance students from an initial understanding of whole number through more sophisticated aspects of whole numbers in kindergarten mathematics.

A central feature of the ROOTS program is its *explicit* and *systematic* approach to instruction. This approach includes modeling and demonstrating what students will learn, providing guided practice opportunities, using visual representations of mathematics, and delivering academic feedback. For example, lessons provide interventionists with specific guidelines for demonstrating concepts and skills associated with whole numbers, and providing timely academic feedback to students as they engage in learning activities. The program also provides students with frequent and structured practice opportunities to promote procedural fluency and incorporates a host of visual representations to deepen conceptual understanding. Once students demonstrate initial proficiency with targeted math content, instructional scaffolds are systematically withdrawn to promote learner independence. Combined, the program's design and delivery principles form an instructional base for interventionists to facilitate overt and dynamic instructional interactions among teachers and students around whole number concepts and skills. An important category of these instructional interactions is mathematical discourse or math verbalizations, which permit students to demonstrate their mathematical thinking and understanding (Gersten et al., 2009; NRC, 2001).

**Professional development.** Participating interventionists attended two curriculum workshops for a total of 10 hours of professional development on the implementation of the ROOTS curriculum. The initial 6-hour workshop targeted the instructional objectives of Lessons 1-25, the critical content of kindergarten mathematics (CCSSM, 2010), small-group management techniques, and the instructional practices that have been empirically validated to increase student math achievement (e.g., teacher provided academic feedback; Gersten et al., 2009). A second 4-hour workshop was provided midway through the intervention and focused on the second half of the ROOTS curriculum, Lessons 26-50.

### **Research Design:**

The study design was a RCT, with students randomly assigned to condition blocking on classrooms. We blocked at the classroom level to control for teacher effects on student outcomes. Our unit of analysis is instructional groups. In Year 1 a total of 58 ROOTS groups from 29 classrooms in Oregon participated. Within each of these classrooms, 10 ROOTS eligible students were randomly assigned to one of three conditions\*: (1) a *low intensity* ROOTS-large group (5:1 student-teacher ratio), (2) a *high intensity* ROOTS-small group (2:1 student-teacher ratio), and (3) a no-treatment control group ( $n = 3$ ). Use of this type of research design allows us to address the efficacy of the ROOTS curriculum compared to a no-treatment control (Aim 1) and the efficacy of the ROOTS curriculum when the size of ROOTS small groups are experimentally manipulated to intensify the instructional interactions between teachers and student around critical whole number concepts (Aim 2).

The Year 1 final analytic sample consisted of 252 students: ROOTS-large ( $n = 49$ ), ROOTS-small ( $n = 124$ ), and no-treatment control group ( $n = 79$ ). Control students did not receive ROOTS instruction but were not prohibited from receiving standard district intervention services. All participants received district-approved (Tier 1) mathematics instruction.

### **ROOTS Eligibility/Screening Process:**

To determine student eligibility for the ROOTS intervention all participating kindergarten students from the 29 classrooms were screened for MD using two standardized measures of early mathematics achievement: (1) Number Sense Brief Screener (Jordan et al. 2009) and the Assessing Student Proficiency in Early Number Sense (ASPENS) measures (Clarke, Gersten, Dimino, & Rolfhus, 2012). Based on the performances of the two screening measures, we calculated an overall standard score (z score) for each student. Within each classroom, students' z-scores were ranked ordered from high to low. Compared to the full sample of kindergarten students assessed in the screening process ( $N = 794$ ), the ROOTS eligible students performed in the low average to well-below average range ( $< 35$ th percentile).

### **Data Collection and Analysis:**

Trained staff members collected all student and classroom observation data. Data collection met acceptable reliability criteria for all student and classroom measures included in the analysis.

**Student outcomes.** Student mathematics performance measures included the Test of Early Mathematics Ability – 3rd Edition (TEMA-3), ASPENS, and the ROOTS Assessment of Early Numeracy Skills (RAENS), a measure considered proximal to the ROOTS intervention. All three measures were individually administered to ROOTS eligible students at pretest ( $T_1$ ) and posttest ( $T_2$ ) times. Each measure demonstrates strong psychometric properties.

**Direct observations.** To measure instructional intensity, we used the Classroom Observations of Student-Teacher Interactions (COSTI) measure, a low-inference, frequency-based observation instrument developed by Smolkowski and Gunn (2012). Previous research on the COSTI documents preliminary evidence that its instructional behaviors are associated with gains in student reading (Smolkowski & Gunn, 2012) and mathematics (Doabler et al., 2013) outcomes. The COSTI targets seven instructional behaviors: (a) teacher demonstrations, (b) guided practice opportunities for two or more students, (c) guided practice for individuals, (d) independent practice opportunities for two or more students, (e) independent practice opportunities for individuals, (f) student mistakes, and (g) teacher-provided academic feedback. Trained observers conducted all observations. Each ROOTS group was observed three times across the 10 intervention weeks

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\* It is important to note that with exception to group size, the treatment groups used the same intervention materials and adhered to the same implementation plan (i.e., one lesson per day, 5 days per week for ~10 weeks).

**Statistical analysis.** To address Aim 1, we will analyze intervention effects on each of the outcome measures with a *nested time by condition analysis* (Murray, 1998) to test differences between conditions on change in outcomes from the start of the intervention ( $T_1$ ) to the end of the intervention ( $T_2$ ). This analysis approach will include all data—whether or not a student’s scores were present at both time points—to estimate differences between assessment times and between conditions. The nested time by condition analysis accounts autocorrelation among assessments within individual students and the intraclass correlation associated with multiple students nested within same schools. As a test of net differences, it also provides a more straightforward interpretation of the results.

To address Aim 2, we will use a series of multilevel models, with students nested within classrooms, to test whether the instructional intensity data generated by the COSTI predicts student mathematics achievement (Raudenbush & Bryk, 2002). We will estimate these associations by regressing  $T_2$  student-level math achievement scores (i.e., TEMA-3, ASPENS, and RAENS), adjusted for  $T_1$  scores, on each predictor, separately. Multilevel modeling will be conducted using HLM (Raudenbush, Bryk, Cheong, & Congdon, 2004), and parameters will be estimated using restricted maximum likelihood. To ease the interpretation of results, we will compute Pseudo- $R_2$  (Singer & Willett, 2003) as a measure of effect size for each fixed effect of the instructional intensity scores on math achievement. Pseudo- $R_2$  represents the decrease in classroom-level variance between unconditional and conditional models, or the proportion of classroom-level variance explained in the outcome measure by a predictor or set of predictors.

### **Findings:**

Data analysis is currently underway. For the study’s first aim, we plan to investigate the impact of the ROOTS intervention on distal and proximal measures of student mathematics achievement. Preliminary analyses generated in an earlier investigation of the ROOTS intervention revealed small to medium effect sizes for the TEMA-3 (Pro-Ed, 2007) scaled score (Hedges’  $g = 0.37$ ,  $p = .037$ ), EN-CBM total score ( $g = 0.30$ ,  $p = .187$ ). All effect sizes generated in this earlier study meet the What Works Clearinghouse Standards (WWC, 2013) for showing a “substantively important positive effect” (p. 60). For the current study, we expect to find similar results to those described above. Replication of these earlier findings would generate additional efficacy evidence for the ROOTS intervention.

The second aim will investigate the association between student-teacher instructional interactions and student mathematics achievement, and test for differences between the ROOTS groups on instructional intensity scores (i.e., instructional intensity). Table 1 shows descriptive statistics for the first round of ROOTS observations with COSTI. While preliminary, these results suggest that students in the ROOTS-small group are receiving rates of practice opportunities that are greater than or equal to their at-risk peers in the ROOTS-large groups. Because the ROOTS-small groups have smaller student-teacher ratios one could argue that the practice opportunities taking place in these groups are more individualized and thus more intensive for students.

### **Conclusion:**

There is convincing evidence that many students experience early and lasting difficulties in mathematics. This presentation will cover the Year 1 findings of a RCT involving the ROOTS Tier 2 intervention. ROOTS was implemented within 29 kindergarten classrooms from the state of Oregon. While preliminary, we will discuss possible implications of our findings in the context of multi-tiered delivery models of mathematics instruction. The findings from this study will be used to illustrate how research-based curricula can be used at Tier 2 to address the learning needs of at-risk students, and increase the intensity and frequency of student-teacher interactions around critical whole number content. As we delve into our data, we expect to (a) demonstrate initial efficacy of the ROOTS intervention and (b) unpack the nature and function of the student-teacher instructional interactions and determine their relevance for boosting the mathematics achievement of kindergarten students at risk for MD.

## Appendices

### Appendix A. References.

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**Appendix B. Tables and Figures**

Table 1. Descriptive Statistics for Round-1 of ROOTS Observations with COSTI

**ROOTS Group Size: Small (2:1)**

<b>Variable – rate per minute</b>	<b><i>M</i></b>	<b><i>SD</i></b>	<b>Min</b>	<b>Max</b>	<b><i>N</i></b>
<i>Teacher model</i>	.41	.22	.06	.83	16
<i>Group guided practice</i>	.71	.36	.19	1.43	16
<i>Individual guided practice</i>	.33	.32	.00	1.05	16
<i>Group independent practice</i>	1.49	.36	.71	2.05	16
<i>Individual independent practice</i>	1.64	1.18	.52	5.63	16
<i>Mistake practice</i>	.14	.14	.00	.43	16
<i>Feedback practice</i>	1.51	.78	.48	3.33	16

**ROOTS Group Size: Large (5:1)**

<b>Variable – rate per minute</b>	<b><i>M</i></b>	<b><i>SD</i></b>	<b>Min</b>	<b>Max</b>	<b><i>N</i></b>
<i>Teacher model</i>	.47	.32	.18	1.56	16
<i>Group guided practice</i>	.80	.42	.24	1.67	16
<i>Individual guided practice</i>	.24	.22	.00	.68	16
<i>Group independent practice</i>	1.26	.66	.37	2.35	16
<i>Individual independent practice</i>	1.25	1.05	.33	4.67	16
<i>Mistake practice</i>	.15	.09	.00	.29	16
<i>Feedback practice</i>	1.20	.35	.47	1.75	16