THE IMPACT OF A COMPREHENSIVE TIER I CORE KINDERGARTEN PROGRAM ON THE ACHIEVEMENT OF STUDENTS AT RISK IN MATHEMATICS

ABSTRACT
This study examined the efficacy of a core kindergarten mathematics program, ELM, a 120-lesson comprehensive curriculum providing instruction in (*a*) number operations, (*b*) geometry, (*c*) measurement, and (*d*) vocabulary. ELM is designed to address the learning needs of all students, including at-risk students in the general education or Tier I classroom setting. The study utilized a randomized block design, with 64 classrooms randomly assigned within schools to treatment (ELM) or control (standard district practices) conditions. Measures of achievement were collected at pretest and posttest to measure student achievement. Students did not differ on mathematics assessments at pretest. Gain scores of at-risk treatment students were significantly greater than control peers, and the gains of at-risk treatment students were greater than the gains of peers not at risk, effectively reducing the achievement gap. Implications for Tier I instruction in a Response to Intervention (RTI) model are discussed.

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EDUCATORS and the general public have expressed substantial concern about the persistently low mathematics achievement of American students. Results of international (Olson, Martin, & Mullis, 2008) and national (National Center for Education Statistics, 2009) longitudinal studies have recently produced encouraging news in some areas, but not others. Trends in International Mathematics and Science Study (TIMSS; Olson et al., 2008) results continue to document the poor performance of American students compared to students in

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other industrialized countries, and National Assessment of Educational Progress (NAEP; National Center for Education Statistics, 2009) results continue to show that too many students fall short of national benchmarks measuring mathematics proficiency. On the most recent fourth-grade NAEP, only 39% of students were at or above proficient, while 18% were below basic. By eighth grade the percentages were somewhat worse. The percent of students at or above proficient dropped to 34%, while the percent below basic increased to 24%.

On the positive side, however, recent trends showing improvement on the NAEP (National Center for Education Statistics, 2009) have begun to emerge. Specifically, small increases in the percentage of students reaching proficient levels have occurred for most student groups (e.g., based on ethnicity, disability, socioeconomic status) in both fourth and eighth grade over the past 13 years. Although improvements have occurred, the increases are not uniform and large differences between student groups remain a central problem.

Concern about low mathematics achievement levels, the stable and large gap between students based on poverty, ethnicity, and other factors unrelated to learning potential, as well as the nearly universal recognition that mathematics knowledge will play a vital role in life opportunities, meaningful employment, and economic independence led the National Research Council (2001) to assert that "all young Americans must learn to think mathematically, and they must think mathematically to learn" (p. 16). Job opportunities in mathematics or STEM careers (science, technology, engineering, and mathematics) are expected to outpace overall job growth by a 3:1 ratio in the coming years (National Science Board, 2008).

Response to Intervention

One suggested approach for systematically improving the mathematics achievement of students is through the use of a Response to Intervention (RTI) model of service delivery. As part of the 2004 reauthorization of the Individuals with Disabilities Education Act (IDEA, 2004), states can identify a specific learning disability as lack of learning progress after documenting that students have had the opportunity to learn from evidence-based instructional programs and practices. In this process, schools use student response to scientific, research-based interventions to determine eligibility for special education. That is, students who do not make adequate learning progress despite the fact that their teachers use research-based interventions for instruction are given a full evaluation, and the basis of their progress over time and the full evaluation data are used to determine eligibility for special education services.

RTI is made up of two major parts, and it is necessary to understand which part is being considered in discussions about RTI. First, RTI is a process that can be used to identify students with learning disabilities. Second, RTI is broadly conceptualized as a system of multitiered instructional supports for all students. There remains a great deal of controversy surrounding the use of RTI to detect the presence of a learning disability and determine special education eligibility (Fuchs, Mock, Morgan, & Young, 2003; Reynolds & Shaywitz, 2009). While the evaluation of RTI models as a whole is limited (Kovaleski & Black, 2010), individual components of RTI are supported empirically, including the use of research-based interventions and instructional practices (Gersten, Chard, et al., 2009; Newman-Gonchar, Clarke, & Gersten, 2009), as well as assessments, including screening (Fuchs, Fuchs, Compton, et al.,

2007) and progress monitoring (Foegen, Jiban, & Deno, 2007) to carefully track student progress toward critical learning outcomes and adjust instruction when necessary.

When schools and districts refer to their RTI efforts, they typically mean a tiered instructional approach that emphasizes research-based instruction with increasing levels (or tiers) of intensity used with students in relation to their instructional need (Burns & Vanderheyden, 2006; Fuchs, Fuchs, & Zumeta, 2008). Although variations in RTI models exist (Gersten, Beckmann, et al., 2009; National Association of State Directors of Special Education [NASDSE], 2006), most tiered models have three levels of support. Tier I consists of the instruction delivered in general education by the classroom teacher, Tier II is targeted instruction delivered in small groups to at-risk students, and Tier III is provided to students who have not responded to Tier II small-group interventions. Tier III typically consists of highly intense interventions, including one-on-one tutoring. The Early Learning in Mathematics (ELM) curriculum and research described in this article constitute Tier I support.

Prevention and Early Intervention

One of the most significant changes in education practice over the past 2 decades has been in reading instruction. As evidence accumulated that students who did not learn to read proficiently in the early grades remained poor readers throughout school (Lyon et al., 2001), educators and researchers began to emphasize prevention—that is, preventing early reading difficulties from becoming more serious reading problems. This focus on early intervention is reflected in the revision of IDEA (2004), in which RTI was first formally acknowledged and regulatory emphasis was placed on the prevention of academic difficulties. RTI is as much a general education initiative as it is a special education initiative, and effective instruction in general education is the foundation on which the entire system rests. One of the desired results of the effective implementation of a comprehensive RTI system is a reduction in the inappropriate placement of students into special education (Council for Exceptional Children, 2007; Learning Disabilities Association/Division for Learning Disabilities, 2007; National Association of School Psychologists, 2007), a situation exacerbated when the overriding reason that a particular student is struggling academically is not because of a learning disability but because of poor initial instruction and ineffective instructional support.

Unfortunately, the significant advances that have been made in the prevention of reading difficulties (Baker et al., 2008; Gersten, Chard, et al., 2009; Greenwood, Kratochwill, & Clements, 2008; National Reading Panel, 2000; Vaughn & Fuchs, 2006), both prior to and after the reauthorization of IDEA (2004), have not been realized in mathematics (Clarke, Baker, & Chard, 2008; Clarke, Gersten, & Newman-Gonchar, 2010; Gersten, Beckmann, et al., 2009). This is true despite increasing evidence that mathematics difficulties are as persistent and as difficult to remediate as reading difficulties, and that the long-term consequences of struggling early in mathematics exact the same degree of long-term academic difficulties.

Using longitudinal databases, researchers have documented the long-term mathematics trajectories of students in the early grades (i.e., kindergarten through grade 4). Evidence is clear that students who start poorly in mathematics during kindergarten and first grade are likely to continue struggling with mathematics in third and fourth grade (Bodovski & Farkas, 2007; Duncan et al., 2007; Hanich, Jordan, Kaplan, & Dick, 2001; Morgan, Farkas, & Wu, 2009). For students with severe early difficulties, the consequences are dire. For example, Morgan et al. (2009) found that students entering and exiting kindergarten below the 10th percentile at both time points on nationally normed mathematics assessments had a 70% chance of scoring below the 10th percentile 5 years later, and their mathematics achievement was roughly 2 standard deviations below that of their peers. In addition, a meta-analysis involving a number of longitudinal databases found that the association between early and later mathematics proficiency exceeded a similar association for reading achievement (Duncan et al., 2007).

The Current State of RTI Mathematics Research

The overall importance of mathematics and the value early learning experiences have in establishing successful learning trajectories strongly support an RTI service-delivery model. Despite calls for research on effective mathematics instructional approaches that could be used in RTI (Clarke et al., 2008, 2010; Crawford & Ketterlin-Geller, 2008; Gersten, Beckmann, et al., 2009), only a small number of studies exist. A recent review of research on mathematics interventions for use in RTI found only nine studies (Newman-Gonchar, Clarke, & Gersten, 2009), most of them focused on Tier II. In studies that examined Tier I interventions, either a supplementary program was used (Fuchs, Fuchs, & Hollenbeck, 2007; Fuchs, Fuchs, & Prentice, 2004; Fuchs et al., 2009) or an intervention was implemented that focused on a limited aspect of mathematics such as fluency with basic procedural operations delivered across a short time span (Ardoin, Witt, Connell, & Koenig, 2005; Burns & Vanderheyden, 2006; Vanderheyden, Witt, & Gilbertson, 2007). Although these supplemental interventions show promising results (Fuchs et al., 2004, 2009; Fuchs, Fuchs, & Hollenbeck, 2007), they require the delivery of a second program (i.e., in addition to regular instruction) in the Tier I setting. For example, Fuchs et al. (2004) developed a 32-lesson program to teach third-grade students how to solve complex, multistep word problems. Lessons were taught by the classroom teacher to the whole class and ranged from 25 to 40 minutes in length. Positive effects were reported for subgroups of students, including students at risk in mathematics.

Other interventions may lack sufficient intensity, or the limited content focus may not result in the sustained impact needed to have a positive effect on long-term achievement trajectories (Ardoin et al., 2005; Burns & Vanderheyden, 2006; Vanderheyden et al., 2007). For example, in the Vanderheyden et al. study (2007), Tier I intervention was provided to the whole class if the mean score for the class on a measure of computational accuracy and fluency was below a specified threshold. The intervention provided 10 minutes of instruction over 10 days in the specific area of computation accuracy and fluency. Although performance in this area is a key indicator of mathematics difficulties (Geary, 2004), the limited content and duration of the intervention may produce an initial boost on measures aligned with the intervention but not have an impact on long-term mathematics achievement. It should be noted as well that the Tier I intervention was linked to the Tier II intervention. That is, if a student did not respond to the Tier I intervention delivered to the whole class, the student was provided with a similar-in-content Tier II intervention delivered individually by the classroom teacher.

There is a particular dearth of information on effective core (Tier I) programs in mathematics for the early elementary grades. Agodini et al. (2009) completed an evaluation of four first-grade mathematics curricular programs, but only evaluated overall impacts. While providing critical information, the Agodini study, because it did not evaluate impact on at-risk students, does not provide information about how students who were at risk (those who might need Tier II or Tier III services) responded to a core Tier I program. We know of no similar evaluation of kindergarten mathematics curricular programs that either evaluated overall impact or impact for at-risk students.

Effective Tier I Instruction in Mathematics

The question of how best to address the needs of struggling students is particularly vexing in kindergarten. Whether due to philosophical opposition to instruction and intervention at a young age or practical considerations (e.g., time constraints), schools may face resistance to providing kindergarten interventions in mathematics. One potential approach to improving math achievement is to meet the instructional needs of at-risk students through the delivery of effective core or Tier I instruction to all students.

If a Tier I core program is to be implemented successfully in kindergarten, what elements need to be present? Two key components that should form the foundation of an effective Tier I core program are (*a*) a focus on critical content and (*b*) the incorporation of research-based instructional design principles. The National Research Council (2001) noted that mathematics curricula used in the United States were plagued by "a mile-wide, inch-deep approach" where textbooks attempt to cover a wide array of mathematical concepts. In direct contrast, the curricula used in countries with strong mathematics achievement cover a limited number of topics in great depth. This approach results in students mastering foundational concepts that lay the groundwork for more advanced mathematical content encountered in later grades (Milgram & Wu, 2005; National Mathematics Advisory Panel [NMAP], 2008; Schmidt & Houang, 2007). Recognizing the severe shortcomings in the mile-wide, inch-deep approach, the National Council of Teachers of Mathematics (2006) released a set of curricular focal points for each grade level. The intent has been to help educators focus on the critical content students should learn at each grade level, and it follows that this content should form the core of instructional programs used in classrooms.

Although only a limited number of high-quality intervention studies in mathematics have been conducted, there is a burgeoning body of research addressing the types of instructional strategies or instructional design features that are most effective for students who struggle with mathematics or have a mathematics learning disability. Three recent meta-analyses on low-achieving students (Baker, Gersten, & Lee, 2002) and students with learning disabilities (Gersten, Chard, et al., 2009; Kroesbergen & Van Luit, 2003) identified 15, 58, and 38 studies, respectively. Summaries of these findings (Gersten, Chard, et al., 2009; NMAP, 2008) have attempted to articulate what instruction incorporating these elements would look like in classrooms. Foremost, instruction would be explicit and systematic. Systematic instruction would build proficiency in a logical and coherent manner, introducing students to critical concepts and providing multiple opportunities to work with those concepts to mastery. Explicit instruction includes teachers proving models or think-alouds as they solve problems in which concepts and processes are made overt. Following teacher models, students solve similar problems and are provided specific and immediate feedback by the teacher as they verbalize and explain their solutions and understanding of the underlying mathematical concepts. Finally, instructional materials would include frequent and cumulative review of key concepts. Unfortunately, a number of reviews (Bryant, Bryant, Kethley, et al., 2008; Doabler, Fien, Nelson-Walker, & Baker, 2010; Sood & Jitendra, 2007) of existing Tier I curricula have documented that many programs fail to attend to these critical design elements, leaving at-risk learners at higher risk for failure (Carnine, 1997).

Early Learning in Mathematics

ELM is a comprehensive mathematics curriculum specifically designed to support a wide range of learners in kindergarten classrooms. The program consists of 120 45-minute lessons, with supplemental 15-minute calendar activities. Every fifth lesson comprises a whole-class problem-solving activity. On average, lessons contain four to five activities, each of which focuses on one of three content areas or strands: number and operations, measurement, and geometry. A fourth stand, vocabulary, is imbedded across the three content strands and is designed to increase the amount of math discourse and use of critical mathematics vocabulary.

Typically, the first activity introduces or reviews a math concept or skill that is central to the lesson's overall objective. For this part of the lesson, the teacher provides concrete examples and makes explicit the focus of the activity's targeted content. The second and third activities involve either an extension of the first activity or a review of previously learned material. The fourth activity often targets previously learned material from a different content area. For example, if the first three activities focus on rational counting and teen numbers (number and operations), the fourth activity will address material related to geometry or measurement. This way, children receive continuous practice in different content areas. The last activity entails a paper-pencil review. Facilitated by the teacher, this worksheet activity provides children with a cumulative review of the lesson's content. Included in every worksheet is a "note home" (in both English and Spanish) so that families can become familiar with the day's activities in class and can provide additional practice opportunities at home.

ELM was constructed around two main principles that specifically target at-risk students. First, it was designed to cover the most essential mathematics knowledge kindergarten children need to develop. Second, it includes the use of research-based instructional design principles found to be effective with at-risk students in mathematics. Together, these two components were hypothesized to specifically target the learning needs of at-risk students.

Each math content strand reflects the critical content identified in the National Council of Teachers of Mathematics Focal Points for kindergarten (NCTM, 2006) and aligns with the recommendations of the National Math Advisory Panel (NMAP, 2008) and other experts in the field (Cross, Woods, & Schweingruber, 2009; Kilpatrick, Swafford, & Findell, 2001; Wu, 2009). The focus on limited critical content is in direct contrast to the current approach taken by most curricula (NMAP, 2008). A strong focus of ELM is the development of early number sense and an understanding of whole numbers and number operations (Strand 1). Gersten and Chard (1999) defined the construct of number sense as "a child's fluidity and flexibility with numbers, the sense of what numbers mean, and an ability to perform mental mathematics and to look at the world and make comparisons" (pp. 19–20). Because number sense is important to subsequent growth in mathematics, students require early instruction in this key construct (Berch, 2005; Clements, 2004). Toward this end, ELM teaches students numbers through 100 with the goal of mastering numbers 1–30. Among other things, students learn one-to-one correspondence, efficient counting strategies, and how to decompose numbers, add 1 to a number, and solve simple addition and subtraction story problems.

A second content focus of ELM is geometry (Strand 2). Geometric and spatial thinking are important components of early mathematics as they allow children to represent figures and understand their spatial environment (Clements & Sarama, 2007; Van de Walle, 2001). In ELM, lessons introduce the names and attributes of common two- and three-dimensional shapes. For example, an instructional objective is to have children recognize and name circles, rectangles, hexagons, and ovals. Another part of the program is teaching children to recognize and extend basic AB and AABB patterns with numbers, and like and unlike objects.

The third strand of ELM is measurement. Children use measurement to compare and describe objects, and specify "how much" (Clements, 2004). ELM addresses the measurement strand by teaching the concepts of time (telling time to the hour) and money (identifying and counting coins). Children also learn how to use nonstandard and standard units of measurement. Lessons, for example, first introduce students to caterpillar rulers (where the nonstandard unit is a caterpillar) and then transition to measuring with traditional rulers (where the standard unit is an inch). Children make this bridge through explicit teacher demonstrations and guided practice.

Although ELM contains three content strands, the strands are not given equal weight. Consistent with the recommendations of the NMAP (2008) and NCTM (2006), a greater emphasis is placed on building an understanding of number and number operations. In addition, activities in the geometry and measurement strands are purposely designed to include work with number and number operations (e.g., comparing units of measurement using numerical representations) to further develop and reinforce student understanding of whole numbers.

ELM incorporates critical research-based instructional design principles specifically targeting the needs of at-risk students (Gersten, Chard, et al., 2009; NMAP, 2008) found to be lacking in instructional programs (Doabler et al., 2010; Sood & Jitendra, 2007). ELM is systematic in its approach to introducing mathematics content and utilizes a scope and sequence that builds student understanding of critical concepts from initial understanding to mastery. To aid in this process, instruction is scaffolded, with teachers beginning instructional sequences by providing extensive modeling. Scaffolded instruction in ELM also involves different representations of mathematics concepts. Concepts are often taught using a CRA sequence (Concrete Representation Abstract) (Witzel, Mercer, & Miller, 2003) where students and teachers first work with concrete manipulatives, advance to using visual representations, and conclude by working with abstract symbols. As students develop understanding, ELM gradually removes instructional supports and moves students from teacher models to teacher-guided practice, and finally to student independent practice. As students work with math concepts and procedures, ELM engages students in the process of verbalizing their thinking as they solve mathematical problems. Lastly, to ensure content mastery, ELM embeds frequent and cumulative review both within and across lessons. Across instructional activities, an explicit instruction approach is followed. ELM provides suggested scripted dialogue for teachers. Two integrated areas of ELM distinguish it from other kindergarten curricula. First, research-based instructional design principles (Gersten, Chard, et al., 2009; NMAP, 2008) are integrated throughout the program. These are currently either lacking altogether in other curricula or not integrated in a cohesive manner (Doabler et al., 2010; Sood & Jitendra, 2007). Second, ELM's major emphasis on the three content strands with a particular emphasis on whole-number understanding (NMAP, 2008) is more pervasive than found in current programs, and the integration of these strands throughout the entire curriculum is distinctly different.

Previous research indicated the promise of ELM in improving student mathematics achievement (Chard et al., 2008). An initial pilot study was conducted with 11 classrooms (6 treatment and 5 control) and 254 students. Classrooms in the treatment condition (ELM) had participated in the curriculum-development process in previous years (e.g., testing out sample lessons and curricular materials). Although assignment to condition was not random, performance at pretest was comparable on measures of mathematics achievement. At posttest, student performance on the Stanford Early School Achievement Test—Fourth Edition (SESAT-2; Harcourt Brace Educational Measurement, 1996) was examined using a mixed-model ANCOVA. On the SESAT-2, students in ELM classrooms exceeded the performance of students in control classrooms by approximately 2.7 raw-score points ($t = 2.18$, $df = 9$, $p = .0571$); this was statistically significant with α set at .10. This effect represented a partial r of .59, or approximately 35% of the classroom-level variance, controlling for pretest scores. Total variation—individual plus classroom variation—transplanted into a partial r of .13 and an effect size, d, of .26.

Purpose of the Study

The purpose of this study was to test the impact of a core kindergarten mathematics program, Early Learning in Mathematics, on the achievement of students at risk for mathematics difficulties. Specifically, our primary research question was, what is the impact of the ELM curriculum on the mathematics achievement of at-risk students in general-education kindergarten classrooms? We hypothesized that ELM would improve the mathematics achievement of at-risk students when compared to standard district practice. As a secondary question, we asked, does the at-risk sample in ELM classrooms make greater gains than their peers in the same classrooms who are not at risk, thereby reducing the achievement gap?

The focus of the ELM program—critical mathematics content, and the inclusion of research-based instructional design principles for at-risk students—allows an initial examination of how these factors operate in a Tier I instructional context and how they affect the achievement of at-risk students. The study has the potential to add to the expanding knowledge base on effective mathematics instruction for at-risk students and programs for use in tiered RTI models, particularly instruction designed to address the needs of the majority of students through Tier I supports.

Method

Design

A randomized controlled trial was the research design used. Math achievement data were collected from individual students, and random assignment and instructional delivery took place at the classroom level. Classrooms were randomly assigned to treatment or control conditions, blocking on school. Classrooms within schools were matched on half- or full-day kindergarten status and randomly assigned. Our primary analysis framework is a group-randomized trial (Murray, 1998, 2001), with students nested within classrooms and classrooms nested within condition. Thirty-four classrooms were in the treatment condition, and 30 classrooms were in the comparison condition. Initial randomized assignment resulted in 33 classrooms in the treatment condition and 33 classrooms in the control condition. Prior to the start of the study, two control classrooms were dropped due to low enrollment numbers. One control teacher inadvertently attended the initial ELM training; we subsequently reclassified this classroom as a treatment classroom. Comparison classrooms continued to use their existing kindergarten math curriculum and materials, and time was controlled so that treatment and control classrooms provided the same amount of daily mathematics instruction.

Participants

The study sample included two participant groups: kindergarten classroom teachers and students in the participating kindergarten classrooms. The teacher sample included 65 teachers teaching 64 general-education classrooms of kindergarten students (one classroom included two teachers who shared one job). The student sample initially included 1,349 students whose parents provided consent. A subset of these students (n = 1,302, or 97%) provided math data on at least one measure during some point during the study, with 3% of students not providing data because of absence for illnesses or other reasons, or because of transfer into another classroom, school, or district. For these reasons, the specific sample of students available for an analysis differs between nearly any pair of variables, which is common in most large-scale, school-based studies. Missing data were more prevalent at pretest, in the fall of kindergarten, than at posttest because of challenges associated with testing young children new to the school environment and late enrollees. We were unable to collect data from approximately 21.5% of students at pretest and 9.8% of students at posttest.

In the student sample, 56.3% were eligible for free or reduced-price lunch, 38.4% were English learners, and 8.4% were receiving special education services. The breakdown by ethnicity was 49.5% white, 36.4% Hispanic, 4.8% Asian American/Pacific Islander, 2.3% African American, and 6.9% other. The Test of Early Mathematics (TEMA) was used to classify the student sample as not at risk for mathematics difficulties or at risk for mathematics difficulties. The score used for this classification was the 40th percentile. This was selected because it corresponds to the designation of "at risk" used by common screening systems in early reading, such as DIBELS (Kaminski, Cummings, Powell-Smith, & Good, 2008), and with cut scores used in comprehensive evaluations of core (Tier I) curricular programs (Gamse, Jacob, Horst, Boulay, & Unlu, 2008). Table 1 provides descriptive information about the sample of students and teachers. Three districts participated in the study, with 33 classrooms

Table 1. Descriptive Statistics for Students, Teachers, and Schools by Condition

Measure	ELM	Control
Students:		
Age at T_1 (months):		
M	66.5	66.6
SD	3.79	3.70
L1 English (%)	67.7	62.7
L1 Spanish (%)	29.3	32.9
L1 other (%)	3.0	4.4
English language learner (%)	33.9	37.6
Pulled out from math instruction (%)	91.2	93.5
Individualized education plan:		
Total (%)	7.8	7.9
Speech and language (%)	5.9	6.1
Autism (%)	.4	.2
Specific learning disability (%)	.3	.4
Emotional disturbance (%)	.2	.5
Sample size	660	553
Teachers:		
Years teaching:		
M	3.6	3.6
SD	1.24	1.17
Years teaching kindergarten:		
M	3.7	3.6
SD	1.19	1.18
Sample size	34	30

Note.—L1 represents the teacher's report of student first language. Teachers reported that .8% of students were English learners and spoke English as their first language. Students were pulled from math instruction for English-language instruction, special education services, or other reasons. Of those students pulled from math instruction, approximately 5.5% were pulled out less than half of the time, and 2% missed more than half of their math instruction. The sample size represents teacher reports of English learner status, the maximum number of students available across all student demographic items. The remaining items were reported on at least 96% of that sample. Teaching experience refers to the number of years teaching including their first year of participation in this study.

(in 12 schools) from District A, 18 classrooms (in 9 schools) from District B, and 13 classrooms (in 3 schools) from District C. Overall poverty rates and percent of English language learners were 38.1% and 16% for District A, 37% and 7% for District B, and 26% and 12.6% for District C.

Protections against treatment diffusion. To minimize treatment diffusion, control teachers did not participate in ELM curriculum trainings, and intervention teachers were asked not to share ELM ideas and materials with their non-ELM colleagues. Both treatment and control teachers also were formally observed conducting their math lessons three times throughout the year using the ELM fidelity-of-implementation observation instrument, which included a specific item addressing whether or not the teacher used the ELM curriculum and ELM materials. Fidelity observations and classroom visits by project staff revealed that treatment diffusion did not occur. Of the 30 control classrooms in the study, 27 used a published curriculum as the primary means of instruction. The most popular curricula used were Harcourt (13) and Scott Foresman (7). Of the 27 teachers who used a published curriculum, 7 supplemented with teacher-made materials and 5 supplemented with another published curriculum. Three teachers used only teacher-made materials.

Table 2. Early Learning in Mathematics Instructional Objectives

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Numbers and operations:				
Rote counts	1–10	1–30	1–60	1–100
Reads numbers	1–10	1–30	1–60	1–100
Counts objects/pictures	1–10	1–20		
Counts on from a number	# < 5	# < 10	# < 20	# < 30
Skip counts		10s to 100	5s to 50	25s to 100
Sequences numbers	1–10	11–30	31–60	61–100
Matches sets to number	1–10	1–30		
Writes numbers	1–10	11–20	21–30	
Identifies quantity more/less	<10			
Identifies number more/less		<10		
Identifies ordinals		1st–4th	1st–5th	
Estimates number			√	√
Adds with objects/pictures		√	√	√
Subtracts with objects/pictures			√	√
Adds 1 to a number			√	
Subtracts 1 from a number				√
Geometry:				
Identifies, extends, creates patterns	√	√	√	√
Identifies shapes	circle, square, triangle	rectangle, oval	hexagon	cube, sphere, cone, cylinder
Creates and interprets graphs	√	√	√	√
Measurement:				
Identifies coins, value		penny, dime	nickel	quarter
Counts coins by value		penny, dime	nickel	quarter
Tells time to the hour			√	
Measures with inches				√
Calendar:				
Says days of the week	√			
Identifies and says daily date	√			
Names current month/year	√			
Identifies seasons		√		
Identifies "yesterday"		√		
Identifies "tomorrow"		√		
Says months of the year			√	
Identifies month before/next			√	

Professional development. Treatment teachers received three 4-hour ELM curriculum trainings throughout the school year (fall, winter, and spring) led by the lead author of the curriculum, a math teacher-educator from the University of Oregon. During the first training, teachers completed a questionnaire about their perceptions of the program, received their materials kits, and learned about the program's key components and first-quarter objectives (see Table 2 for a list of ELM objectives for each quarter), as well as ways to achieve high-quality instructional delivery. The second training focused on key concepts and instructional strategies, second-quarter objectives, and alignment of the ELM objectives with NCTM and district standards. During the third training, third- and fourth-quarter objectives were the focus; more general professional development (PD) regarding research on effective practices in math was also provided. The PD provider requested ELM teachers to attend each PD session prepared to discuss any component of the ELM program that they had questions about regarding implementation. Control teachers did not receive professional development.

Student Measures

Five measures were administered at both pretest and posttest. Early Numeracy—Curriculum Based Measurement (EN-CBM) included four subtests (Oral Counting, Number Identification, Quantity Discrimination, Missing Number) and the Test of Early Mathematics Ability—Third Edition (TEMA-3). The EN-CBM measures are 1-minute fluency measures designed to assess key mathematical concepts. Validity information reported for each of the EN-CBM measures below is from Clarke, Baker, Chard, Braun, and Otterstedt (2006) for number identification, quantity discrimination, and missing number, and from Clarke and Shinn (2004) for oral counting. Measures from the EN-CBM were summed to create a composite measure, EN-CBM total.

Oral Counting measure. The experimental Oral Counting measure required participants to count from 1 as high as they could. The measure was scored as the number of correct counts completed before an error was made, or if no error was made, the number of correct counts in one minute. Concurrent validity correlations ranged from .49 to .70, and predictive validity correlations with the Woodcock-Johnson Applied Problems (Woodcock & Johnson, 1989) subtest and the Number Knowledge Test (NKT; Okamoto & Case, 1996) ranged from .46 to .72 with first-grade students. Alternate-form, test-retest, and interrater reliability coefficients were all greater than .80.

Number Identification measure. The experimental Number Identification measure required participants to orally identify numerals between 0 and 10. Participants were given two pages of randomly selected numerals formatted in an 8 by 7 grid (i.e., 56 numerals per page). Concurrent and predictive validity correlations for Number Identification with the Stanford Achievement Test—Ninth Edition (SAT-9; Harcourt Brace Educational Measurement, 1996) and the NKT ranged from .45 to .65. Test-retest reliability was .88.

Quantity Discrimination measure. The experimental Quantity Discrimination measure required participants to name the larger of two visually presented numerals (one number was always numerically larger). Participants were given a sheet of paper with a grid of individual boxes. Each box included two randomly sampled numerals from 1 to 10. Quantity Discrimination concurrent and predictive validity correlations with the SAT-9 and NKT ranged from .52 to .71. Test-retest reliability was .80.

Missing Number measure. The experimental Missing Number measure required students to name the missing numeral from a string of numerals between 0 and 10. Kindergarten students were given a sheet with 21 boxes containing strings of three numerals, with the first, middle, or last numeral of the string missing. The student was instructed to orally state the numeral that was missing. Missing Number concurrent and predictive validity correlations with the SAT-9 and NKT ranged from .51 to .64. Test-retest reliability was .88.

Test of Early Mathematics Ability—Third Edition (TEMA-3; Ginsburg & Baroody, 1990). The TEMA-3 is a norm-referenced, individually administered measure of early mathematics for children ages 3 years to 8 years, 11 months. The TEMA-3 is designed to identify student strengths and weaknesses in specific areas of mathematics. The TEMA-3 measures both formal and informal mathematics, including skills related to counting, number facts and calculations, and related mathematical concepts. The alternate-form reliability of the TEMA-3 is reported as .97, and test-retest reliability ranges are reported to be from .82 to .93. Concurrent validity with other criterion measures of mathematics are reported as ranging from .54 to .91. The TEMA-3 provides age norms to calculate standard scores and percentile ranks.

Data Collection

All measures were individually administered to students. Trained staff with extensive experience in collecting educational data for research projects administered all student measures. All data collectors were required to obtain interrater reliability coefficients of .90 prior to collecting data with students. Follow-up trainings were conducted prior to each data-collection period to ensure continued reliable data collection.

Statistical Analysis

We assessed intervention effects on each of the primary outcomes with a nested time × condition analysis (Murray, 1998). This tests differences between conditions on change in outcomes from the beginning of kindergarten (T_1) to the end of kindergarten (T_2). This analysis approach included 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 × condition analysis accounts for autocorrelation among assessments within individual students and the intraclass correlation associated with multiple students nested within the same schools. As a test of net differences, it also provides an unbiased and straightforward interpretation of the results (Cribbie & Jamieson, 2000; Fitzmaurice, Laird, & Ware, 2004).

The specific model tests time, coded 0 at T_1 and 1 at T_2; condition, coded 0 for control and 1 for ELM; risk status, coded 0 for students with no risk and 1 for students at risk; and all interactions. Students were defined as at risk if they scored below the 40th percentile on the TEMA at pretest. The time × condition × risk effect estimates the difference in gains in the dependent variable between risk and no-risk groups. The model also allowed us to estimate time × condition effects separately within the risk and no-risk groups (the focus of the analysis), using the same model. That is, estimates of gain by condition were generated from the fixed-effect parameter estimates. All tests used 61 degrees of freedom.

Model estimation. We fit models to our data with SAS PROC MIXED version 9.1 (SAS Institute, 2004) using restricted maximum likelihood (REML), generally recommended for multilevel models (Hox, 2002). From each model, we estimated fixed effects and variance components. Maximum likelihood estimation for the time × condition analysis allows the use of all available data and provides potentially less biased results even in the face of substantial attrition, provided the missing data were missing at random (Schafer & Graham, 2002). In the present study, we did not believe that attrition or other missing data represented a meaningful departure from the missing-at-random assumption, meaning that missing data did not likely depend on unobserved determinants of the outcomes of interest (Little & Rubin, 2002).

The estimated models assume independent and normally distributed observations. We addressed the first, more important assumption (van Belle, 2002) using multilevel statistical models. Regression methods have also been found quite robust to violations of normality (Fitzmaurice et al., 2004), and several studies have found

Table 3. Descriptive Statistics for Mathematics Measures by Condition and Assessment Time

	ELM		Control	
Measure and Statistic	T_1	T_2	T_1	T_2
TEMA raw score:				
M	19.6	32.1	20.0	30.2
SD	9.58	9.42	9.57	10.17
TEMA percentile score:				
M	33.8	46.8	34.2	41.5
SD	28.51	27.56	27.97	28.42
CBM total:				
M	70.4	154.9	70.1	142.2
SD	51.22	52.66	51.21	57.12
Sample size				
N	599	621	548	554

Note.—The sample sizes represent the maximum students available across measures for each assessment period. At T_1, 52 students in the ELM condition and 49 students in the control condition were missing TEMA scores. Measures collected at T_2 included at most five fewer students than the maximum for both ELM and control.

that nonnormal data lead to acceptable results in a variety of multilevel modeling scenarios (Donner & Klar, 1996; Maas & Hox, 2004a, 2004b; Murray et al., 2006). This feature of multilevel models eases concerns about the different scoring methods used for different measures. The TEMA, for example, provides raw, scaled, and percentile scores. The analysis of the TEMA focused primarily on raw scores, and to facilitate interpretation we also analyzed TEMA percentile scores.

Effect sizes. To ease interpretation of effects, we computed an effect size, Hedges's *g* (Hedges, 1981), for each fixed effect. Hedges's *g* represents an individual-level effect size comparable to Cohen's *d* (Rosenthal, Rosnow, & Rubin, 2000), except that Cohen's *d* uses the sample standard deviation, while Hedges's *g* uses the population standard deviation (Rosnow & Rosenthal, 2008). For conditional effects that depend on moderators, however, we report Hedges's *g* for the appropriate subsamples.

Results

Table 3 presents means, standard deviations, and sample sizes for the TEMA-3 and CBM outcomes by assessment time and condition. We addressed our research hypotheses with the nested time × condition model defined above, focusing on tests of gains by condition within (*a*) the group of children not at risk and (*b*) the group of children at risk for math achievement problems. Complete model results can be found in Table 4. We supplemented the results of this model with an analysis of transitions from one risk category to another.

Attrition

Student attrition was defined as students with data at T_1 but missing data at T_2. For the TEMA-3, we experienced 9.8% attrition at T_2, with 8.0% of the sample missing data in control classrooms and 11.3% missing in ELM classrooms ($\chi^2(1) = 4.03$, $p = .0446$). EN-CBM scores were missing for 9.9% of students, with 8.0% of the students missing data in control classrooms and 11.6% missing in ELM classrooms ($\chi^2(1) = 4.69$, $p = .0303$). Thus, attrition rates differed between conditions.

Table 4. Fixed Effect, Variance Component, and Specific Effect Estimates from the Test Risk Status as a Moderator of Condition on Mathematics Outcomes

Effect or Statistic	TEMA Raw Score	CBM
Fixed effects:		
Intercept	28.04****	112.70****
	(.68)	(3.96)
Time	10.28****	72.38****
	(.52)	(3.69)
Condition	.73	6.32
	(.93)	(5.43)
Time × condition	.04	−.27
	(.72)	(5.07)
Risk	−14.04****	−66.93****
	(.68)	(3.83)
Risk × condition	−1.21	−7.66
	(.93)	(5.22)
Risk × time	2.82****	9.55*
	(.57)	(3.61)
Risk × condition × time	1.94*	11.09*
	(.79)	(4.95)
Variance components:		
Residual	16.07****	653.76****
	(.79)	(30.07)
Student	31.87****	919.47****
	(1.89)	(57.25)
Classroom intercept	3.88**	102.73*
	(1.29)	(41.30)
Classroom gains	1.04*	77.15***
	(.41)	(21.97)
Specific effects:		
No risk: time × condition	.04	−.27
	(.72)	(5.07)
Risk: time × condition	1.98**	10.81*
	(.60)	(4.26)
Hedges's *g*		
No risk: time × condition	.006	−.007
Risk: time × condition	.242	.215

Note.—Table entries show parameter estimates with standard errors in parentheses. Time is coded 0 for T_1 and 1 for T_2. Condition is coded 0 for control and 1 for ELM. Risk is coded 0 for no risk and 1 for students below the 40th percentile. All tests fixed effects used 61 *df*.

* $p < .05$.
** $p < .01$.
*** $p < .001$.
**** $p < .0001$.

Participant attrition, also called experimental mortality, can pose a threat to both the external and internal validity of a study (Barry, 2005; Shadish, Cook, & Campbell, 2002). Although differential rates of attrition are undesirable, differential scores on math tests present a far greater threat, so we conducted an analysis to test whether student math scores were differentially affected by attrition across conditions. The analysis examined the effects of condition, attrition status, and their interaction on pretest scores of TEMA and EN-CBM within a mixed-model ANOVA, which nests students' T_1 scores within classrooms and condition (Murray, 1998). We tested for differential attrition on T_1 measures with the T_2 attrition variables and found no statistically significant interactions between attrition and condition.

Effects for Children Not at Risk of Math Difficulties

For students not at risk, we did not expect substantial gains due to the ELM curriculum, since these students generally make gains in all classrooms. Descriptively, control students began the year with an average TEMA raw score of 28.8 ($SD =$ 7.3, 65th percentile), and students in ELM began with a mean score of 29.0 ($SD = 6.8$, 66th percentile). Control and ELM students ended the year with mean TEMA raw scores of 39.2 ($SD = 7.9$, 68th percentile) and 39.6 ($SD = 6.3$, 70th percentile), respectively. On the EN-CBM, students scored on average 116.7 (43.5) in control and 120.3 (44.0) in ELM classrooms at the beginning of the year and 187.9 (38.1) and 193.1 (35.8), respectively, at the end of the year.

The analysis demonstrated that students not at risk for math achievement difficulties in ELM classrooms did not make gains over those in control classrooms. This result was established with the TEMA raw scores ($t(61) = 0.05$, $p = .9586$) and CBM scores ($t(61) = -0.05$, $p = .9570$). For the TEMA, students in ELM gained .04 on students in control classrooms. Note that the nested time × condition model estimates will not align perfectly with the descriptive means.

Effects for Children at Risk of Math Difficulties

We hypothesized that the ELM curriculum would most benefit students at risk of math achievement difficulties. At-risk students, 66% of students in the sample, began the year with an average TEMA score of 14.6 ($SD = 6.2$, 15th percentile) in control classrooms and 14.1 ($SD = 6.0$, 14th percentile) in ELM classrooms. At posttest on the TEMA, control students averaged 26.9 ($SD = 8.0$, 31st percentile), and ELM students scored a mean of 28.6 ($SD = 8.4$, 36th percentile). On the EN-CBM measures, students scored an average of 45.5 ($SD = 35.5$) in control classrooms and 45.0 ($SD =$ 32.6) in ELM classrooms at pretest, and at posttest, they scored 126.6 ($SD = 50.5$) and 138.4 ($SD = 50.3$).

Within this subgroup of children, we found statistically significant improvements for ELM classrooms over controls on the TEMA raw scores ($t(61) = 3.29$, $p = .0017$) and EN-CBM total score ($t(61) = 2.54$, $p = .0138$). From the nested time × condition model, these results correspond to differences in gains between intervention conditions of 2.0 for the TEMA raw scores and 10.8 for EN-CBM. Hedges's g effect sizes were .24 on the TEMA and .22 on the EN-CBM. Also, in ELM classrooms at-risk students made greater gains on their not-at-risk peers than the gains at-risk students made on their not-at-risk peers in control classrooms. On the TEMA, in control classrooms, at-risk students made 2.8-point gains on their not-at-risk peers, while in ELM classrooms at-risk students gained 4.8 points on their no-risk peers. The same pattern was evident on the EN-CBM measure. In control classrooms, at-risk children gained 9.6 points on their no-risk peers, while at-risk students in ELM classrooms gained 20.6 points on their no-risk peers.

Transitions between Risk Categories

To address the practical implications of the effects of the ELM curriculum, we created a cross-tabulation of transitions between risk categories from pretest to posttest. This analysis included the 1,019 students with TEMA data at both T_1 and T_2. In both conditions, students migrated from the at-risk category to the no-risk category at a statistically significant rate (control, McNemar's $S = 55.11$, $p < .0001$; ELM, McNemar's $S = 113.14$, $p < .0001$).

In the control condition, 342 of 532 students (64.3%) at pretest were identified as at risk, as were 313 of the 487 ELM students (64.3%). Of the at-risk students at pretest, 102 (32.6%) in control classrooms and 143 (41.8%) in ELM classrooms shifted into the no-risk category by the end of the school year. Thus, about 9.2% more students in ELM classrooms transitioned from the at-risk to no-risk categories than in control classrooms, a difference that was statistically significant ($\chi^2(1) = 5.96$, $p = .0155$).

A few students who initially scored well enough to be classified as not at risk scored sufficiently poorly at posttest to fall into the at-risk category. Note that because the risk categories were defined by TEMA age norms, these students did not necessarily perform more poorly at posttest, but may have simply been unable to keep pace with their peers. In control classrooms, of the 174 students classified initially as not at risk, 20 (11.5%) were classified as at risk of math difficulties in the spring. In ELM classrooms, the corresponding percentage was approximately half the control percentage: 11 (5.8%) of 190 students with no risk at pretest fell below the 40th percentile by posttest. This difference was not statistically significant ($\chi^2(1) = 3.83$, $p = .0606$), but the p value is close. The chi-square and their associated p values were estimated with SAS PROC FREQ version 9.1 (SAS Institute, 2004) using exact likelihood ratio tests to account for the small cell sizes in the latter test.

Discussion

This study reports the results of a randomized control trial with 64 classrooms randomly assigned to treatment or comparison conditions. More than 1,300 students participated. In contrast to much of the research on RTI that is available (Newman-Gonchar et al., 2009), ELM was implemented by classroom teachers under the day-to-day conditions normally found in schools. Our findings, while preliminary, indicate that at-risk students in ELM classrooms outperformed their control counterparts on standardized measures of mathematics achievement (TEMA), as well as on a more proximal, formative measure (EN-CBM). In addition, at-risk students reduced the achievement gap with their average-achieving peers.

As part of our development and research of the ELM kindergarten program, we have begun to articulate and follow a framework that conceptualizes how general education, or instruction in Tier I settings, can be fully engaged in RTI efforts. One fundamental premise of our work is that a keystone for RTI is effective instruction in Tier I through the use of a core program. However, we recognize that if we are to get beyond general statements asserting that Tier I instruction must be of high quality, we should provide precise definitions and guidelines for general education and for schools that address the role of Tier I in an RTI model (Clarke et al., 2008). For general education to be a full partner with special education in the complex work of implementing RTI, tangible steps that classroom teachers and schools can take to provide effective Tier I instruction must be clear (Gersten, Beckmann, et al., 2009). In our study, we hypothesized that two key variables, coverage of critical content and the use of research-based instructional design principles, would result in a positive impact on the mathematics achievement of at-risk students.

In mathematics, an effort to improve Tier I instruction should start with careful consideration of the core curriculum, specifically the content covered by the core (NCTM, 2006; NMAP, 2008). Our development of the content coverage in ELM was undertaken to represent this approach. Because ELM functioned as a core program, it needed to cover multiple strands (number, measurement, geometry) while placing the greatest emphasis on developing understanding of whole numbers. This approach is similar to approaches taken in the delivery of other effective Tier II intervention programs in early mathematics (Bryant, Bryant, Gersten, Scammacca, & Chavez, 2008; Fuchs et al., 2005). For example, Fuchs et al. (2005) designed a 64-lesson Tier II intervention program for first-grade students targeting content in the area of whole numbers and found positive effects on a range of outcomes assessing whole number operations and understanding. Similar effects were found in second grade by Bryant, Bryant, Gersten, and colleagues (2008), who developed a 100-lesson curriculum targeting whole number operations and understanding.

Also, independent of content coverage, any attempt to improve outcomes for at-risk students should incorporate additional critical instructional design elements. For example, our contention is that the systematic inclusion into Tier I core instruction of research-based design elements that are normally targeted with students receiving Tiers II and III supports (Fuchs, Fuchs, Craddock, Hollenbeck, & Hamlett, 2008; Jitendra et al., 1998) will substantially increase the probability that at-risk students will learn key mathematical concepts presented in Tier I core instruction. By including these elements in Tier I, ELM specifically targets the learning needs of at-risk students in a Tier I instructional context.

We believe schools should evaluate any attempt to provide effective Tier I support for students by examining key findings for groups of students. That is, any Tier I effort to address the instructional needs of at-risk students must demonstrate, at a minimum, that it does not suppress achievement of average and high-performing students. It is easy to conceptualize how this type of suppression might occur: Instructional efforts that are particularly targeted to the needs of students who have some degree of difficulty learning mathematics could run the risk of not providing challenging instruction for students for whom learning mathematics comes easily. Our contention, however, is that the right integration of instructional design and delivery features in Tier I programs can meet the needs of the majority of students. This hypothesis was supported by our results.

If the achievement gap is going to be reduced in ways other than the unintentional suppression of learning by average and high-performing students, Tier I efforts must work across all levels of achievement but have measurably greater gains for at-risk students. Evidence from this study suggests that ELM may display the desired impact of a Tier I program where on-track students learn successfully and at-risk students reduce the gap with their on-track peers. In this study, at-risk students in ELM not only outperformed at-risk students in the control group, but also, and perhaps more importantly, reduced the gap between their performance and the performance of their no-risk peers. In practical terms, the evidence suggests that ELM might decrease the number of students identified as at risk at entry into first grade. If this hypothesis were true, it would have serious and positive implications for schools in terms of resource allocation, and it could provide a tangible way to increase the capability of schools to provide effective instructional support for all students across the continuum of educational need.

Limitations and Future Research

In this study a number of limitations must be noted. First, this study was completed in one region of the country. We are currently conducting a second efficacy trial in Texas to address concerns about the generalizability of findings. Second, while we have preliminary evidence that ELM "works," we do not yet have confirmatory information regarding why it works. With classroom observation data and other data, we are beginning to examine associations among fidelity of implementation, mediation and moderation variables, and student achievement. A deeper understanding of these patterns will help us determine potential causal associations with student achievement. Future research efforts and professional development can incorporate these more nuanced findings by targeting, for example, an increase in certain types of teacher-student interactions in an effort to produce greater student outcomes. Lastly, treatment teachers participated in three 4-hour sessions of PD. Although the PD was focused specifically on ELM and not generally effective mathematics teaching practices, the fact that control teachers did not receive a corresponding amount of PD means that the delivery of PD to ELM teachers cannot be ruled out as a possible explanation for observed results.

Findings from this study also raise a number of interesting questions. ELM demonstrated a significant impact on the overall achievement of at-risk students, and, in the ELM condition specifically, at-risk students made significantly greater growth over the course of the year than students not at risk. In other words, the intervention was effective for these students and it helped reduce the achievement gap. However, the achievement gap was not eliminated, nor did the at-risk students reach the level of desired overall performance that would be described as performing at grade level (i.e., 50th percentile). One consideration for additional efforts to boost the performance of at-risk students to further reduce the achievement gap and perform at grade-level expectations is to make additional adjustments in the context of their Tier I support system for at-risk students. Providing differentiated instruction within Tier I has shown promise in early reading (Connor et al., 2009; Scanlon, Gelzheiser, Vellutino, Schatschneider, & Sweeney, 2008) and holds promise in early mathematics instruction specifically and as an overall approach for enhancing the quality of tiers of instructional support for students generally.

Any RTI research should be concerned with examining questions of differential impact based on student level of risk. It may be that any intervention delivered in Tier I will have a limited impact on those students who exhibit the most intense academic deficits (e.g., within a subgroup of at-risk students below the 40th percentile or those students below the 10th percentile). Perhaps the needs of high-risk students can best be met by the integrated use of a strong core program (Agodini et al., 2009) plus a supplementary program (Fuchs et al., 2005). This approach fits an RTI model in which successively more intensive interventions are provided when a student does not respond adequately to the combination of instructional supports provided in a particular tier (Fuchs, Fuchs, & Vaughn, 2008; NASDSE, 2006). For example, Fuchs and colleagues (Fuchs, Fuchs, & Hollenbeck, 2007) have studied the impact of multiple tiers of instruction linked together. Third-grade students are first provided a supplemental program at the whole-class level (Tier I), and then students who do not respond are provided the same program but in a small-group setting (Tier II). Results indicate that this "double dose" approach reduces the percentage of students who are at risk above approaches where the students receive no intervention or only one of the two tiers of support. When thinking about applications for kindergarten, schools could use a program like ELM as the first part of their double dose (Tier I), and then provide an intervention program (Tier II) for students who do not respond to ELM.

Expanding research efforts to determine effective instruction across multiple tiers of RTI is a critical first step in improving educational practice. Such efforts must eventually be coupled with appropriate support to schools and teachers who attempt to transfer research findings into effective classroom practice. Quality implementation in schools is essential, of course, both as a way to ensure that programs are implemented as intended and to better understand why some students may not make adequate progress despite the use of evidence-based programs. It is also important that local schools and districts develop the capacity to conduct serious evaluations of the practices they implement and the outcomes students achieve. The combination of expanding research efforts and effective implementation in schools holds the promise for the benefits of RTI in mathematics to be fully realized.

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