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The KeyMath-3 Essential Resource Program: Mathematics Achievement of Students Served in Resource Settings

Diana Linn, Ph.D.

Randel Brown, Ph.D.
Texas A&M International University

Abstract

Special Education teachers serve students who are struggling in mathematics and continue to fall further behind each year. Educators are faced with the challenge of selecting the most effective program for assessing and teaching mathematics that will promote mathematics achievement for students who are served in resource settings. The KeyMath-3 Essential Resources (KeyMath-3 ER) is a mathematics program aligned with National Council of Teachers of Mathematics standards, which incorporates research-based practices for teaching mathematics to students with disabilities. This study utilized the KeyMath-3 ER program as an intervention with five second-grade students with various disabilities receiving their mathematics instruction in a resource setting. The results demonstrated the potential usefulness of KeyMath-3 ER as an effective program for students in a resource setting. The one outlier was a student with autism who did not show significant progress demonstrating a need for further research to assess the effectiveness of using this program with like students.

Keywords: students with disabilities, KeyMath-3, mathematics, resource setting, intensive intervention

The KeyMath-3 Essential Resource Program: Mathematics Achievement of Students Served in a Resource Setting

Failure to master mathematics affects students' academic achievement and their futures as independent adults because basic mathematics skills are part of life skills that are needed to be productive citizens (Witzel, et al., 2012). Students who are struggling with mathematics require intensive instruction and supplementary support early in their academic careers before the gap becomes so large that the students are diagnosed or misdiagnosed as students with disabilities. It is critical that educators implement early intervention that include instructional methods and strategies to help all students experience success in mathematics (Fuchs et al., 2008).

Driven by the demand to improve mathematics achievement and the requirements of federal and state mandates including Individuals with Disabilities Education Improvement Act of 2004, No Child Left Behind of 2002, and individual state accountability measures, educators are responsible for implementing programs that will meet the needs of these diverse learners (Jitendra, 2013). Powel and Fuchs (2015) note that many educators do not have the research-based material and resources needed to provide intensive instruction. Likewise, it is reported that a lack of appropriate materials for teaching and evaluating mathematics skills, based on the National Council of Teachers of Mathematics (NCTM) standards prevents implementing the standards (Maccini & Gagnon, 2002). These standards are widely accepted by mathematics educators as offering appropriate focus in the development of schools' mathematics programs (Conolly, 2007). NCTM recommends that ongoing assessment should be used to lead teachers as they make instructional decisions resulting in maximized student performance and learning (Hunt & Little, 2014). Finding a program that is based on NCTM standards incorporating research-based best practice methods for teaching math both at the assessment level and the instructional level is a priority. The KeyMath-3 Essential Resources (KeyMath-3 ER) is based on the NCTM principles and standards for teaching mathematics and is constructed on research- based best practice for teaching mathematics to students with disabilities (Connolly, 2008). Therefore, the KeyMath-3 ER has the potential of meeting the individual needs of these students. The purpose of this study was to determine the effect of KeyMath-3 ER program on the mathematics achievement of students with disabilities receiving mathematics instruction in a resource setting.

Literature Review

The National Council of Teachers of Mathematics NCTM (2000) developed principles and standards for teaching mathematics. The five NCTM standards include numbers and operations, algebra, geometry, measurement, and data analysis and probability. The five main goals of these standards include improvement in problem solving, thinking mathematically, seeing the value of mathematics, gaining confidence in the ability to use mathematics, and learning to communicate in mathematical terms. Furthermore, the NCTM (2000) standards require a program that teaches mathematical concepts using manipulatives, real objects, application to real life, group work, discussions, active student involvement, and teacher-led instruction. Effective research-based mathematics interventions for students with disabilities should be aligned to the NCTM principles and standards and should be grounded in research-based best practice methods for teaching mathematics to students with disabilities (Wadlington & Wadlington, 2008).

Fuchs and colleagues (Fuchs et al., 2008) outline seven principles that are components of effective research-based interventions for students with mathematics disabilities. These include explicit instruction, instructional design that minimizes the learning challenge, a strong conceptual basis, daily drill and practice, cumulative review, motivators that manage behavior and attention, and ongoing progress-monitoring. The KeyMath-3 ER program addresses the seven principles outlined by Fuchs and colleagues (Fuchs et al., 2008) and is aligned to NCTM standards.

First, an effective mathematics program must have explicit instruction, whereby the teacher provides direct teaching to students (Fuchs et al, 2008). Likewise, Doabler and colleagues (2012) reaffirm that students with disabilities and students in at-risk situations require instructions in mathematics that are explicit and systematic. Additionally, Kroesbergen and Van Luit (2003) indicate that students with disabilities need explicit instruction using illustrated flip charts to teach lessons. Guided practice in which the teacher further supports students' learning is included as needed (Connolly, 2008).

Second, Fuchs and colleagues (Fuchs et al, 2008) argue that explicit instruction be part of an instructional design that minimizes the learning challenge. The content must be introduced in a sequence that maximizes learning by building on what the student already knows. The instructional design of the KeyMath-3 ER aligns to this participle. It has clusters of lessons, which must be taught in a specific order (Connolly, 2008). The KeyMath-3 ER utilizes the KeyMath-3 Diagnostic Assessment (KeyMath-3 DA) to place students in the appropriate level in the program, which minimizes the learning challenge. After conducting the KeyMath-3 DA and entering data into the companion computer program, a report is generated, indicating the clusters of objectives that need to be taught. The content is introduced in a specific order, with students taking a pre- test to ensure that they have the foundational skills before they begin the cluster of new concepts or skills. Students are given a posttest at the end of each cluster and can advance to the next level when they master the skills of the cluster.

Third, the program/intervention must have a strong conceptual basis. When this is lacking a student may have learning gaps, be confused, or forget previously mastered concepts (Fuchs et al., 2008). With the widespread adoption of Common Core Standards, word problems became more frequently used in the classrooms for both instructional and state assessment purposes leading to a crucial necessity to build on and facilitate conceptual knowledge. Using number lines to visually denote word problems demands thorough and efficient teaching before students become skillful and increase their problem-solving abilities (Gonzalves & Krawec, 2014). For example, conceptual instruction can include the use of manipulatives and role-playing when learning to solve word problems.

Other visual representations can include finger models, tally marks, base-10 blocks, place value charts, and hundreds charts (Doabler et al., 2012). Having a strong conceptual basis is evidenced in KeyMath-3 ER's rich usage of manipulatives and visuals throughout the lessons (Connolly, 2008).

Fourth, Fuchs and colleagues (Fuchs et al, 2008) maintain drill and practice is necessary daily to retain what has been taught. Additionally, it is essential that teachers provide multiple practice opportunities in both guided and independent practice to help students acquire math proficiency (Archer & Hughes, 2010). The KeyMath-3 ER incorporates daily drill and practice in the guided and individual worksheets used as part of classwork, independent work, and/or homework.

The fifth principle of Fuchs and colleagues (Fuchs et al, 2008) is a cumulative review in which previously learned skills are accessed for maintenance and mastery. Cumulative review allows verification toward a student's comprehension of learned skills, and educators can access comprehension through work that may include paper-based end discussions (Doabler et al., 2012). Each cluster of the KeyMath-3 ER has sufficient material that the teacher can use as cumulative review for previously learned skills.

The sixth principle of Fuchs and colleagues (Fuchs et al., 2008) involves maintaining the students' motivation to ensure performance for adequate progress. Once a student experiences success, their self-confidence improves, and their motivation is likewise strengthened. The KeyMath-3 ER captures student attention through engaging materials. Teachers can include additional incentives to help students stay focused and involved with instructional materials.

The last principle contends that an effective mathematics program must have a way to monitor progress (Fuchs et al., 2008). The teacher uses information from progress monitoring data to adjust instruction as needed. Connolly (2008) includes progress monitoring throughout the KeyMath-3 ER program. First, after placement in the program at the appropriate level, students are assessed at the end of each cluster. If they do not demonstrate satisfactory progress, the skills are retaught, and students are retested. Finally, progress in the program can be monitored using the KeyMath3-DA as a formative and/or summative assessment. The KeyMath3-DA shows students' beginning level of mathematics achievement, progress throughout the intervention and summative data at the end of the school year.

In addition to outlining the seven principles in their seminal article, Powell and Fuchs (2015) assert that intensive intervention is required for students who continue to struggle with mathematics and are performing considerably below grade level. They suggest an intervention that consists of three elements: planning of intervention/instruction, the implementation of intensive instruction, and monitoring interventions. The first step in planning for intensive intervention is to determine a student's individual strengths and weaknesses using a diagnostic assessment. An assessment that is diagnostic in nature will identify any gaps in foundational mathematical skills for teachers to include in mathematics instruction. Assessment data is used to plan instruction that includes foundational and critical skills. Then, intensive interventions are implemented beginning with a brief warm-up review of mathematics skills already learned, utilizing explicit instruction of new learning, ending each lesson with a review of skills learned, and building on a foundation of a high motivational plan. Finally, progress is monitored through observation and weekly measures with the intent to use data to adjust instruction as needed. The KeyMath-3 ER includes all three elements of the intensive instruction suggested by these authors.

A literature review more specific to KeyMath-3 ER is difficult as research concerning the efficacy of the program is negligible. However, the program's components, (clear, well-organized lessons, whole group instruction, effective modeling, open-ended questions, critical thinking, pair work and group work, guided individual practices and lesson summaries) have been researched previously (Connolly, 2008) and provide the potential supposition that the KeyMath-3 ER will increase the mathematical achievement of students participating in this program. These standards are widely accepted by mathematics educators as offering appropriate focus in the development of school mathematics programs (Connolly, 2007). The purpose of this study was to determine the effect of the KeyMath-3 Essential Resources mathematics program on the mathematics achievement of elementary students with disabilities receiving their mathematics instruction in a resource room.

The third edition of the KeyMath3-DA, published in 2007, has a mathematics education program (Essential Resources) that accompanies it. According to the author (Conolly, 2008), the KeyMath-3 Essential Resources is a "comprehensive mathematics intervention program" that is linked to a "valid and reliable assessment [KeyMath-3 Diagnostic Assessment, 2007] patterned after the National Council for Teachers of Mathematics (NCTM) content and process standards" (p. 1) The program is recommended as targeted instruction for students who are at-risk or are performing below grade level in mathematics. It can be used in a variety of settings including, for the purpose of this study, the resource classroom. While components of the program are research-based, research using the mathematics program with students with disabilities has not yet been conducted.

Federal and state testing requirements require yearly assessment in core subjects such as mathematics for all students including those with disabilities, and schools are required to make adequate yearly progress (Malmgren, McLaughlin, & Nolet, 2005). KeyMath-3 DA is a nationally standardized, norm and criterion referenced assessment (Connolly, 2007). Before the KeyMath-3 DA was released to educators, a pilot study was conducted to make any necessary revisions. After, samples were conducted to check standardization and brought about more revisions. Additional studies were conducted to check the reliability and validity. The norm sample included an accurate representation of students in the United States including Hispanic, African American, White, and other groups. Included in the study are schools in South Texas along the Texas and Mexican border in communities similar to that of the setting of this study (Connolly, 2007). The KeyMath-3 DA manual provides complete information on the results of these studies.

Method

Setting

The present study was conducted at an elementary campus located in a school district in South Texas. The following table summarizes the characteristics of the state of Texas, district, and campus of this study.

Characteristics of students in Texas, District, and Campus			
Characteristics	State of Texas	District	Campus
Enrollment	5,284,252	23,597	799
Latino Students	52	98.8	98.7
ELLs	18.5	39.5	33.4
Poor	59	76.7	47.2
SPED	8.6	7.5	6.3

Note: All numbers, except those for enrollment, are in percentages. ELLs indicate enrollment of English Language Learners. Poor indicate enrollment of poor/underserved students. SPED indicate enrollment of students in special education programs.

Source: Texas Education Agency (2016a; 2016b; 2016c).

Participants

Participants in the study include five students with disabilities receiving mathematics instruction in a resource room setting. All students are Hispanic, two males and three females. The youngest was 7 years, 3 months at the onset of the study, and the oldest was 9 years. The average age of participants was 8 years, 5 months, and the median age was 8 years, 8 months. One student was diagnosed with autism, one with an intellectual disability, and three were classified as other health impaired (OHI). Of those in the last category, one had attention deficit hyperactivity disorder (AD/HD), another had neurofibromatosis, and the third had myasthenia gravis. Three of the participants were also receiving services for speech and language impairment.

Parental consent for students to participate in the study was obtained, and the Instructional Review Board (IRB) approved the study in the fall of the academic year. The study employed a pre-experimental design, which includes a pre-test measure followed by a treatment and a posttest measure for a single group. The KeyMath-3 Diagnostic Assessment (KeyMath-3 DA), Forms A and B, was used for all testing throughout the study. The timeline for testing is presented in Table 2. Results of the pre-testing were used to place students at a level in the KeyMath-3 Essential Resources (KeyMath-3 ER) program. Students received mathematics instruction with the program for 45 minutes a day, five days a week, throughout the academic year. The following table outlines the testing timeline.

Testing Timeline			
Time Frame	Pre-test	Progress Monitoring	Post-test
September	Form A	----------	----------
February	----------	Form B	----------
May	----------	----------	Form A

Instrumentation

KeyMath-3 Diagnostic Assessment. The KeyMath-3 Diagnostic (KeyMath-3 DA) instrument "is a comprehensive, norm-referenced measure of essential mathematical concepts and skills … [That can be] ... use[d] to develop effective and individually tailored intervention programs" (Connolly, 2007, p.1).

The instrument is organized into three content areas: Basic Concepts (conceptual knowledge), Operations (computational skills), and Applications (problem solving). Also, the instrument reflects the content and process standards from the National Council of Teachers of Mathematics (NCTM) Principles and Standards for School Mathematics (NCTM, 2000).

To establish content validity, state mathematics standards and those from the NCTM are used to create a "comprehensive blueprint reflecting essential mathematics content," and items are developed that "accurately assess [ed] student proficiency in the specified concepts and skills" (Connolly, 2007, p. 85). Finally, input is obtained from practitioners and consultants with expertise in the development of mathematics curricula. The KeyMath-3 DA uses three methods to establish reliability. Split-half reliability coefficients to establish internal consistency ranged from .85 -.98. Across grade levels and subtests. Alternate form reliability coefficients ranged from .88-.96. Test-retest reliability coefficients ranged from .93-.97 (Connolly, 2007).

Following administration, the students' scores are entered into the accompanying computer software to generate reports and data. The data garnered from KeyMath-3 DA is used to design individual and small group instruction, which addresses the student's individual mathematics areas of growth. The educator then uses the KeyMath-3 DA to monitor students' progress three times a year. The reports generated from these assessments are shared with parents and other educational professionals. Additionally, the information about the students' strengths and areas of growth are used to create individualized education programs (IEPs) for math instruction.

KeyMath-3 Essential Resources Program. Once the educator completes the assessment, they enter the information in the companion computer program. A report is generated that will show exactly which lessons the student needs from the companion KeyMath-3 ER. In contrast with most other assessments, the teacher has to search and gather materials from various places to teach the needed skills to students. The results from the KeyMath-3 Diagnostic Assessment indicate skills the student has and has not mastered; KeyMath-3 ER provides the specific lessons each student needs. The teacher can print out the required lessons from the ER CD and use large flip charts to teach the lessons needed (Connolly, 2008).

The KeyMath-3 ER lessons require little preparation time and use hands- on material and manipulatives that are readily available in most classrooms. These are added pluses for educators with limited time and budgets. The KeyMath-3 companion resources save time and money for the educator because all the needed material is at their fingertips. The colorful, visual large-format instructional easels and manipulatives meet the visual needs of learners and engage the students. The lessons are well organized and come with a script and easy to follow instructions (Connolly, 2008). The material comes in two levels with two easels per level and clear overlays to use with a dry erase marker (Connolly, 2008).

Data Collection and Analysis

Raw scores from all testing conducted throughout the study were entered into the ASSIST Scoring and Reporting System, a software program that accompanies the KeyMath-3 DA. The ASSIST software identifies a functional range for each participant and generates an intervention plan, comprised of KeyMath-3 ER lessons. Connolly (2008) defines the functional range as "compri[sing] concepts and skills the student has begun to develop, but has not mastered.… Although it varies from student to student, the functional range contains between 5 and 10 items" (p. 23).

The software facilitates intervention planning by linking the results from testing directly into appropriate lessons for each participant in the study. Using the raw scores from the pre-test, the software program creates links "by comparing the behavioral objective for each test item (i.e., the specific mathematical skill the student would be demonstrating by responding correctly to that item) to the content covered in each of the KeyMath-3 ER [italics added] lessons" (Connolly, 2008, p.23).

Subsequently, raw scores from the progress-monitoring testing in February and May were entered into the ASSIST software. Progress reports for each participant in the study were generated. In the progress report, the KeyMath- 3 DA utilizes the growth scale value (GSV), which "represents an equal-interval scale that measures an examinee's mathematical proficiency on a developmental continuum … [in each of the] content areas (Basic Concepts, Operations, and Applications) and for the Total Test" (Connolly, 2007, p. 27). Use of the GSV permitted the researcher to report the participants' progress in mathematics over the three test administrations" pretest, progress monitoring, and posttest.

Results

The following table delineates results for the participants in the study on the subtests of Concepts, Operations, and Applications, as well as the Total Test scores.

Growth Scale Value (GSV) Scores with Change over Baseline Scores						
Test and subtests	Name of student	Baseline GSV	February GSV	May GSV	Change over baseline Student	Change over baseline Norm Group
Concepts						
	Dalia	142	143	153*#	17.2	10.3
	Ana	139	154*#	166*#	45.6	12.1
	Susana	136	129	128*	-13.1	10.9
	Osvaldo	157	171*#	173*	24.2	9.8
	Juan	139	119*#	144#	5.5	9.9
Operations						
	Dalia	114	142*#	144*	46.1	12.6

	Ana	154	157	159	9.5	15.8
	Susana	114	124*#	138*#	34.9	13.8
	Osvaldo	161	162	161	0.0	11.8
	Juan	149	132*#	152#	0.8	11.9
Applications						
	Dalia	135	146	139	6.4	11.2
	Ana	135	156*#	153*	33.1	13.2
	Susana	124	135	116#	-7.7	12.0
	Osvaldo	153	165	170*	25.4	10.6
	Juan	135	130	142#	12.5	10.7
Total Test						
	Dalia	137	143*#	149*#	17.6	11.6
	Ana	143	155*#	162*#	33.4	14.0
	Susana	131	130	128	-5	12.6
	Osvaldo	157	167*#	169*	17.5	10.9
	Juan	141	124*#	146#	5.4	11.0

Note. * Denotes change over baseline is significant; #denotes change over previous administration is significant

[a] in GSV units per year

"The change in GSV scores is considered significant if there has been a change greater than would be accounted for by standard error of measurement" (J. DiPasquale, personal communication, May 5, 2014). As indicated by the growth scale values on the Concepts subtest, Dalia and Ana showed significant gains during the May testing over both baseline and the February testing. Additionally, Ana and Osvaldo showed significant gains in basic concepts from the baseline testing in September to the progress-monitoring in February. Finally, Osvaldo showed significant improvement in GSV scores from the baseline to the May testing.

On the Operations subtest, growth scale values indicated that two students, Dalia and Susana, showed significant gains from the baseline testing during the May testing. After posting a significant decrease in his GSV score between baseline and February testing, Juan's overall gains were significant from baseline in September to the May testing. Two students, Ana and Osvaldo did not make significant progress on the Operations subtest.

On the Applications subtest, growth scale values indicated that only Ana showed significant gains during both the February and May testing over baseline. Additionally, Osvaldo showed significant gains in his GSV scores in the May post testing over his baseline score. Finally, Juan showed significant gains in his scores in May from the February progress monitoring scores, but this was after a five- point decrease, albeit insignificant, between baseline and the progress-monitoring testing. Dalia and Susana showed no significant gains in their mathematics achievement as measured by the KeyMath-3 DA.

Three students, Dalia, Ana, and Juan, showed significant gains during the May testing over both baseline and the February testing on the aggregate Total Test score. Osvaldo showed significant gains during the February testing over baseline and in May over baseline. Susana did not show significant gains on her score on the Total Test. In fact, her average change over baseline for the Total Test was -5.0 compared to a gain of 12.6 for the norm group.

Limitations

There is a limited amount of information that has been researched with the KeyMath-3 program and its application success, although the sample size population of the assessment provides us with the necessary comparison range for the sample population in this study. This indicates the essential need for future research to enhance the results of this study.

Limitations of this study include a small sample size. The present includes five students with a disability that received their mathematics support in a resource classroom at an elementary school. The data collected was only limited to the progress that was shown from the students participating in the program. The limitations from this study indicate future research opportunities to increase the sample size and gather a greater amount of data, including a bigger range of participating students. The program can be implemented in different resource classrooms within the same school district. The data can then be compared to the different disabilities that students share or do not share and whether the program works best for them. Bearing in mind the sample size from this research and the information gathered from the school district, the program showed the potential of substantial progress through the implementation of this program. Keeping the same school district for future research, a study can be conducted on a larger Hispanic population.

An additional limitation of this study was the minimum length of the study. The program implementation complied with the monitoring period and started with a baseline collected in September and included a progress monitoring in both February and May. Though it was implemented throughout the entire school year and demonstrated progress for students, the results did not indicate whether students made enough progress to get to their grade level of mathematics. Considering this limitation, future research calls for an extended time the program is implemented to ensure students reach their full potential of mathematics skills that allows them to build those basic concepts that are necessary for advanced mathematics subjects. Furthermore, a follow-up study can be conducted within a year after program implementation to ensure if the skills learned from the program are retained even if the students are no longer participating in the program implementation.

Of particular interest for future research is the lack of progress in this program for the student with autism; future research is recommended to determine if the student in this study was an outlier or if this program be effective for students with autism. There is little to no information at this moment that can give us a definite response as to why this program failed to build mathematics concepts for this student with autism.

Conclusion

Results were strongest for Ana, Dalia, and Osvaldo, who showed an average change in baseline for the three subtest and total test scores of 30.4, 21.82, and 16.77 respectively. With the given results, the KeyMath-3 program shows potential to increase knowledge in basic concepts, operations, and applications in a resource classroom, if implemented correctly.

According to the teacher who implemented the program, lesson preparation was efficient. Additionally, the students enjoyed the daily lessons including the visuals and manipulatives that allowed for multiple ways for students to engage with the mathematics content. Finally, when the student was exposed to material that was difficult, they had the support they needed to complete the tasks including getting through difficult wording that comes with mathematics, especially for English learners.

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About the Authors

Dr. Diana Linn is an associate professor of Special Education at Texas A&M International University. Prior to this appointment, she worked for 22 years in public and private K-12 schools in Mexico City and Laredo, Texas. Since 2009, she has led a summer study abroad program in Madrid. In her free time, she enjoys reading books about history and spending time with her two grandsons.

Dr. Randel Brown is an associate professor of Special Education. He has been in that position for the last 28 years. Prior to this appointment, he served many years as a Special Education Teacher, Oklahoma Education Department Compliance Officer, and as an Educational Professional working with adults who have disabilities.