The Effects of a Multi-Component Intervention to Increase Math Performance for Students with EBD in Alternative Educational Settings

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Abstract: Historically, secondary students with emotional behavioral disorders (EBD) have made poor progress in mathematics putting them at risk for school failure and placement in an alternative setting. Two under studied areas essential to success in mathematics are fractions and algebra. The purpose of this study was to test the effects of a multi-component intervention on the math performance for middle school students with EBD in an alternative educational setting. This study used a one-group nonequivalent dependent variables design (Shadish, Cook, & Campbell, 2002) with multiple measures in multiple waves to assess the effects. Repeated measures ANOVA indicated that students significantly improved their math performance on both fractions and algebra using researcher developed measures. Social validity results indicated that teacher and students found the intervention to be an acceptable intervention. Implications from fidelity and social validity data are discussed in addition to intervention components for this population.

Keywords: mathematics, emotional behavioral disorders, secondary, alternative educational settings, at risk

Students with disabilities should have access to and be held to the same challenging academic standards as their peers without disabilities (Every Student Succeeds Act, 2015; Individuals with Disabilities Improvement Act, 2006). Yet, achieving these standards can be difficult for students with disabilities. This is particularly true in the area of mathematics for students with disabilities in general (Butler, Miller, Crehan, & Babbit-Pierce, 2003) and more specifically for those with emotional and behavioral disorders (EBD; Mulcahy, Maccini, Wright, & Miller, 2014) as they often perform several grade levels below their peers in mathematics (Reid, Gonzalez, Nordness, Trout, & Epstein, 2004).

Mathematics Progress and Characteristics for Students with EBD

Students with EBD often struggle behaviorally and academically in the general education classroom (Reid, Gonzalez, Nordness, Trout, & Epstein, 2004). They often (a) perform several grade levels below their peers (Ralston et al., 2014); (b) show less progress in academics across grade levels (Wagner et al., 2006); (c) exhibit low levels of on-task behavior and task completion (Haydon et al., 2012); (d) lack self-regulation skills (Levendoski & Carledge, 2000); and (e) lack academic skills and content when compared to their same aged peers (Reid et al., 2004). Students with EBD have difficulties attending to instruction, relating new information to what is already known, and establishing productive school environments (Carr & Punzo, 1993). Many of these students struggle to act purposefully and strategically for their academic benefit and do not manage their own academic behavior in the school setting (Levendoski & Cartledge, 2000). These struggles cause them to have low math performance (Reid et al., 2004).

Using national longitudinal data, Wagner et al. (2006) found that mathematics scores for students with EBD declined across grade levels. At the elementary school level, students with EBD performed at the 34th percentile level while the average score in high school was at the 28th percentile level. Nelson, Benner, Lane, and Smith (2004) found that 56% of children with EBD ages 5 - 12 years old scored below the norm on mathematics achievement subtests, while 83% of adolescents 13 years old and older scored below the norm. In a longitudinal study, Greenbaum and Dedrick (1996) reported that 93% of students with EBD 12 - 14 years old performed below grade level in mathematics. Considering the low mathematics performance of secondary students with EBD, it is imperative to find interventions that are more effective for them.

Mathematics Research for Students with EBD

Limited fraction or algebra research for secondary students with EBD is available (Mulcahy et al., 2014; Ralston et al., 2014). Most intervention studies have focused on lower level skills and do not emphasize conceptual understanding (Mulcahy et al., 2014; Ralston, Benner, Tsai, Riccomini, & Nelson, 2014; Templeton, Kneel & Blood, 2008). Since mathematic conceptual understanding is a vital part of mathematic instruction, teaching students to acquire the underlying concepts behind mathematical operations is important (Riccomini, Witzel, & Robbins, 2008). The National Mathematic Advisory Panel (2008) suggested that middle school students must master fractions, as they are foundational for success in algebra. Students' conceptual knowledge of fraction magnitude has been linked to algebra readiness in equations and proportional reasoning (Booth & Newton, 2012). Thus, fraction and algebra instructional strategies for students with EBD are needed (Booth & Newton, 2012).

Math Intervention Components for Students with EBD

Explicit instruction and SRSD. While mathematic research studies for students with EBD is limited (Mulcahy et al., 2014; Ralston et al., 2014), some key findings have emerged. Researchers have suggested that math instruction should involve (a) explicit and clear instruction; (b) material presented in a structured and systematic fashion; (c) daily review of previously learned concepts; (d) sufficient supports provided in the early stages of learning; (e) high levels of opportunities to respond to ensure maximum student engagement; and (f) repeated practice opportunities (Billingsley, Scheuermann, & Webber, 2009; Ralston et al., 2014). Researchers also have found that self-regulation have produced positive mathematical outcomes for students with EBD (Mooney, Ryan, Uhing, Reid, & Epstein, 2005; Mulcahy et al., 2014; Ralston et al., 2014). Ralston et al. (2014) suggested that teachers use the self-regulated strategy development (SRSD) model as a means of providing mathematics instruction to students with EBD. SRSD instruction involves goal setting, self-monitoring, self-instruction, and self-reinforcement and has been shown to be effective for students with math learning disabilities (Case, Harris, & Graham, 1992; Cuenca-Carlino, Freeman-Gree, Stephenson, & Hauth, 2016).

Multiple representations. One way to increase mathematical conceptual knowledge is to use multiple representations of mathematical operations (Gersten et al., 2008). For example, requiring students to use drawings to model each step in fraction computation can help students conceptualize the mathematical operations behind fractions (Butler et al., 2003). Drawings can help students link abstract numbers to underlying mathematical concepts (Riccomini et al., 2008). Multiple representations have shown effectiveness for students with LD in fractions (Butler et al., 2003) and algebra (Witzel, Mercer, & Miller, 2003) and shows potential to increase the mathematical conceptual knowledge for students with EBD (Riccomini et al., 2008).

Graphic organizers. One tool that has shown positive outcomes for students with disabilities are graphic organizers (Dexter & Hughes, 2011). Graphic organizers have been recommended to aid students with disabilities to understand abstract concepts (Dexter & Hughes, 2011). Graphic organizers are visual arrangements of words, phrases, and sentences, and can include elements such as arrows and boxes (Ives, 2007). Using a graphic organizer may help students with EBD organize their thinking and different representations of fraction and algebra problems (Levendoski & Carrtledge, 2000; Mooney et al., 2005).

While the SRSD model instruction in math has potential for students with EBD, minimal research has been conducted on the topic. This is particularly true of algebra and fraction research for students with EBD (e.g., Hodge, Riccomini, Buford, & Herbst, 2006). Creating multiple representations of a math problem and using graphic organizers have shown to help secondary students with disabilities develop conceptual knowledge in algebra and fractions (Myers, Jun, Brownell, & Gagnon, 2015), and may help students with EBD develop a better understanding of algebra and fraction concepts. Considering the dearth of research for secondary students with EBD in mathematics (Mulcahy et al., 2014), it is important to test the effects of these components particularly for those in alternative educational settings (AES).

AES and EBD

Students with EBD may display such high levels of inappropriate behavior and low academic skills that they require placement in an AES specifically focused on behavior (Wilkerson, Afacan, Perzigian, Justin, & Lequia, 2016). AES focused on therapeutic services can benefit students with EBD by providing mental health services in addition to special education services (Gagnon & Leone, 2006). Students in AES: (a) have not demonstrated academic success in traditional school settings (Wilkerson et al., 2016); (b) have lower graduation rates than traditional schools (Carver et al., 2010; Ruzzi & Kraemer, 2006); and (c) may not have access to effective academic interventions (Lehr, Tan, & Ysseldyke, 2009). Yet, the academic needs of youth with EBD in AES are one of the most neglected areas in practice and research (Carver, et al., 2010; Lehr et al., 2009; Schwab, Johnson, Ansley, Houchins, & Varjas, 2016). In additions students at risk may have lower self-efficacy in their ability to master academic content (Matheson, 2015). Thus, it is important to test the effects of math interventions for this population.

Purpose

Fraction and algebra intervention research for students with EBD in AES is limited (Schwab et al., 2016). Since students with EBD are several grade levels below in math (Ralston et al., 2014), math strategies to improve math performance are necessary. Students with EBD struggle with understanding underlying mathematical concepts, self-regulation (Levendoski & Cartledge, 2000) and require supports to organize their math thinking. Using a graphic organizer may help them organize different representations of a math problem. In addition, using self-regulation may help them complete all steps to solve a math problem. Therefore, the purpose of this study was to test the effects of a multi-component intervention on fraction and algebra performance for middle school students with EBD in an AES. This study sought to answer the following research questions: (1) Does the intervention influence student math outcomes in fractions and algebra, including maintenance? (2) Does the intervention influence student math overall ability? (3) Do middle school teachers of students with EBD in AES implement the instruction with fidelity? (4) Do middle school teachers and students with EBD in AES find the instruction to be a socially acceptable intervention?, and (5) Does the intervention influence self-efficacy?

Method

Setting

Students were selected from two urban public AES that offered therapeutic services for students with behavioral and mental health issues in the Southeastern United States. School A was comprised of 400 students in grades K-12. About 75% were classified as EBD while 25% were identified as having an autism spectrum disorder. At school A, two self-contained middle school classrooms were used. Two teachers (Teachers 1 and 2) had a classroom where they taught all academic classes (reading, math, social studies, science) while other teachers taught elective classes (e.g., music, physical education). School B was comprised of 791 students in middle school and included one AES classroom within a regular education middle school. A small group of students with EBD rotated between special education classrooms with one teacher teaching language arts and social while another taught math and science.

Participants

Student participants. Fifteen middle school students across the three classrooms returned both consent and assent forms. Students were selected based on the following criteria: (a) had a history of math difficulty according to their classroom teacher; (b) had a least one Individualized Education Plan math goal on their; (b) had EBD or challenging behaviors; (c) scored below 50% on researcher-developed fraction and algebra pretests; and (d) scored above 80% on the third grade Monitoring Basic Skills Progress Basic Math Computation (MBSP; Fuchs, Hamlett, & Fuchs, 1998) using a calculator. Two students refused to participate in the study. Two students were withdrawn from the school before data collection of all phases were complete. Eleven students completed the study except one student did not complete the maintenance measure. This student was included in all analyses except for the maintenance phase thus 10 students completed all phases of the study (see Table 1 for student demographics).

Teacher participants. Four special education teachers certified in middle school mathematics participated in the study. At School A, teachers 1 and 2 were recruited at the start of the study and provided instruction to their own respective classes. At School B, teacher 3 taught the first two lessons. Due to a scheduling change, teacher 4 implemented lessons 3 through 10 (see Table 2 for teacher demographics).

Table 1. Student Demographics

	Teacher 1 (School A)	Teacher 2 (School A)	Teacher 3,4,5 (School B)	Total
Total	3	4	4	11
Age				
11	2	0	0	2
12	0	2	3	5
14	0	2	1	3
15	1	0	0	1
Gender				
Male	2	3	4	9
Female	1	1	0	2
Race				
Black	3	2	4	9
White	0	2	0	2
Grade				
6th	2	1	2	5
7th	0	3	2	5
8th	1	0	0	1
Primary Disability				
EBD	3	4	2	9
OHI	0	0	1	1
Autism	0	0	1	1
Secondary Disability				
EBD	0	0	1	1
LD	0	1		1
LI	0	0	1	1
OHI	0	0	1	1

IQ			
Mean scores	90.67	78.25	69.00
Standard deviation	17.24	2.22	5.60
Range	72-106	76-81	61-74

Note. The IQ score was taken from Woodcock Johnson Test of Cognitive Abilities; LD= Learning Disability; EBD=Emotional Behavioral Disorder; OHI= Other Health Impaired; LI= Language Impaired

Table 2. ***Teacher Demographics***

Variable	Teacher 1 (School A)	Teacher 2 (School A)	Teacher 3 (School B)	Teacher 4 (School B)
Age	50	52	60	30
Gender	Female	Female	Male	Female
Race	Black	Black	Black	Black
Highest degree earned	Master's	Master's	Educational Specialist	Bachelor's
Number of years teaching	3	19	36	2
Number of years teaching in an alternative school	3	19	15	1
Certification	Special Education	Special Education	Special Education	None

Assessments

Pretest measure. One MBSP (Fuchs et al., 1998) assessment was administered to the students to determine study eligibility. The MBSP is a curriculum-based measurement for grades 1 to 6. The third grade form was selected because it measures the basic operation skills that students will need to be able to perform with a calculator to solve the fraction and algebra problems. The test has a reliability coefficient range of .94-.98 and a criterion validity median coefficient score of .82 for students with disabilities (Fuchs et al., 1998). A percentage score was calculated by taking the number of problem solved correctly divided by the total number of problems.

Standardized measure. The KeyMath-3Revised: A Diagnostic Inventory of Essential Mathematics (KeyMath3-R; Connolly, 1998) was used as the standardized math measure. The KeyMath3-R is a content-referenced test designed to assess student understanding and application of important mathematics concepts and skills. The assessment is available in two parallel forms, designated as Form A and Form B, each of which contain 372 full-color test items grouped into 10 subtests that represent three general math content areas: Basic Concepts, Operations, and Applications. Eight subtests were administered with a flip easel, and two subtests were administered with the Written Computation Examinee Booklet. The KeyMath3-R has a validity score for middle school students ranging from .92-.98 and an internal consistence reliability score ranging from .89-.97. It includes 13 mathematical domains (e.g., numeration, rational numbers, geometry) organized into three areas (basic concepts, operations, and applications). The numeration and algebra tests were used for this study because they measured the skills closest to the areas targeted in the intervention. Scaled score was used for analyses.

Researcher developed measures. Researcher-developed measures included eight problem fraction computation quizzes involving addition and subtraction, and eight problem two-step variable equations quizzes involving solving equations created by the researcher and then examined by a math expert. The measure included four problems measuring conceptual knowledge and four problems measuring computation or solving equations. For validity purposes, a math expert was given a copy of each measure and confirmed that all the probes measured the skills. Scores for each probe were calculated by dividing the number of digits answered correctly by the total number of total number of digits possible to obtain a percentage score. The primary investigator scored all the assessments while for each test wave, a second person scored six (40%) randomly selected tests. Inter-observer agreement (IOA) between scorers during all tests for fractions was 100%.

Social validity. The social validity measure was the Treatment Acceptability Rating Form–Revised (TARF-R; Reimers & Wacker, 1992). The TARF-R is a brief 20-question seven-point Likert scale assessment. Teachers were asked the entire 20 questions, while the student version was modified to include 10 questions. Means and standard deviations were reported.

Treatment fidelity. Checklists were created to measure adherence, quality of instructional delivery, and student engagement (Dane & Schneider, 1998). The adherence checklist was based upon the modified SRSD intervention instruction. As the teacher completed each step that was planned, observers checked off each component. A math quality of instruction form was created based on Hill et al. (2008). The quality of instruction form required teachers to (a) use the math vocabulary consistently; (b) perform the math correctly or self-correct mistakes; and (c) call on a variety for students (more than two) to answer questions. Each criteria was rated on a scale of 1 to 3. A three indicated high quality of instruction and one indicated low quality of instruction.

Student engagement. Student engagement was measured based on Sutherland, Wehby, and Copeland (2000). A momentary time sample procedure with one-minute intervals measured students' on-task behavior. The classroom was divided into three quadrants, with each group of students representing one quadrant. Student engagement was defined as orientation by the target students toward the appropriate objective or person. This behavior included: (a) following direction given by the teacher, (b) paying attention to the speaker, and (c) working assigned tasks. If any student in the observed quadrant during the time sample did not demonstrate any of the criteria for student engagement, then the observers recorded not engaged for that interval.

Self-efficacy measure. The Sources of Middle School Mathematics Self-Efficacy Scale (Usher & Pajares, 2009) was used to assess student math self-efficacy. The scale has a Cronbach's alpha of .95 across four constructs (a) mastery experience (past successes and failures); (b) vicarious experience (experience by watching others); (c) social persuasions (by peers and others); and (d) psychological state. Items were written as first-person statements where students were asked to rate how true or false each statement was for them on a scale from 1 (definitely false) to 6 (definitely true).

Intervention and Materials

The intervention consisted of a one page graphic organizer, developed by the first author, comprised of a three-by-one table with three boxes that prompted different student actions designed to reinforce conceptual understanding and help students solve given fraction and algebra problems. Students were to solve the problem numerically in the numerical square, with a drawing in the visual square, and then wrote down the steps to solving the math problem. Students were given sentence starters to reduce the cognitive load while writing down each step (see Figure). Lessons were based on a modified SRSD framework (Ralston et al., 2014). Modification involved providing teachers with lesson scripts to increase instructional fidelity across all 10 lessons (i.e., five fraction computation lessons and five algebra equations lessons). Lessons were 30-45 minutes in length and provided three times weekly. The teacher received (a) formal lesson plans, (b) all teacher materials, and (c) all student materials. Teacher materials included dry erase markers and a laminated graphic organizer chart. Teachers used the laminated graphic organizer to work problems for each lesson. Student materials included blank graphic organizers and math worksheets for each lesson.

Procedures

Pre- and post-assessment procedures. Students were administered the MBSP by their classroom teacher to determine if the students had the necessary computation skills with a calculator. Teachers were trained to mastery on how to administer the MBSP by the first author. Next, students were individually administered the *KeyMath3-R* numeration and algebra subtests and self-efficacy survey by the first author. Third, students took the fraction pretest on one day and on the next day completed the algebra pretest. Fourth, students received instruction on the fraction graphic organizer for five days. At school A, teachers one and two provided instruction for all five fraction lessons. At school B, teacher three provided instruction for the first two fraction lessons, and teacher four provided the remaining three fraction lessons. Fifth, students completed the fraction and algebra posttest one across two consecutive days. Sixth, students received instruction on the algebra graphic organizer for five days from teachers one, two and four. Seventh, students took the fraction and algebra posttest two across two consecutive days. Eighth, one week later, students were given the fraction and algebra maintenance tests each on a separate day. Ninth, students were individually administered the *KeyMah3-R* and self-efficacy survey as the posttest by the first author. Finally, students and teachers completed the TARF-R.

Teacher training. Teachers were trained by the first author for a total of six hours divided into two three-hour trainings with the first training focusing on fraction instruction and the second training focusing on algebra. Teachers at school A attended the trainings together while at school B, teachers were trained individually. The training followed the practice-based professional development outlined in McKeown, Fitzpatrick, and Sandmel (2014). First, teachers shared their concerns about fractions and algebra. Next the rationale for SRSD and graphic organizer was briefly explained as teachers examined the teacher materials. Finally, the researcher modeled teaching lessons one and two to the participants using the same materials that would be used in the classroom. Teachers then taught each other a lesson. Teachers then received feedback from the trainer. The researcher used a fidelity checklist to ensure that all components were completed. All teachers demonstrated 100% on the fidelity checklist.

Data collector training. Two special education doctoral students were trained on student engagement observational procedures and fidelity instrumentation. They also were trained by the first author to score all math assessments. Once trained, researchers scored all protocols with a minimum of 30% of protocols rescored by a second research staff member independently to calculate IOA. IOA was 100%.

Intervention procedures. All lessons required teachers to (a) develop the background knowledge; (b) discuss the graphic organizer; (c) memorize it; and (d) lesson wrap up. To develop student background knowledge, prerequisite math skill vocabulary was reviewed. For the fraction lessons, the words "fraction," "numerator," "denominator," and "equivalent fractions" were reviewed. How to draw fractions and create equivalent fractions visually were reviewed. For the algebra lessons students were taught the vocabulary words "variable," "inverse operations," and "equation." Students practiced using drawings to represent equations. In the discussion portion, the teacher showed students a completed graphic organizer and students discussed it. The teacher asked students "What do you notice about the graphic organizer?" and "What are the benefits to using it?" In the memorization section, students practiced memorizing the skills and vocabulary that were used in that particular lesson. In the wrap-up section, the teacher summarized the lesson with a discussion of what they had learned and what students were to learn the next instructional day. After the first lesson, teachers modeled the steps to completing the graphic organizer and in subsequent lessons the students practiced completing the graphic organizer with support and then independently. Specific math steps to completing each graphic organizer are described below (See Figure 1 for both graphic organizers).

***Fraction graphic organizer*.** First, the teacher provided a fraction computation problem in the numeric box such as 1/2 + 1/3. Second, the teacher drew each fraction in the visual box using the denominator to decide how many pieces to divide the rectangle in and the numerator to determine how many of those pieces to shade in (e.g., in the fraction 1/3 the rectangle is divided into three pieces with one part shaded in). Third, the teacher explained that due to different denominators the two fractions could not be added or subtracted so a common denominator must be found. Fourth, the teacher used the two fraction denominators to decide how many pieces to divide each fraction into using horizontal lines (e.g., in the fractions 1/2 and 1/3 the teacher would divide the rectangles into thirds and halves respectively). Fifth, the teacher demonstrated that each rectangle now has the same number of pieces and a common denominator of six. Sixth, the teacher used the new shaded portions to determine the new equivalent fractions (e.g., 3/6 and 2/6 for 1/2 and 1/3 respectively). Seventh, the teacher wrote these new fractions in both the numeric and visual boxes. Eighth, the teacher demonstrated adding or subtracting the numerators and leaving the denominator the same with a final answer of 5/6. Finally, in the steps box, the teacher reviewed the steps to solve the problem and wrote: (a) I drew each fraction, (b) I divided my first rectangle into thirds, (c) I divided my second rectangle into halves, (d) I created equivalent fractions, (e) I added the numerators together, and (f) I kept the same denominator. To provide scaffolding, students were provided with sentence stems with key vocabulary as a word bank and students had to fill in the words "fractions," "divided," "thirds," halves," "added," and denominator."

***Algebra graphic organizer*.** First, in the numeric box the teacher provided an equation to solve (e.g., 2x + 5 =15). Second, the teacher drew the equation in the visuals box using longer rectangles to represent 2x and smaller squares for five and 15. Third, the teacher showed students how to use inverse operations to isolate the 2x (instead of adding 5, subtract 5 from both sides). Students were shown the inverse operation numerically and visually in the respective boxes. Fourth, numerically and visually, the teacher demonstrated using the inverse operation to isolate x by itself (instead of multiplying by two, divide by two on both sides of the equation). Finally, in the steps box, the teacher reviewed the steps and wrote: (a) I drew my equations, (b) I subtracted five from both sides, (c) I brought down 2x and subtracted five from 15 to get 10, (d) I divided both sides by two, and (e) I divided ten by two to get two. Students were provided with sentence stems with key vocabulary as a word bank and students had to fill in the words "equations," "subtracted," "divided," as well as the numbers and variables.

Figure 1 Sample Graphic Organizers for Fractions and Algebra

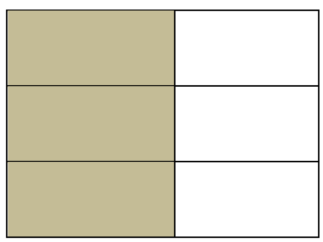
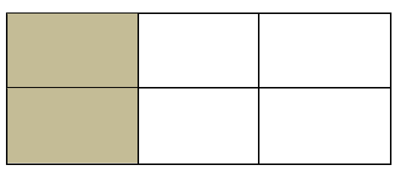
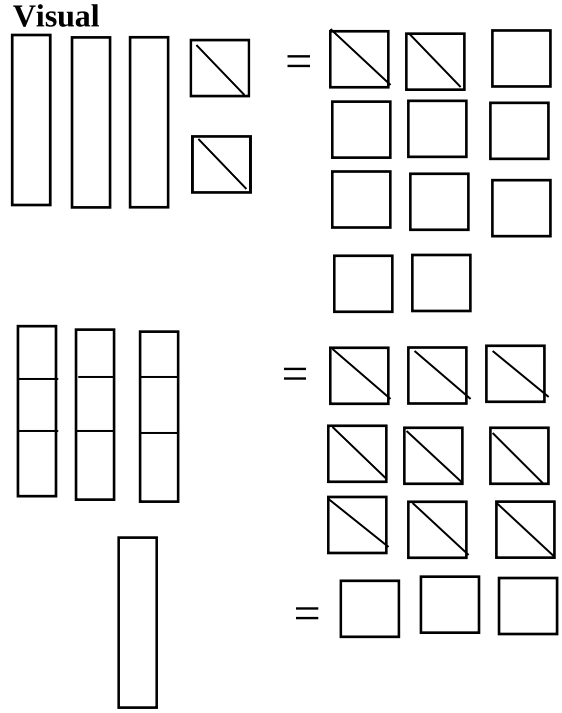
Numerical	**Visual**	**Steps**
$\frac{1}{2} + \frac{1}{3} =$ $\frac{3}{6} + \frac{2}{6} = \frac{5}{6}$	 $\frac{1}{2} = \frac{3}{6}$  $\frac{1}{3} = \frac{2}{6}$	**1. I drew my <u>fractions.</u>** **2. I <u>divided</u> my first square into <u>thirds</u>** **3. I <u>divided</u> my second fraction square into <u>halves</u>** **4. I created <u>equivalent</u> fractions.** **5. I <u>added</u> the numerators together.** **6. I kept the same <u>denominator.</u>**

Figure 1 Sample Graphic Organizers for Fractions and Algebra

Numerical	Visual	Steps:
$3X + 2 = 11$ $\quad -2 \quad \underline{-2}$ $\frac{3X}{3} = \frac{9}{3}$ $X = 3$		1. I drew my <u>equation.</u> 2. I <u>subtracted</u> <u>2</u> from both sides. 3. I brought down <u>3X</u> and <u>subtracted 2</u> from <u>11</u> to get <u>9.</u> 4. I <u>divided</u> both sides by <u>3</u>. 5. <u>9</u> divided by <u>3</u> gives me <u>3.</u>

Experimental Design and Analysis

A one-group nonequivalent dependent variables design (Shadish, Cook, & Campbell, 2002) with multiple measures in multiple waves was used to assess the effects of the graphic organizer. This design involves a single group of students being tested on two scales that are conceptually similar, but only one of which is expected to change because of the treatment. The design has effectively been used with previous math research for students with EBD in AES (Bottge, Rueda, & Skivington, 2006). For this study, the fraction measure was expected to change, while the algebra measure was expected to remain the same until algebra instruction was provided. When multiple repeated measures are used in conjunction with this design, and the patterns of achievement are predicted, most plausible threats to internal validity can be ruled out (Bottge et al., 2006). To answer research questions one, two, and five a repeated measures ANOVA was conducted to determine significant differences between each time point. Research questions three and four were answered by reporting means and standard deviations.

Results

Researcher Developed Measures and KeyMath

Table 3 shows the means standard deviations for all measures. There was a statistically significant effect of time on fraction quizzes $F(1.701, 15.309) = 7.770$, $p < .05$, $\eta2 = .46$, and on algebra quizzes, $F(1.617, 14.555) = 9.718$, $p < .05$, $\eta2 = .52$. Post hoc tests using the Bonferroni correction revealed that fractions quizzes showed statistically significant differences between wave 2 and wave 3 (p=.031), and between wave 2 and wave 4 (maintenance) (p=.011). Comparisons for algebra quizzes showed significantly higher achievement for wave 3 compared to wave 2 (pre and post instruction) (p =.003), and for wave 2 compared to wave 4 (maintenance) (p = .046). For fraction pretests, students treated the fractions as whole numbers and added the numerators and denominators. After fraction instruction, the majority of students still treated the fractions as whole numbers, while some used the graphic organizer instruction strategy. KeyMath3-R subtests results indicated no significant differences in achievement in numeration, $F(1,10) = 1$, $p = .09$, or in algebra, $F(1,10) = .102$, $p = .76$.

Table 3. Means and Standard Deviations (SD) by Measure and Test Wave

Measure	Test Wave			
	1	2	3	4
Fraction Quiz				
Mean	19.30	36.50	43.80*	38.00*
SD	7.30	24.18	24.69	17.56
Algebra Quiz				
Mean	7.50	0	57.20*	30.50*
SD	23.72	0	34.67	28.20
KeyMath Numeration				
Mean	4.82	--	--	5.09
SD	2.27	--	--	2.07
KeyMath Algebra				
Mean	4.45	--	--	4.36
SD	1.97	--	--	2.01
Self-Efficacy ME				
Mean	3.85	--	--	3.89
SD	1.15	--	--	
Self-Efficacy VE				
Mean	3.79	--	--	4.28
SD	1.09	--	--	1.40
Self-Efficacy SP				
Mean	3.83	--	--	4.53
SD	1.23	--	--	1.39
Self-Efficacy PS				
Mean	3.25	--	--	3.14
SD	1.52	--	--	1.57

Note. -- indicates that the measure was not given at that time point; ME= Mastery Experience; VE= Vicarious Experience; SP=Social Persuasions; PS=Psychological State

Treatment Fidelity

On adherence and quality of instruction, 14 (43%) of the lessons were observed by the first author and six (43%) of those lessons were observed by a second observer. IOA was calculated by taking the number of agreements and dividing by the number of agreements plus the number of agreements and disagreements. IOA was calculated at 98%. The mean percentage for steps completed across the intervention was 59% for teacher 1, 86% for teacher 2, and 95% for teachers 3 and 4. The quality of instruction for teachers 1 and 2 was low with teachers making multiple math errors, forgetting steps and partially using the math vocabulary. Anecdotally, teachers 1 and 2 struggled to create the equivalent fractions correctly despite multiple practice with the first author. The quality of instruction for teachers 3 and 4 was high.

For student engagement, 14 (47%) of the lessons were observed and six (43%) of those were observed by a second observer. IOA was calculated at 95%. The mean percentage of intervals for student engagement was 52% for teacher 1, 46% for teacher 2, and 75% for teachers 3 and 4. Student engagement was low for teacher 3, who taught the first two lessons, but after teacher 4 began instruction student engagement was near 100% for four out of the five students.

Social Validity

Student results on the TARF-R indicated that they felt they (a) were clear about the procedures of the study (M=5.45); (b) found the graphic organizer acceptable (M=6.00); (c) found the graphic organizer helped them want to participate in math class (M=5.63); (d) were willing to use it in the future (M=5.27); (e) found it reasonable (M=5.91); (f) were confident it was effective (M=6.00); and (g) overall liked the procedures (M=5.00). Students indicated that they were neutral on whether or not there were disadvantages to using the graphic organizer (M=4.00) and whether or not other students liked using the graphic organizer (M=4.36). Teacher results on the TARF-R indicated (a) they were clear about the study procedures (M=5.67); (b) found the graphic organizer acceptable (M=5.67); (c) found it reasonable (M=5.00); (d) felt there were some disadvantages (M=5.00); (e) felt much time would be needed to implement instruction (M=5.33); (f) were willing to work with other teachers on the graphic organizer (M=5.33); (g) thought some undesirable side effects were likely (M=5.00); and (f) would be willing to change their class routine (M=5.67). Teachers indicated that they were neutral to disagreeing with (a) the likelihood the graphic organizer will make permanent improvements (M=2.67); (b) their confidence level at how effective the instruction was (M=3.00); (c) their students had serious problems in math (M=3.33); (d) the instruction would disrupt their class (M=4.67); (e) the graphic organizer was effective for them (M=3.67); (f) affordability of the graphic organizer (M=3.00); (g) liking the procedures (M=3.00); (h) felt student would feel no discomfort (M=1.67); (i) students' math abilities are not severe (M=4.67); and (j)how well it fits into their curriculum (M=4.67).

Self-efficacy

The Sources of Middle School Mathematics Self-Efficacy Scale (Usher & Pajares, 2009) results indicated no significant differences for scores on mastery experience, $F(1,10) = .025$, $p = .88$ vicarious experience, $F(1,10) = 1.739$, $p = .22$ social persuasions, $F(1,10) = .069$, $p = .80$ or psychological state, $F(1,10) = .069$, $p = .80$.

Discussion

The primary study purpose was to test the effects of a multi-component instruction on fraction and algebra performance for students with EBD in an AES. With regard to the first research question, students did significantly improve their ability to solve both fraction computation and two-step algebra equations indicating that the intervention did improve their math performance. However, despite graphic organizer instruction, the majority of students continued to treat fractions as whole numbers as most students with math difficulties tend to do (Woodward, Baxter, & Robinson, 1999). Yet, on the algebra pretests, students did not have any prior knowledge on how to solve two step equations. To facilitate proper fraction instruction for students in AES, who have not picked up effective mathematic habits, "unteaching" student misconceptions about fractions may be needed (Woodward et al., 1999) initially. With algebra, no "unteaching" was necessary, which could account for why algebra scores were higher than fraction scores. Also, informal interviews indicated that two of the teachers were more comfortable with algebra, which could account for the higher scores.

With regard to the second research question, students did not significantly improve their performance on the *KeyMath3-R* subtests (Connoly, 1996). The lack of significance with the *KeyMath3-R* could have been because it was a distal measure. Considering the *KeyMath3-R* test measures a wide range of math skills in addition to fraction computation, it is not entirely surprising that student gains made on the researcher-developed measures did not show up on the standardized measure. It also is difficult to get a significant change on a standardized measure within a short time period of intervention (Bottge, Rueda, Grant, Stephens, & Laroque, 2010).

With regard to the third research question, instruction quality and student engagement for two of the teachers 1 and 2 were low, while for teacher 4 was higher. This could explain why the students did not meet mastery. If the students received improper instruction and were not engaged, they may have decided to use what they had been taught previously (i.e., treat fractions as whole numbers). Teachers in AES may not have the resources or knowledge to effectively teach academics (Wilkerson et al., 2016) so it is important to provide quality professional development and support for them. In general, researchers have struggled to find ways to improve the fraction knowledge for teachers who struggle with fractions instruction (Jayanthi, Gersten, Taylor, Smolkowski, & Dimino, 2017.) Jayanthi et al. (2017) suggested that a fraction professional development program that differentiates instruction for teachers with varying math knowledge might be needed especially in an AES. Future research should consider adding a content measure as part of the professional development and/or analyses.

Teachers were provided scripted lessons to help them with adherence to the instruction. Teachers indicated that they felt the scripted lessons helped them use consistent vocabulary. Increasingly, researchers acknowledge the importance of concise math language from grade level to grade level when providing instruction to students (Hughes, Powell, & Stevens, 2016).

Student engagement was low for teachers 1 and 2, which could also explain why the students did not master fractions or algebra. Students with EBD in AES tend to struggle with on-task behavior (Haydon et al., 2012) and motivation (Wehby, Falk, Barton-Arwood, Lane, & Cooley, 2003). Some AES researchers have suggested adding a behavior component to an intervention in order to enhance academic engagement (e.g., Bowmann, Perrot, Greenwood, & Tapia, 2007).

With regard to the fourth research question, overall students and teachers found the graphic organizer instruction to be socially acceptable. It is important to note that students who did not like math did not change their opinions after receiving the intervention instruction. These students were also the students that continued to have low engagement. It is interesting that some students perceived fractions to be easier than algebra. This could be because their misconceptions about fractions were not directly addressed. These students could have thought fractions were easier than algebra due to treating them as whole numbers (Woodward et al., 1999). In addition, it should be noted that students never saw their scores on pretests or posttests. When students self-monitor their math performance, they tend to do better academically (Shimabukuro, Prater, Jenkins, & Edelen-Smith, 1999). The student perceptions may have been different if they had seen their math scores.

With regard to the fifth research question, student self-efficacy scores did not significantly improve because of intervention instruction. Students remained neutral on all four constructs. However, the power was low on all four constructs (R=.223-.57). If the study had used a larger number of students, then the results may have been different. However, it is important to examine the relationship between student math performance and self-efficacy more closely (Hughes & Riccomini, 2011) with a larger number of students especially in AES.

Limitations and Future Directions

There are several study limitations that should be considered. First, the power using the ANOVA's on the fraction measures was lower (.87) due to low number of students and a lower effect size. Since the difference between fraction scores was not as large as the algebra scores, the power was lower. Therefore, it is more difficult to know whether or not there was a statistical difference between time points on the fraction measures. Future studies should attempt to replicate the results with a larger number of students.

Second, our study design did not require the use of a control group. Using a design with a control might make it easier to tell whether graphic organizer instruction is a more effective intervention than typical classroom instruction for this population. The lack of a control group may have led to inflated effect sizes (Borenstein, Hedges, Higgins, & Rothstein, 2011). Future studies should examine the effects of the graphic organizer instruction using a control group to compare it to typical instruction.

Third, students did not meet mastery level (80% or higher) for the mean percentage scores for fractions (M=43.80) or algebra (M=57.20). This could be because the students only received five lessons on each type of math problem. Since students in AES are several grade levels below their peers (Wilkerson et al., 2016), they may need more than five lessons on fractions and algebra to demonstrate mastery. However, these students had a history of math difficulties and were attending an AES indicating that typical classroom instruction had not been effective for them so seeing some improvement is encouraging. Future researchers should examine the duration and length it takes for students with EBD in AES to master fractions and algebra.

Fourth, for two teachers the fidelity, quality of instruction, and student engagement were low. Future researchers should examine ways to improve teacher fidelity particularly in fraction instruction as well as ways to improve student engagement for students with EBD in AES.

Conclusion

Students with EBD in AES really struggle in math (Schwab et al., 2016) and require supports to improve their math performance. This intervention led to some promising results with this population. However, other factors such as teacher math knowledge, fidelity, student engagement had an impact on their math performance. This study examined each of these, but with a limited number of participants, it was difficult to see some statistical differences. The findings from this study suggest that the intervention can improve fraction and algebra performance, but more time may be needed for these students to reach mastery. Examining these factors in relation to the graphic organizer instruction may lead to improved math outcomes and help students with EBD in AES. With more research on fractions and algebra instruction, students with EBD in AES may obtain more positive math results and return to their regular education schools.

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