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Effects of a Graphic Organizer Intervention Package on the Mathematics Word Problem Solving Abilities of Students with Autism Spectrum Disorders

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Many of the top 21st century careers require advanced mathematics skills. However, mathematics is a known area of difficulty for students with disabilities (SWD), as they struggle in this area at a higher rate than peers without disabilities (O'Brien, 2016). Mathematical word problems incorporate comprehension of written language, an area known to pose additional challenges for SWD identified as having autism spectrum disorders (ASD; Smith-Myles, Simpson, & Becker, 1995). The authors describe an intervention involving the K-N-W-S graphic organizer, studied for the first time with the intent of examining its effect on mathematical word problem solving of students with ASD. In addition to the background, methods, and results of the current study, the authors discuss implications and future directions of this research.

The top 10 careers available today that are projected to grow at the highest level in the next decade all require advanced skills in mathematics (O'Brien, 2016). However, fewer than 20% of students with disabilities (SWD) are proficient in mathematics when they begin middle school, compared to 53% of their peers without disabilities (U.S. Department of Education, 2018). This population lacking proficiency in mathematics consists of approximately 500,000 students identified as having autism spectrum disorders (ASD) in 2012 (U.S. Department of Education, 2016). The prevalence of students with ASD has increased 78% over the last decade alone (Centers for Disease Control and Prevention, CDC, 2012). The current prevalence rates indicate an estimated 1 in 59 children have ASD (CDC, 2018). Individuals with ASD exhibit "persistent deficits in social communication and social interaction across multiple contexts" and "restricted, repetitive patterns of behavior, interests, or activities" (American Psychiatric Association, APA, 2013, pp. 50-51) and often present with a wide variety of social, emotional, behavioral, and academic abilities.

Although many students with ASD are highly successful when it comes to rote computational tasks in mathematics (Whitby & Mancil, 2009), word problems often present difficulties. Word problems are abstract, complex, use technical language, and require advanced cognitive and metacognitive skills for solving. A primary characteristic of individuals with ASD, especially students with high-functioning autism, is a difficulty understanding written and verbal language (Smith-Myles, Simpson, & Becker, 1994). Additionally, almost 25% of students with ASD are diagnosed with a mathematics learning disability (Mayes & Calhoun, 2008), compared with 3% to 14% of students without ASD (Gregoire & Desoete, 2009). Furthermore, mathematics has been deemed "the most difficult content area material to read because there are more concepts per word, per sentence, and per paragraph than in any other subject" (Braselton & Decker, 1994, p. 276). Supporting mathematical learning for students with ASD is critical given that currently 40% of students with ASD are included in general education classroom settings for most of the school day (U.S. Department of Education, 2016).

Why do Students with ASD Struggle with Word Problems in Mathematics?

Typically, students with ASD are given support in language areas, due to the definition of the disability, which includes difficulty with language and communication (APA, 2013). The recent shift to a more constructivist-based approach to mathematics (Lui & Bonner, 2016) may have an effect on the ability of students with ASD to successfully solve mathematical word problems. Word problems involve comprehension of language, as well as writing tasks, and students with ASD consistently struggle with comprehension of text (Chiang & Lin, 2007; Nation, Clarke, Wright, & Williams, 2006). Several theories exist relating to why comprehension of text is so difficult for students with ASD. O'Connor and Klein (2004) suggested problems with the cognitive processes of integrating information and accessing prior knowledge, two skills essential for comprehension of expository text, contribute to a general weakness in this area. Other researchers have suggested deficits in working memory and executive functioning, along with language impairments, may factor into the academic difficulties, including in mathematics, of students with ASD (Barnhill, Hagiwara, Myles, & Simpson, 2000; Donaldson & Zager, 2010; Happe, Booth, Charlton, & Hughes, 2006; Griswold, Barnhill, Hagiwara, & Simpson, 2002; Norbury & Nation, 2011).

Sophisticated expository text structures (i.e., complex, unpredictable, inconsistent; Carnahan & Williamson, 2013), such as those found in mathematical word problems (Rockwell, Griffin, & Jones, 2011) are particularly difficult for SWD (Gersten, Fuchs, Williams, & Baker, 2001), including students with ASD (Williamson, Carnahan, & Jacobs, 2012). In addition to the difficulties this genre of text already poses for students with ASD, the complexity of steps a student must also successfully use in solving a word problem can add further difficulties in the process. Solving word problems involves a number of complex cognitive abilities in which students must accurately decode, comprehend, interpret, and apply a strategy to solve a mathematical word problem.

The process of decoding and solving word problems is complex. Most students in elementary grades progress through three levels of mathematical thinking: direct modeling strategies, counting strategies, and number facts (Carpenter et al., 1999). Direct modeling strategies are concrete, physical representations of word problems. Many students use these strategies first, utilizing objects, such as counting cubes or blocks, to explicitly represent the quantities in the problem. The second and more advanced level of mathematical thinking is counting strategies. Counting strategies are more efficient than direct modeling strategies, but they also are more abstract as students realize it is unnecessary to physically construct and count sets. Number facts are the most advanced level of mathematical thinking. At this level, children use number combinations, memorized facts, and "derived facts" (Carpenter et al., 1999, p. 24) to solve word problems.

Furthermore, students must use different levels of mathematical thinking to solve different types of word problems (Carpenter et al., 1999). The structure, or type, of word problem dictates which strategies can be applied to find the solution. With some word problems, it is not possible to directly model the problem or to use counting strategies to solve it. Thus, a student must use the more advanced number facts strategy. However, if a student has not yet moved past the concrete developmental level of direct modeling it will be difficult to solve these more advanced types of word problems.

Mathematical Word Problem Solving Interventions

Some solutions as to how the fields of mathematics education and special education might address concerns with the current emphasis on problem analysis, interpretation, and conceptual understanding of content (Cai & Lester, 2010) are best examined from researchers who have implemented and investigated the effects of a number of academic interventions for students with ASD (Rockwell et al., 2011; Whitby, 2012). The current research has produced successful and unsuccessful tools for SWD; however, very few of these interventions have been examined with the population of students with ASD and research in mathematics is very limited.

Strategy instruction. Schema based strategy instruction (SBI) and cognitive strategy instruction (CSI) are the most commonly cited tools to consider for SWD. Schema-based strategy instruction is grounded in the schema theory of cognitive psychology (Jitendra & Star, 2011), and combines procedural instruction with conceptual knowledge and understanding (Jitendra, DiPipi, & Perron-Jones, 2002). Schema-based strategy instruction is comprised of three strategies utilized for teaching the solution of mathematical word problems: visual representations, heuristics, and direct instruction.

Cognitive strategy instruction "integrates ideas from behavioral, social, and cognitive learning theories and assumes that cognitive behavior (thinking processes), like observable behaviors, can be changed" (Vaughn & Bos, 2012, p. 40). The CSI theory integrates social learning theory (Bandura, 1977) and cognitive behavior modification (Harris, 1985; Meichenbaum, 1977). The ultimate goal of CSI is to "change the way the student thinks" (Vaughn & Bos, 2012, p. 40). The primary features of CSI include "strategy steps, modeling, self-regulation, verbalization, and reflective thinking" (Vaughn & Bos, 2012, p. 40).

Only two studies have used either SBI or CSI with students with ASD. Rockwell and colleagues (2011) investigated the effects of SBI on the word problem solving ability of a student with ASD in a single-case, multiple-probe across behaviors design. The participant in the study was a 10-year old female student with ASD who struggled with word problems in mathematics. Treatment took place during the summer and consisted of three distinct phases in which the student was taught how to solve three different problem types (group, change, and compare) using a four-step heuristic. The ability to solve each of the three problem types was treated as a separate behavior. Researchers created the assessment materials, which included problem solving probes that consisted of six items derived from previous SBI research. The participant demonstrated increased scores when measuring her ability to solve one and two-step addition and subtraction problems, from an average of 3.75 points (out of 6) during baseline to an average of 5.75 points (out of 6) after receiving the SBI instruction. The largest increases occurred with the compare problem type; the participant improved from a baseline score of zero across all 11 probes to a steady score of six across all three probes (which she was able to generalize and maintain when retested six weeks after instruction). While these results are promising, the single-case design and small sample size do not allow for generalization of the findings. Other limitations include the fact the study only focused on addition and subtraction problems, and the research took place in a one-to-one, separate setting. Finally, the participant had difficulty distinguishing which problems were *not* group problems, so the researchers implemented a problem sorting activity. This adaptation leads to additional questions about whether or not students with ASD may need specific instructional components added to an intervention in order for it to be effective for this population.

To date, only one study has been implemented to look at the effects of the *Solve It!* curriculum on the word problem solving ability of students with ASD. The *Solve It!* curriculum is founded on CSI principles. Whitby (2012) conducted a study with three middle school students with ASD. This multiple-baseline across participants design was implemented to test the *Solve It!* curriculum on the ability of the participants to solve mathematical word problems correctly. Whitby used materials from the *Solve It!* curriculum to implement the intervention, which included scripted lessons, pre-/post-assessments, strategy cue cards, and strategy posters. Students with ASD were evaluated using a curriculum-based measure of five word problems; the researcher reported the percentage of correctly solved word problems.

Results of the intervention were mixed. Student one had a mean of 35% of correctly solved word problems in the baseline phase, improved to a mean of 84% during the intervention training phase, and showed some variability in the acquisition phase, with a mean of 68% of correctly solved word problems. Student two had a mean of 50% of correctly solved word problems in the baseline phase, improved to a mean of 88% during the intervention training phase, and was stable in the acquisition phase, with a mean of 92% of correctly solved word problems. Student three had a mean of 60% of correctly solved word problems in the baseline phase, improved to a mean of 96% during the intervention training phase, and was stable in the acquisition phase, with a mean of 96% of correctly solved word problems.

While all three students improved their problem-solving abilities in the short term, there was no maintenance of the strategies (35%, 80%, 60%), and each of the students struggled with different aspects of the intervention. All three participants had trouble with the paraphrasing step of the intervention; this is not surprising, as students with ASD are often rigid and have trouble communicating concepts in their own words. Communication and language deficits also were apparent in the very first step of the intervention, in which students were taught to read and reread the problem until they understood it. One student in particular could not identify the meaning of a phrase in one of the word problems and needed the instructor's help to define the phrase.

K-N-W-S graphic organizer. Another strategy that has emerged in mathematics for SWD is the use of graphic organizers (e.g., Ives, 2007; Sheriff & Boon, 2014; Strickland and Maccini, 2014). These tools use a visual representation model to represent the abstract concepts of word problems and can be very effective for students with ASD given their strong preference for visual supports (Dettmer, Simpson, Myles, & Ganz, 2000; Myles, Grossman, Aspy, & Coffin, 2007; Odom, Collet-Klingberg, Rogers, & Hatton, 2010). The K-N-W-S strategy is one example of a mathematics graphic organizer. K-N-W-S is comprised of four steps, each of which contribute to the name of the strategy: (1) "What do I KNOW (K) from the information stated in the problem?" (2) "What information do I NOT (N) need in order to solve this problem?" (3) "WHAT (W) exactly does this problem ask me to find?" and (4) "What STRATEGY (S) or operation will I use to solve this problem?" (Barton & Heidema, 2009).

The K-N-W-S graphic organizer, intended to support students in planning, organizing, and analyzing mathematical word problems, has not yet been explored with students with ASD. Usage of the organizer and the four steps could allow students with ASD to reorganize the language of a word problem in a structured, visual, and concrete way. This graphic organizer, when paired with strong, direct instruction of mathematical concepts, may provide a bridge between constructivist approaches to teaching mathematics and the more direct instruction needed for some SWD, specifically students with ASD (Flores et al., 2013).

Video Modeling

Video modeling is a well-researched tool to enhance learning for students with ASD. Use of visual supports in general has been recognized as an evidence-based practice (EBP) for students with ASD (Myles et al., 2007) in the acquisition of a wide variety of skills, including social, communication, and functional skills (Bellini & Akullian, 2007). Video modeling is a specific "technique that involves demonstration of desired behaviors through video representation of the behavior" (Bellini & Akullian, 2007, p. 266). Video modeling is considered to be effective for students with ASD because it reduces the amount of superfluous social information and discretely captures only one targeted behavior (Hart & Whalon, 2008). Furthermore, researchers suggested video modeling might be more effective than live, in-person modeling of behaviors or skills (Ogilvie & Dieker, 2010). In a study comparing the effects of video modeling with "in vivo modeling," or modeling involving the use of live models, Charlop-Christy, Le, and Freeman (2000) found video modeling "led to faster acquisition of tasks than in vivo modeling and was effective in promoting generalization" (p. 537).

Students with ASD often display an inability to engage in appropriate social interactions with peers and adults (Rao et al. 2008). Students with autism may have difficulty paying attention in classes, working in large groups, and attending to lessons. Technology is an engaging medium for these same students, as they prefer to learn visually (Mineo et al., 2009).

Video modeling combines the positive effects of technology with the necessary lessons and direction for students to learn academic skills (Bellini & Akullian, 2007).

Building upon this foundation of research, which is rich but still limited with regards to students with ASD, in this study, the researcher incorporated several promising EBPs for students with ASD. This study included the use of strategy instruction supported with graphic organizers, video modeling, and the use of simulation technology to determine the impact on the mathematical word problem solving ability of students with ASD.

Method

Research Questions and Design

A quasi-experimental design was used in this study, in which existing classes were assigned to treatment or control groups based on the population of SWD and students with ASD in the class. The purpose of this study was to examine the following three research questions (RQ):

(1) What are the effects of the K-N-W-S graphic organizer intervention package on the mathematical word problem solving abilities of fourth and fifth grade SWD in inclusive elementary classrooms, when compared to SWD in the control group, as measured by a curriculum-based measure?

(2) What are the effects of the K-N-W-S graphic organizer intervention package on the mathematical word problem solving abilities of fourth and fifth grade SWD in inclusive classrooms, when compared to students *without* disabilities in the treatment groups?

(3) Is there a difference in the effects of the K-N-W-S graphic organizer intervention package on the mathematical word problem solving abilities of students with ASD, SWD, and their peers without disabilities?

Setting and Participants

This study was conducted across two elementary school sites. Both schools were situated in a large, urban, diverse school district in Central Florida. The study was conducted in inclusive fourth and fifth grade classrooms in which students with a variety of disabilities (i.e., ASD, attention deficit disorder, specific learning disabilities, intellectual disabilities, speech and language impairments, as well as students with 504 Plans) were "served primarily in the general education classroom, under the responsibility of the general education teacher" (Mastropieri & Scruggs, 2010, p. 7), alongside their peers without disabilities.

School 1. The first school site was a public, tuition-free, charter school. At the time of the study, the ratio of students to adults was 9:1. Due to the unique, supportive nature of the school, the typical structure of each classroom included one teacher leading the class, and at least one teaching assistant or aide providing individual or small group support to students with extensive support needs. The number of adults in the classroom varied, based on the needs of students in the class. Every day during the intervention, one teacher led the activities with the treatment group and one teaching assistant helped students individually or in small groups. This school was a self-designated inclusive school with small class sizes and a low student-to-teacher ratio; as a result, students were often grouped into multi-age classes. Therefore, students in one treatment group from this school were fourth grade students and students in one control group were fifth grade students. Although not on the same grade level, the students were often grouped together and shared classrooms and teachers. Additionally, the researcher ran a *t*-test on the students' pretest scores and found no statistically significant difference between their scores at the beginning of the study, indicating they were of equal abilities on the word problem solving measure used in this study.

School 2. The second school site was a public elementary school that was named a national Blue Ribbon school by the U.S. Department of Education in 2010. During the study, the treatment group teacher was the only teacher in the classroom. The researcher utilized one treatment group (fourth grade) and one control group (fourth grade) from this site.

Participants. A convenience sample was used and a total of 84 students across four inclusive fourth and fifth-grade classrooms were included. Four students either left the study or were excluded for reasons set a priori by the researcher, for a final sample size of 80 students. Two classes served as the control group (n = 39), and two classes served as the treatment group (n = 41). A total of 47 SWD (including students with Section 504 Plans), 30 students without disabilities, and 3 students with ASD participated in the study.

Student participants with ASD. Throughout the course of the study, the researcher observed each of the students with ASD, and kept field notes of the students' behaviors, comments, and reactions to the intervention. The three students who participated in this study were very different from one another with regards to abilities, strengths, and needs. These differences clearly highlight the diversity and "spectrum" nature of autism.

Student 1, or "Annie," is a female who, at the time of the study, was a 10-year old diagnosed with Level 1 ASD. Based on the most recent guidance from the APA (2013), Level 1 ASD refers to individuals who "require support" (p. 52). She was enrolled in fourth grade at School 1. Annie's teachers reported she struggled in both core content areas of mathematics and reading. Annie also struggled with socialization and attention. During the intervention, Annie often received small group instruction from the teaching assistant along with two other students.

Student 2, or "Joey," is a male who, at the time of the study, was a 10-year old diagnosed with Level 1 ASD. Joey was in the fourth grade at School 2. Joey's teacher reported he had been successful in all academic areas throughout the school year, but struggled with organizational tasks, such as packing up at the end of the school day. Joey had the strongest academic abilities of the three student participants with ASD.

Student 3, or "Bobby," is a male who, at the time of this study, was a 10-year old diagnosed with Level 1 ASD. Bobby also attended School 2 and was in the fourth grade, in the same class as Joey. Bobby's teacher reported he had social, emotional, behavioral, organizational, and academic difficulties throughout the school year, as well as difficulties paying attention and remaining on task.

Intervention Package

The intervention package used in this study consisted of the K-N-W-S graphic organizer, three pre-recorded, standardized, validated videos, as well as a packet of word problems for students to work on each day.

Graphic organizer and pre-recorded videos. In order to maintain a consistent protocol in teaching the strategy, and to use the technique of video modeling that has been shown to impact the learning of students with ASD, the researcher pre-recorded teaching each step of the K-N-W-S strategy to a TeachLivE^{TM} avatar, Sean. TeachLivE is a virtual, mixed-reality simulator designed for teachers and preservice teachers to practice pedagogy and content area skills in a safe environment. An interactor controls all avatars to respond to participants in real-time. Using the simulated environment to show the strategy allowed for a scripted model and strict fidelity in demonstrating how to use the strategy combined with an avatar to provide the "video model." Three special education experts validated each video for content and clarity. In Video One, the researcher "taught" the first two components of the K-N-W-S graphic organizer. The researcher utilized the gradual release of responsibility model of instruction by demonstrating how she would begin to break down a word problem using the "K" and the "N" to Sean, the TeachLivE avatar. The researcher followed an identical format in Video Two to "teach" the last two components of the K-N-W-S graphic organizer to Sean.

The third video, which was a two-minute "refresher" video, consisted of video clips from the first two videos, edited together with the intention of reminding students of the four components of the K-N-W-S graphic organizer and their purpose. The video included the researcher briefly explaining each component, as well as Sean explaining the components in his own words. All three videos included "titles," which were words that appeared on the screen, similar to closed captions; these words were presented on screen when the researcher read a word problem aloud or introduced one of the four components of the K-N-W-S graphic organizer.

Daily word problems. The daily word problems packet consisted of two word problems per day. All of the word problems were aligned with similar problems in the pre/posttest and adapted from the *Go Math!* curriculum (Dixon et al., 2012) and other assessments. Word problem types included one-step and multi-step multiplication and division, grouping or partitioning, and rate problems, defined in Table 1. Students were provided with a copy of the graphic organizer along with the word problems and were instructed to use the graphic organizer.

Table 1: Word Problem Types

<table>
<tr><th colspan="3">Multiplication and Division Word Problems
Adapted from (Carpenter et al., 1999)</th></tr>
<tr><th>TYPES</th><th colspan="2">EXAMPLES</th></tr>
<tr><td rowspan="3"><u>Grouping and partitioning problems</u> involve three quantities (Carpenter et al., 1999).</td><td colspan="2"><u>Multiplication</u>: Gardeners at the Seed Store are planting seeds in 12-row seed trays. They plant 10 seeds in each row. How many plants will there be in each tray if all the seeds grow?</td></tr>
<tr><td colspan="2"><u>Measurement division</u>: Gardeners at the Seed Store have some plants. There are 10 plants in each row. Altogether there are 120 plants. How many rows of plants are there?</td></tr>
<tr><td colspan="2"><u>Partitive division</u>: Gardeners at the Seed Store have 120 plants. There are 12 rows of plants. How many plants are in each row?</td></tr>
<tr><td rowspan="3"><u>Rate (or Proportion) problems</u> are similar to grouping and partitioning problems, except they "involve a rate instead of a number of objects" (p. 46).</td><td colspan="2"><u>Multiplication</u>: Lauren bikes 9 miles in an hour. How many miles does she bike in 3 hours?</td></tr>
<tr><td colspan="2"><u>Measurement division</u>: Lauren bikes 9 miles in an hour. How long will it take her to bike 27 miles?</td></tr>
<tr><td colspan="2"><u>Partitive division</u>: Lauren biked 27 miles. It took her 3 hours. How many miles did she bike in one hour?</td></tr>
<tr><td rowspan="3"><u>Price problems</u> are a "type of rate problem in which the rate is a price per item" (p. 47).</td><td colspan="2"><u>Multiplication</u>: Birthday cakes cost $12 each. How much do 3 cakes cost?</td></tr>
<tr><td colspan="2"><u>Measurement division</u>: Birthday cakes cost $12 each. How many cakes can you buy for $36?</td></tr>
<tr><td colspan="2"><u>Partitive division</u>: John bought 3 birthday cakes. He spent a total of $36. If each cake costs the same amount, how much did one birthday cake cost?</td></tr>
<tr><td rowspan="3"><u>"Multiplicative comparison problems</u> involve a comparison of two quantities in which one is described as a multiple of the other… the relation between quantities is described in terms of how many times larger one is than the other" (p. 47).</td><td colspan="2"><u>Multiplication</u>: A newborn snake measures 6 inches long. An adult snake measures 4 times the length of the newborn. How long is the adult?</td></tr>
<tr><td colspan="2"><u>Measurement division</u>: An adult snake is 24 inches long. A newborn snake is 6 inches long. The adult snake is how many times longer than the newborn snake?</td></tr>
<tr><td colspan="2"><u>Partitive division</u>: An adult snake is 24 inches long. He is 4 times as long as a newborn snake. How long is the newborn snake?</td></tr>
<tr><th colspan="3">SUB-TYPES</th></tr>
<tr><th>Multiplication</th><th>Measurement division</th><th>Partitive division</th></tr>
<tr><td>The total number is unknown.</td><td>The number of groups is unknown.
*Students may have to interpret remainders</td><td>The number of objects in each group is unknown.
*Students may have to interpret remainders</td></tr>
</table>

Procedures

After receiving all necessary human subjects approvals, the classroom teachers administered the pretest to all four classes (treatment and control), and ensured students' testing accommodations were met as required by their Individualized Education Programs (IEPs). Following the pretest, the researcher, along with the classroom teachers, implemented the intervention with treatment groups. The teacher read a script created by the researcher in order to introduce the videos and word problems each day, while the researcher provided all of the materials and took on the role of observer during the intervention. Each day for nine consecutive school days, the teacher would show one of the pre-recorded videos. Students would then practice applying the K-N-W-S to two mathematical word problems while the teacher circulated to answer questions, provide feedback, correct misconceptions, and manage behavior. During this independent work, the researcher observed student activity and collected field notes regarding students' reactions to the videos and the word problems. The researcher did not provide any further instruction or help to students in order to avoid researcher bias. During the last four days of the study, students only worked on two word problems per day; they did not watch any of the videos. On these four days, students were provided with the K-N-W-S, reminded of the special project they were working on, and instructed to use the K-N-W-S to solve the two word problems. On the final day of the study, the teachers administered the posttest.

The teachers of students in the control group delivered the pretest before the study began. Students did not receive any instruction on the K-N-W-S, but did receive their traditional classroom mathematics instruction, *GO Math!* (Dixon et al., 2012). At the end of the study, teachers delivered the posttest to all students.

Measurement

The researcher collected pretest and posttest data using a researcher-created curriculum-based measure (CBM), consisting of ten questions, including one-step and multi-step multiplication and division grouping or partitioning and rate problems. This CBM was used to perform a quantitative analysis of the dependent variable, word problem solving ability. Each problem in the CBM was worth ten points, for a total score of 100 points. Nine of the questions were multiple-choice problems, and the final question was a two-part, short response question in which the students were provided with the K-N-W-S on the page, directly below the question. Given that question ten was a two-part question, each part was worth five points; therefore, it was possible for students to earn partial credit for this question if they responded correctly in one part but not the other. Two experts in the field validated the CBMs for content validity, including one of the *Go Math!* curriculum developers, as well as a special education expert. The Flesch-Kincaid grade level for each word problem was determined by using the readability tool in Microsoft Word, and the final reading level was determined to be 4.3.

The researcher implemented this quasi-experimental control group design with the primary goal of examining the differences in mathematical word problem solving ability between three distinct groups of students: SWD, students without disabilities, and students with ASD. Student scores were analyzed first as a whole test, and then individually by question. However, given individual test scores were ordinal level data, the item analyses consisted of descriptive and non-parametric statistics only.

Fidelity of Procedures

Two independent, graduate level researchers used a treatment protocol rubric to ensure fidelity of instruction for three out of the nine intervention sessions (33%). For instructional fidelity, point-by-point inter-rater observation agreement (IOA) was used to determine the number of rubric components scored identically by the two observers. The IOA percentage was calculated by dividing the number of components with identical scores by the total number of rubric components from the six sessions. The IOA was determined to be 100%. With regards to inter-rater reliability (IRR) on the pre/posttest, the researcher scored all assessments first. Then, one of two research assistants scored 25% of the assessments. The scores were compared with the researcher's original scores. Point-by-point IOA was used to ensure accuracy of scoring. The criterion for IRR was established at 95%. The final IRR was 99%.

Results

The researcher performed several different analyses on the pretest and posttest CBM data, including descriptive statistics, parametric statistics, and non-parametric statistics. These statistical analyses were used because an a priori power analysis was conducted using G*Power, indicating 44 students in each group were needed in order to have a moderate effect size (Cohen's *d*); these group sizes were not met in this study when the larger sample was disaggregated into smaller groups.

Overall Pretest to Posttest Analyses

RQ1. The first research question was an investigation of the differences between SWD in the treatment group and SWD in the control group. To determine whether any changes occurred in mean scores from pretest to posttest, student scores were analyzed via two dependent t-tests for SWD treatment group ($n = 20$) and SWD in the control group ($n = 27$). No statistically significant difference between pretest (M = 32.25) and posttest (M = 39.00) was found for SWD in the treatment group ($p > .05$). Similarly, no statistically significant difference ($p > .05$) was found between pretest scores ($M = 42.78$) and posttest scores ($M = 49.44$) for SWD in the control group. Finally, an independent t-test was performed to determine whether any mean differences existed between the posttest scores of the two groups. No statistically significant difference ($t = -1.2$, $df = 45$, $p > .05$) was found between the posttest scores of SWD in the treatment group ($M = 39.00$) and SWD in the control group ($M = 49.44$).

RQ2. Research question 2 was posed as an investigation of the differences between SWD ($n = 20$) and students *without* disabilities ($n = 18$) in the treatment group. First, pretest and posttest scores were analyzed via two dependent t-tests to determine if there were any changes in mean scores within groups. No statistically significant difference ($p > .05$) was found between the pretest scores ($M = 32.25$) and posttest scores ($M = 39.00$) for the SWD in the treatment group. For students without disabilities in the treatment group, no statistically significant difference ($p > .05$) was found between pretest scores ($M = 51.67$) and posttest scores ($M = 59.44$). Finally, an independent t-test was performed to determine whether any mean differences existed between the posttest scores of the two groups. A statistically significant difference ($p < .05$) between SWD in the treatment group ($M = 39$) and students without disabilities in the treatment group ($M = 59.44$) at posttest was found.

RQ3. Research question 3 was an investigation of the differences between SWD, students without disabilities, and students with ASD who received the intervention. Due to the small sample size of students with ASD, the researcher utilized only descriptive statistics to compare the performance of students with ASD to their peers with and without disabilities. Students' mean scores at pretest and posttest of the students with ASD were compared. Additionally, student performance across each individual test question was examined in order to identify any patterns in the raw data with regards to performance by word problem type (i.e., one-step vs. multi-step problems; division vs. multiplication). At pretest, the three students with ASD performed as follows: Annie scored a 20%, Joey scored an 80%, and Bobby scored a 45%. At posttest, Annie increased to a score of 30%, Joey decreased to a score of 70%, and Bobby decreased to a scored of 30%.

Summary of Item Analysis for All Students

Interesting changes were noted from pretest to posttest on some of the individual test questions, but this summary has to be viewed with caution due to the limited sample size. Individual word problem descriptions are included in Table 2. Despite the limitations, an interesting change was with question 8, as the group of SWD in the treatment group and the group of SWD in the control group both demonstrated a statistically significant difference in their performance from pretest to posttest. The SWD in the control group also showed statistically significant differences on Questions 1 and 5. The three students with ASD who received the intervention demonstrated wide variability from pretest to posttest and across the different word problem types. No patterns emerged in the item analysis with regards to the types of word problems in which the students with ASD showed improvement or decline. Furthermore, each student with ASD demonstrated very different reactions to the use of the graphic organizer.

Table 2: Word Problem Types

Multiplication and Division Word Problems *Adapted from (Carpenter et al., 1999)*	
TYPES	**EXAMPLES**
Grouping and partitioning problems *involve three quantities (Carpenter et al., 1999).*	Multiplication: Gardeners at the Seed Store are planting seeds in 12-row seed trays. They plant 10 seeds in each row. How many plants will there be in each tray if all the seeds grow?
	Measurement division: Gardeners at the Seed Store have some plants. There are 10 plants in each row. Altogether there are 120 plants. How many rows of plants are there?
	Partitive division: Gardeners at the Seed Store have 120 plants. There are 12 rows of plants. How many plants are in each row?
Rate (or Proportion) problems *are similar to grouping and partitioning problems, except they "involve a rate instead of a number of objects" (p. 46).*	Multiplication: Lauren bikes 9 miles in an hour. How many miles does she bike in 3 hours?
	Measurement division: Lauren bikes 9 miles in an hour. How long will it take her to bike 27 miles?
	Partitive division: Lauren biked 27 miles. It took her 3 hours. How many miles did she bike in one hour?
Price problems *are a "type of rate problem in which the rate is a price per item" (p. 47).*	Multiplication: Birthday cakes cost $12 each. How much do 3 cakes cost?
	Measurement division: Birthday cakes cost $12 each. How many cakes can you buy for $36?
	Partitive division: John bought 3 birthday cakes. He spent a total of $36. If each cake costs the same amount, how much did one birthday cake cost?
"Multiplicative comparison problems *involve a comparison of two quantities in which one is described as a multiple of the other… the relation between quantities is described in terms of how many times larger one is than the other" (p. 47).*	Multiplication: A newborn snake measures 6 inches long. An adult snake measures 4 times the length of the newborn. How long is the adult?
	Measurement division: An adult snake is 24 inches long. A newborn snake is 6 inches long. The adult snake is how many times longer than the newborn snake?
	Partitive division: An adult snake is 24 inches long. He is 4 times as long as a newborn snake. How long is the newborn snake?

SUB-TYPES		
Multiplication	**Measurement division**	**Partitive division**
The total number is unknown.	The number of groups is unknown. *Students may have to interpret remainders	The number of objects in each group is unknown. *Students may have to interpret remainders

Table 3: Individual Word Problem Descriptions

Q#	Word Problem Type	Steps	Text of Word Problem	Nuances of Word Problem
1	Three-digit by two-digit partitive division problem (Part Unknown)	One-step	Mr. Rogers bought 420 pencils for the school. If there are 10 pencils in a box, how many boxes of pencils did he buy?	• Power of ten • Multiple Choice
2	Two-digit by two-digit multiplication (grouping) and addition problem (Total unknown)	Multi-step	Jill sold 35 adult tickets and 48 child tickets for a dinner. An adult ticket costs $18 and a child ticket costs $14. How much did Jill collect for the tickets?	• Multiple Choice
3	Two-digit by one-digit partitive division (Part unknown)	Multi-step	Maria wants to buy the same number of bracelets for 4 of her friends. She has a total of $60. Each bracelet costs $5. What is the largest number of bracelets that Maria can buy for each of her friends?	• Multiple Choice
4	Multiplication (Rate) problem (Total unknown)	One-step	Louis bikes 20 miles in a week. Louis also jogs 10 miles in a week. How far will he have jogged in 26 weeks?	• Extraneous information • Multiple Choice
5	Two-digit by one-digit measurement division problem (Part Unknown)	One-step	There are 27 students in a gym class. The gym teacher wants to make teams for a race. Each team must have <u>exactly</u> four students. How many teams of four can be made from the 27 students?	• Interpret the remainder • Multiple Choice
6	Two-digit by one-digit partitive division and subtraction problem (Part Unknown)	Multi-step	Billy collected 43 cans and some bottles. He received 5¢ for every can or bottle. If Ben received a total of $4.95, how many bottles did he collect?	• Involving money (decimals) • Multiple Choice
Q#	**Word Problem Type**	**Steps**	**Text of Word Problem**	**Nuances of Word Problem**
7	Two-digit by one-digit partitive division problem (Part Unknown)	One-step	Phillip and his 2 friends are playing cards. There are 52 cards in a deck to be shared equally. Phillip wants each player to receive the same number of cards. How many cards will each player receive? How many cards will be left over?	• Interpret the remainder • Multiple Choice

8	Two-digit by two-digit multiplication problem (Total unknown)	One-step	Mr. Gallagher ordered 32 boxes of granola bars. Each box had 24 granola bars. He also ordered 10 boxes of cereal. What is the total number of granola bars that Mr. Gallagher ordered?	• Extraneous info • Multiple Choice
9	Two-digit by one-digit multiplication and addition problem (Total unknown)	Multi-step	Carl bought 3 scarves and 4 hats. The scarves cost $14 dollars each, and the hats cost $6 each. What is the total cost of the items Carl bought?	• Involving money (decimals) • Multiple Choice
10	Two-digit by one-digit multiplication, two by one-digit division, and addition problem.	Multi-step	A baseball league started with 18 bats. The coaches ordered 3 more cases of bats, with 15 bats in each case. They will divide the total number of bats so that each coach receives an equal number. Then they will give any extra sets to a school. a. What is the ***greatest*** number of bats each of the 4 coaches should get? b. How many bats will be donated to the school?	• Interpret remainder • Constructed response • Two-part answer • KNWS provided on page

Results of the Item Analysis for Students with ASD

Due to the diversity amongst students with ASD, and the differences observed in the pre/posttest scores for the three students with ASD who participated in the intervention, the researcher examined the performance of each student on an individual basis.

Student 1 performance. Student 1, "Annie," scored a 20% on the pretest; her posttest score was 30%. With regards to use of the K-N-W-S, the researcher observed Annie using the tool when completing the daily word problems during the intervention phase, but would complete the sections incorrectly. Annie showed improvement on questions 4 and 6. On the pretest, Annie responded with the correct answer on question 6, but on the posttest, she responded incorrectly.

Student 2 performance. Student 2, "Joey," scored an 80% on the pretest and a 70% on the posttest. Throughout the intervention, Joey resisted using the K-N-W-S when completing the daily word problems. He commented, more than once, to both his teacher and the researcher, that he "didn't need it," because the word problems were "easy." Joey showed improvement on question 2 from pretest to posttest. Conversely, Joey responded correctly to questions 6 and 7 on the pretest, but responded incorrectly to those questions on the posttest and therefore, lost points.

Student 3 performance. Student 3, "Bobby," scored a 45% on the pretest and a 30% on the posttest. With regards to his usage of the K-N-W-S, Bobby rarely used it during the intervention when completing the daily word problems; he mostly just ignored the tool. Bobby only showed improvement on one question from pretest to posttest, question 5. On questions 8 and 10, Bobby lost points from pretest to posttest.

Discussion

Implications for Students with Disabilities

An extensive research base exists (e.g., Rockwell et al., 2011; Whitby, 2012) to suggest strategy instruction, such as SBI and CSI, is beneficial to students who struggle with word problems in mathematics. However, given the results of this study, which incorporated principles of strategy instruction in the intervention, the researchers suggest strategy instruction may not be the only-- or the best-- solution for *all* students who struggle with mathematics, or the best solution for every *type* of word problem. When comparing the mean group scores, it is apparent the intervention package did not help every student on every type of word problem. This finding leads to questions the field of special education and mathematics education may want to consider related to supporting SWD, including students with ASD. Why, as a field, are we providing every student with a disability with "strategies" that may not work for them? How does this approach to strategy instruction support individualized, customized education for students, especially given that this type of approach is viewed as the cornerstone of their education and instruction?

Implications for Students with ASD

If, in fact, strategy instruction is not helpful for *all* SWD, this may be especially true for students with ASD, given the individual needs of this population vary so widely from student to student. In this study, two of the students with ASD declined in their word problem solving performance after the intervention. Thus, it is likely that using the intervention package either interfered with one of the cognitive processes necessary to solve the word problem, or increased the amount of written language involved in using this graphic organizer, both of which could have further confused the students and would explain the decline from pretest to posttest scores. Given none of the students with ASD used the graphic organizer correctly or consistently, this strategy may need to be paired with images or additional tools to make this an EBP with strong visual supports for mathematics.

Additionally, as all students vary, individuals with ASD vary even more widely from each other with regards to abilities and needs. Therefore, the researcher proposes applying a “one-size fits all” approach to this particular population of SWD may not be in the best interests of these students. Instead, teachers should utilize highly individualized instruction tailored to each specific student, perhaps aligned with the student’s level of mathematical thinking. Limited research exists in the area of EBPs for students with ASD when it comes to solving word problems in mathematics; perhaps because it is extremely difficult to find a single intervention that works for most or *all* students with ASD, given their diversity.

Limitations of the Study

Some limitations of the study were related to the dependent measure. Although two experts in the field validated the pre/posttest for content validity, it was not possible to assess the reliability of the instrument due to limitations of students not being allowed to take and retake the test due to district and state testing requirements. However, the tool used was an authentic CBM, as test questions were drawn directly from the curriculum currently being used in classrooms. Additionally, although the test was designed to be a measure of word problem solving ability, students still had to compute effectively; therefore, some students were able to identify a correct solution strategy but failed to calculate the answer correctly.

Another primary limitation of this study was related to the statistical analyses. Although the total sample size of the study included 80 students, when the groups were disaggregated by disability status and/or by treatment or control group, the group sizes were too small for statistical power, thus the need to use non-parametric tests arose. Therefore, the results of the statistical analyses should be interpreted with caution. Further, the researcher knowingly took a chance of committing Type I errors by conducting several t-tests to answer Research Questions 1 and 2.

Although video modeling is a strategy that is deemed an EBP for SWD, particularly students with ASD (Bellini & Akullian, 2007), a paucity of research exists in the field of special education regarding best practices for creating and producing video models. Bellini and Ehlers (2009) recommended that educators follow six steps to create video models; although the researcher followed these steps, and all three of the videos were validated for content, they were not validated for level of student engagement or production value.

The final limitation is related to timing issues. First, the intervention only lasted nine days, a very short time frame, because the researcher needed to be sensitive to the time constraints of the teachers and upcoming testing requirements. Further complicating the timing of the intervention were two events during which time the researcher was unable to enter the classroom: spring break and state testing.

Recommendations for Future Studies

Considering the variability in student performance by test question, it might be beneficial when designing future studies to utilize and assess very specific types of word problems. Studies specifically focused on students with ASD should examine only one or two types of word problems, or problems that are identical in nature but with different "stories" and different numbers.

In order to investigate the performance of students with ASD more closely and on an individualized basis, the researcher recommends that a single subject design be used in further studies, as it would be more sensitive to this population of students. Utilizing a single subject design also may be a better way to assess via a CBM because students can be measured repeatedly, two or three questions at a time each day. This research methodology may be a more effective way to assess change over time as well as to assess whether a causal relationship exists between the intervention and student performance on mathematical word problems.

Finally, the researcher suggests that before any further video models are created for use as an intervention tool, research should first be conducted into the most effective practices for creating video models that are engaging to students, including length of video, as well as what the individual student wants to see and will respond to, including students with ASD. Further, SWD, particularly students with ASD, vary widely from one another; therefore, what engages one student with ASD in a video model may not engage another student with ASD; therefore, it will be imperative to identify what works for each individual student.

As a field, special education is about individualization, because at the very core, the whole goal of special education is an individualized education program (IEP). Yet, it appears currently, the field may just be casting strategies at SWD because that is what is proposed to work for *all* SWD, without any regard for individualized needs and abilities, especially for students with ASD. Can a field built upon individualization really say that a single strategy or method is truly an EBP for students with ASD, if their needs are so vastly different?

Along these same lines, leaders in the field need to be examining what students do and do not know, and apply interventions based on what they *do not* know. In the field of literacy, specifically reading, teachers have a vast toolkit for the variety of needs of learners. For example, if a student has issues with reading fluency, teachers can implement the "Great Leaps Reading" program (Campbell, 1998) or the "Helping Early Literacy with Practice Strategies (HELPS)" program (Begeny, 2011; Begeny et al., 2010). If a student has trouble with phonological awareness, teachers can employ the WILSON Reading System® (Education Commission of the States, 1999). Yet, this same type of toolkit in mathematics does not clearly exist. If the field is truly going to meet the individualized needs of students with ASD, a toolkit in mathematics, similar to what we have in reading, needs to be created to apply the right strategy, at the right time, for the right student. While the field should not rule out the K-N-W-S graphic organizer as a potentially viable strategy for students with ASD, a deeper dive into *all* mathematics strategies is needed in order to figure out where, why, what, how, and what type of learner needs individualized strategy work, instead of saying that *all* strategy instruction works for *all* SWD in *all* areas of mathematics. When that individualized approach for SWD and students with ASD is utilized, then the work of the field can move from trying to understand simply what is the best approach to learning, to intersecting within individualized students what is wrong, and setting a path to success with confidence, to ensure the highest level of outcomes for all students.

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