Effects of a Mathematics Graphic Organizer and Virtual Video Modeling on the Word Problem Solving Abilities of Students with Disabilities

Lauren Delisio
University of Central Florida

EFFECTS OF A MATHEMATICS GRAPHIC ORGANIZER AND VIRTUAL VIDEO MODELING ON THE WORD PROBLEM SOLVING ABILITIES OF STUDENTS WITH DISABILITIES

by

LAUREN A. DELISIO
B.A., Rider University, 2000
M.S., Pace University, 2005

A dissertation submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy
in the College of Education and Human Performance
at the University of Central Florida
Orlando, Florida

Summer Term
2015

Major Professor: Lisa A. Dieker

ABSTRACT

Over the last decade, the inclusion of students with disabilities (SWD) in the general education classroom has increased. Currently, 60% of SWD spend 80% or more of their school day in the general education classroom (U.S. Department of Education, 2013). This includes students with autism spectrum disorders (ASD), a developmental disability characterized by impairments in behavior, language, and social skills (American Psychological Association, 2013).

Many of these SWD struggle with mathematics in the elementary grades; fewer than 20% of SWD are proficient in mathematics when they begin middle school, compared to 45% of their peers without disabilities. Furthermore, 83% of SWD are performing at the basic or below basic level in mathematics in the fourth grade (U.S. Department of Education, 2013). As the rate of ASD continues to increase (Centers for Disease Control, 2013), the number of students with this disability who are included in the general education classroom also continues to rise. These SWD and students with ASD are expected to meet the same rigorous mathematics standards as their peers without disabilities. This study was an attempt to address the unique needs of SWD and students with ASD by combining practices rooted in the literature, strategy instruction and video modeling.

The purpose of this study was to determine the effects of an intervention on the ability of students with and without disabilities in inclusive fourth and fifth grade classrooms to solve word problems in mathematics. The intervention package was comprised of a graphic organizer, the K-N-W-S, video models of the researcher teaching the strategy to a student avatar from a virtual simulated classroom, TeachLivE™, and daily word problems for students to practice the strategy. The researcher used a quasi-experimental group design with a treatment and a control group to determine the impact of the intervention. Students were assessed on their performance via a pretest and posttest. Analyses of data were conducted on individual test items to assess patterns in performance by mathematical word problem type.

The effects of the intervention on SWD, students with ASD, and students without disabilities varied widely between groups as well as amongst individual students, indicating a need for further studies on the effects of mathematics strategy instruction on students with varying needs and abilities.

My dissertation is dedicated to my parents, Nanette and Winfield, who taught me the importance of hard work and persistence, and my husband John, who has always believed in me more than I believed in myself. Thank you. I love you all.

ACKNOWLEDGMENTS

To my parents, Nanette and Winfield, whose support, guidance, and patience has never wavered, even through all of my self-doubt, anxiety, tears, fears, and frustration. Thank you for encouraging this bossy little girl to turn that heart and passion into something good. Thank you for working hard your entire lives so that I could have everything I have ever wanted in life. Thank you for teaching me to be humble, to be thankful, to work hard, to be tough, and to never give up. Thank you for believing in me when I didn't believe in myself. I would not be the person I am today if it weren't for you. I know I wasn't always the easiest child (or teenager, or adult, for that matter), so my only hope is that after all of that strife, I have made you proud.

To my husband, John, I owe it all to you. I would not have had the confidence to apply to this program on my own. Where I saw barriers, you saw opportunity, and you knew me well enough to see past my excuses and fears. I know that this program hasn't been easy on you, so thank you for sacrificing so much these past three years so that I could fulfill my lifelong dream. Thank you for putting up with my sleepless nights, my bad moods, my anxiety, the events we had to miss so that I could write or work, the events you had to attend alone because I was home working or away at a conference, and for being strong enough in your self-confidence to have a wife with a higher degree than you. Most importantly, thank you for always making me laugh. We have been through a lot in our 13 years together, but through each crisis, our marriage has only become stronger. I can't wait to start the next chapter of our life together.

To my mentor, dissertation chair, and friend, Dr. Lisa Dieker. Thank you for this amazing ride. I remember when I first met you, and was immediately in awe of your passion, intelligence, and incredible work ethic. I believe strongly in intuition and first impressions, and I knew immediately that I wanted to come to UCF so that I could work with you. Thank you for teaching me everything I know, for your constant support, for allowing me to cry in your office, for always alleviating my anxieties and concerns, for teaching me how to be (a little bit more) flexible, and for pushing me out of my comfort zone on a regular basis. You taught me that I may not always be brave, but I can always be strong.

To my brother Win, who understands my craziness better than anyone, because you share it – it's in our blood! To my sister in law Laura, thank you for allowing me to steal your husband's attention every time I texted him about my latest crisis. To my beautiful first niece, Emily Paige, I love you more than you know. I am so honored to be a part of your life and to have the privilege of watching you grow up.

To my dog, Simba, my little writing buddy—you always knew when I needed your unconditional love. You will always be my first baby. Thank you for being one of my most fiercely loyal protectors, for always warming my heart and making me smile with your wagging tail and infectious love.

To my deceased grandparents, Joseph, Carmela, Winfield, and Dorothy. I know your love transcends this world, and that you have all helped me in ways I couldn't even begin to imagine. I miss you all deeply, but know you are always with me.

To my second families, the Delisio family and the Collins family: John and Jane, Carolyn and Dennis, Thomas and Valerie. Thank you for understanding when I had to miss parties, holidays, or events. Thank you for all of your support and encouragement. And to my father in law, John, I hope you do actually read this dissertation so that you can see exactly what someone writes several hundred pages about.

To my committee: Dr. Rebecca Hines, Dr. Trey Vasquez, and Dr. Juli Dixon, thank you, first and foremost, for the time you have dedicated to supporting me in this process-- I know what a precious commodity it is. Thank you for your words of wisdom, for your brilliant ideas and questions, and for teaching me how to be a caring, collaborative future faculty member.

To the UCF faculty: Dr. Matt Marino, Dr. Suzanne Martin, Dr. Wilfred Wienke, Dr. Mary Little, Dr. Martha Lue-Stewart, Dr. Cynthia Pearl, thank you for allowing me to learn from you and for providing me with so many wonderful, rich learning experiences. You are all amazing mentors, and I feel blessed to have had the opportunity to work with and get to know each of you.

To the amazing, brilliant minds at the Office of Special Education Programs at the U.S. Department of Education, especially Drs. Celia Rosenquist and Pat Gonzalez, thank you for welcoming me with open arms to my summer internship, for teaching me about policy, and for your mentorship. Thank you to Dr. Larry Wexler for always reminding me to have fun.

To my CrossFit family, "WOD'ing" with all of you and, in the meantime, pushing my body to complete exhaustion and pain, and oftentimes, pushing myself beyond the limits of which I thought I was capable, was one of the few things that kept me sane throughout this program.

To my friends for life: Lisa and Brian, Matt and Leigh Anne, Ashley and Mike, Brian and Krista, Michelle, Vicki, Tricia and Mike (and "MPC," of course) – thank you for being so understanding of my crazy schedule and never once faulting or judging me for it.

To my cohort: Kathy, Aaron, and Jenn. It has been quite a ride. Kathy, thank you for being my dissertation writing partner-in-crime, for our venting sessions, and for being a wonderful collaborator and colleague.

To my UCF colleagues- those who came before me, those who came after me, and those in other disciplines- Claire, Matt, Caitlyn, Lisa, Jillian, Stacey, Barb, Katie, Jackie, and Vernita. I could not have possibly been surrounded by a more inspirational, strong, and passionate group of scholars.

To the teachers and principals who so graciously allowed me to come into your classrooms and disrupt your schedules – I DEFINITELY could not have done this without your support.

Finally, last but not least, to all of my former students – thank you for inspiring me to find my passion in life, and for teaching me what's most important in life.

TABLE OF CONTENTS

LIST OF FIGURES ... xvi

LIST OF TABLES ... xvii

CHAPTER ONE: INTRODUCTION ... 1

Background and Need for the Study ... 1

Autism Spectrum Disorders ... 2

ASD and Cognition/Academics ... 3

Mathematical Word Problem Solving Interventions ... 4

ASD and Mathematical Word Problem Solving Strategies ... 5

Intervention Package ... 6

Statement of the Problem ... 9

Rationale ... 9

Research Questions ... 10

Research Design ... 11

Treatment Conditions ... 11

Data Collection Procedures ... 14

Data Analysis ... 15

List of Terms, Acronyms, and Definitions ... 15

CHAPTER TWO: LITERATURE REVIEW ... 23

Chapter Overview ... 23

The Education of Students with Disabilities ... 23

History of the ASD Diagnosis 29
Academic Characteristics of Students with ASD 34
Mathematics 34
Comprehension of Spoken and Written Language 34
Students with ASD and Word Problems in Mathematics 37
Current Mathematical Word Problem Solving Instruction for SWD 40
Mathematics Standards, Curricula, and SWD 40
Teacher Preparation and Content Knowledge in Mathematics 41
Performance in National Assessments 43
Mathematical Word Problem Solving Interventions 44
Schema-Based Strategy Instruction 46
Cognitive Strategy Instruction 54
Graphic Organizers in Mathematics 59
Students with ASD and Graphic Organizers. 60
Video Modeling 63
Technology 63
Video Modeling and Students with ASD 64
TLE TeachLivE™ 68
Chapter Summary of Literature Review 69
CHAPTER THREE: METHODOLOGY 71
Introduction 71
Theoretical Framework 71

Research Questions 72

Research Hypotheses.. 73

Methodology 73

Setting 73

Participants.. 77

Research Design 80

Intervention Package 81

Procedures.. 83

Data Collection 87

Instrumentation 90

Measurement and Data Analysis 92

Excluded Data 93

CHAPTER FOUR: RESULTS 94

Overview of Data Analysis 94

Instrumentation 96

Data Analysis Procedures 97

Overall Pretest to Posttest Analyses 98

Research Question 1 98

Research Question 2 102

Research Question 3 106

Analyses by Individual Question 107

Results of Item Analysis for SWD and Students without Disabilities 111

Question One ... 111
Question Two ... 111
Question Three ... 112
Question Four ... 112
Question Five ... 113
Question Six ... 113
Question Seven ... 113
Question Eight ... 114
Question Nine ... 114
Question Ten ... 114
Results of the Item Analysis for Students with ASD ... 117
Student One Performance ... 117
Student Two Performance ... 119
Student Three Performance ... 120
Summary of Item Analysis for All Students ... 124
Fidelity of Procedures ... 124
Instructional Fidelity ... 125
Reliability of Scores ... 126
Social Validity ... 126
Summary of Data Analysis ... 129
CHAPTER FIVE: DISCUSSION ... 130
Chapter Overview ... 130

Purpose and Procedures of the Study 131
The Current State of Mathematics Instruction 133
Implications for Strategy Instruction 135
Implications for Students with Disabilities 136
Implications for Students with ASD 137
Implications for Mathematics Instruction 141
Implications for Students without Disabilities in Mathematics Instruction 141
Implications for SWD in Mathematics Instruction 142
Implications for Students with ASD in Mathematics Instruction 143
Summary of Findings 145
Limitations of the Study 145
Recommendations for Future Studies 149
Conclusions 151
APPENDIX A: KNWS GRAPHIC ORGANIZER 154
APPENDIX B: STUDY PROTOCOL 156
APPENDIX C: SCRIPTED DAILY LESSONS 170
APPENDIX D: VIDEO LESSON SCRIPTS 179
APPENDIX E: WORD PROBLEM SOLVING INTERVENTIONS FOR STUDENTS WITH DISABILITIES 187
APPENDIX F: DAILY MATHEMATICS WORD PROBLEM PROBES 195
APPENDIX G: UCF IRB LETTER OF APPROVAL 210

APPENDIX H: PRETEST/POSTTEST CURRICULUM-BASED MEASURE 212

APPENDIX I: TREATMENT FIDELITY OBSERVATION FORM 219

LIST OF REFERENCES 222

LIST OF FIGURES

Figure 1: TeachLivE Virtual Classroom 69

Figure 2: Video One in TeachLivE Virtual Classroom 83

Figure 3: Sample of Annie's Work 118

Figure 4: Sample of Joey's Work 120

Figure 5: Sample of Bobby's Work 121

Figure 6: Sample of Annie's Work 139

LIST OF TABLES

Table 1: Word Problem Types 20

Table 2: Treatment and Control Groups 77

Table 3: Disability Status 78

Table 4: Grade Level 78

Table 5: Gender 78

Table 6: Study Timeline 89

Table 7: Sample Sizes of Disaggregated Groups 97

Table 8: Descriptive Statistics for SWD in Treatment 98

Table 9: Dependent t-test for SWD in Treatment 99

Table 10: Pre-Post Descriptive Statistics for SWD in Control 99

Table 11: Dependent t-test for SWD in Control 100

Table 12: Post-test Descriptive Statistics 100

Table 13: Independent t-test Treatment vs. Control at Posttest 101

Table 14: Descriptive Statistics for Students without Disabilities in Treatment 103

Table 15: Dependent t-test for Students without Disabilities in Treatment 103

Table 16: Posttest Descriptive Statistics 104

Table 17: Independent t-test: SWD vs. Students without Disabilities 105

Table 18: Comparison of Scores of Students with ASD from Pre-Posttest 107

Table 19: Individual Test Question Details 109

Table 20: Item Analysis Across Groups 116

Table 21: Test Item Performance of Students with ASD 122

Table 22: IRP-15 Likert Scale 127

Table 23: Social Validity Teacher Responses 127

Table 24: Details of Daily Word Problems 133

CHAPTER ONE: INTRODUCTION

Background and Need for the Study

Students with autism spectrum disorders (ASD) present with a wide variety of social, emotional, behavioral, and academic abilities. Even those who demonstrate advanced academic abilities, including decoding skills, still have difficulties with various endeavors. These students would have previously been diagnosed with high functioning autism (HFA) or Asperger's syndrome, but would now be diagnosed with Level 1 ASD, or "requiring support" (American Psychological Association [APA], 2013, p. 52). The core deficits of students with ASD are typically in the areas of social skills, communication, and behavior; however, many students with ASD struggle with academics, including mathematics.

In fact, almost one-quarter of students with ASD are also diagnosed with a learning disability in mathematics (Mayes & Calhoun, 2008), compared with 3% to 14% of their peers (Gregoire & Desoete, 2009). As a result of the ever-increasing prevalence of ASD, and subsequent increase in the number of students with ASD who are included in the general education classroom (U.S. Department of Education, 2013), all teachers should identify strategies and techniques to meet the diverse needs of this population of students in all content areas, including both the procedural and conceptual skills required in mathematics.

In this study, the researcher addresses this critical area of mathematics, specifically, word problems, for students with ASD. Researchers have studied interventions aimed at improving the word problem solving skills of students with disabilities (SWD). The participants in the majority of these studies have been students with learning disabilities (LD) or disabilities other than ASD (Kroesbergen & Van Luit, 2003). The current needs of students with ASD and other SWD, as well as those at-risk of failure in mathematics provide a compelling need for further research in this area.

Autism Spectrum Disorders

The students receiving services under ASD meet the diagnostic criteria set forth in the APA *Diagnostic and Statistical Manual of Mental Disorders (DSM-5)*. Students with ASD exhibit "persistent deficits in social communication and social interaction across multiple contexts" and "restricted, repetitive patterns of behavior, interests, or activities" (APA, 2013, pp. 50-51). For the purposes of this study, students who meet the diagnostic criteria for the first level of severity, Level 1, or "requiring support," (p. 52) were included in the study. Students with ASD at Level 1 meet the following criteria under the umbrella of social communication: "Without supports in place, deficits in social communication cause noticeable impairments; difficulty initiating social interactions, and clear examples of atypical or unsuccessful response to social overtures of others. May appear to have decreased interest in social interactions" (p. 52). Students with ASD at Level 1 meet the following criteria under the umbrella of restricted, repetitive behaviors: "Inflexibility of behavior, extreme difficulty coping with change, or other restricted/repetitive behaviors markedly interfere with functioning in all spheres" (p. 52). Throughout this study, although the researcher worked with students with a range of disabilities in the general education setting, there was a specific focus on the performance of students with ASD at Level 1 who also were included in the general education classroom.

ASD and Cognition/Academics

Another area that can impact the performance of students with ASD in mathematics is in the area of cognition. Students with ASD have deficits in the areas of spoken and written language (Whitby & Mancil, 2009). In particular, students with ASD consistently struggle with comprehension of text, especially expository text, such as texts found in the content areas of science, social studies, and mathematics. Factors that may contribute to a difficulty with reading comprehension such as those that students with ASD may encounter in word problems are related to the speech and language impairments typically present for this population (Norbury & Nation, 2011), issues with working memory and/or executive functioning (Happe, Booth, Charlton, & Hughes, 2006), as well as cognitive and processing deficits, including problems integrating information and accessing prior knowledge (O'Connor & Klein, 2004).

Expository text is considered to be especially difficult for students with ASD because of the complex, unpredictable, and inconsistent structure; this unpredictability is a challenge for students with ASD because they thrive on routine and predictability. The difficult and unfamiliar vocabulary often found in expository texts also makes it difficult for students with ASD to comprehend this genre. Expository texts usually present a breadth of information with or without contextual supports, which can be problematic for students with ASD who may also have a cognitive impairment (Carnahan, Williamson, & Christman, 2011; Mason & Hedin, 2011). The genre of expository text includes mathematics textbooks, which present the same comprehension difficulties as other expository texts, with the added complexity of applying mathematical processes.

In fact, mathematics is 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). Thus, mathematics is a form of expository text that students with ASD often have difficulty with when they encounter it. In particular, students with ASD may struggle when it comes to gathering the meaning from the text to conduct the more procedural operations required to solve the mathematical problem (Minshew, Goldstein, Taylor, & Siegel, 1994), perhaps because of their language deficits, or language "interference" (Whitby, 2012, p. 85). In particular, mathematical word problems, which typically consist of abstract, complex, and technical language, are especially problematic for students with ASD (Whitby & Mancil, 2009).

Mathematical Word Problem Solving Interventions

The majority of the research on mathematical word problem interventions for SWD has focused on two main strategies: schema-based strategy instruction (SBI), and cognitive strategy instruction (CSI). Schema-based strategy instruction, which is grounded in the schema theory of cognitive psychology (Jitendra & Star, 2011), combines procedural instruction with conceptual knowledge and understanding (Jitendra et al., 2002), and is comprised of three strategies utilized for teaching the solution of mathematical word problems: visual representations, heuristics, and direct instruction. Schema-based strategy instruction has been widely researched and has shown promise as a potentially effective practice for SWD, especially students with LD. Overall, researchers have found that SBI has the potential for improving the word problem solving abilities of students with LD at both the elementary and middle school grade levels (Fuchs et al., 2010; Jitendra, DiPipi, & Perron-Jones, 2002; Jitendra & Hoff, 1996; Jitendra, Hoff, & Beck, 1999; Jitendra & Star, 2011).

The CSI strategy "integrates ideas from behavioral, social, and cognitive learning theories" (Vaughn & Bos, 2012, p. 40), with the ultimate goal to "change the way the student thinks" (p. 40). The primary features of CSI include "strategy steps, modeling, self-regulation, verbalization, and reflective thinking" (p. 40). A number of researchers have investigated the effects of CSI on the word problem solving skills of SWD, with mostly positive results across both large-group and single subject designs (Krawec, Huang, Montague, Kressler, & Melia de Alba, 2012; Montague, 1992; Montague & Dietz, 2009; Montague, Enders, & Dietz, 2011). However, neither the SBI nor the CSI strategy has yet been proven effective for students with ASD.

ASD and Mathematical Word Problem Solving Strategies

Currently, from a review of 20 articles, only two studies were directly focused on the effects of SBI or CSI on the mathematical word problem solving abilities of students with ASD. Rockwell, Griffin, and Jones (2011) studied the effects of SBI in a single-case, multiple probes across behaviors design. The single female participant with ASD demonstrated an increase in scores that measured 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.

Similarly, only one researcher has studied the effects of CSI on the word problem solving ability of students with ASD. 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. Results of the intervention were mixed; while all three students improved their problem solving abilities in the short term, there was no maintenance of the strategies, and each of the students struggled with different aspects of the intervention. The areas in which the participants struggled are consistent with the communication and language deficits of many students with ASD. Both studies are limited in their generalizability due to the small sample sizes (1 and 3) and single subject designs.

Intervention Package

Building upon the literature that is emerging related to SBI and CGI, as well as the relationship between reading comprehension and solving word problems in mathematics (Kintsch & Greeno, 1985; Whitby & Mancil, 2009), the researcher proposes that students with ASD might benefit from a more structured, concrete approach to effectively comprehend the language of a word problem in mathematics and then apply an appropriate strategy to solve the problem (Kurth & Mastergeorge, 2010; Myles, Barnhill, Hagiwara, Griswold, & Simpson, 2001; Myles & Simpson, 2002).

Graphic organizers have traditionally been used in the content areas of reading and writing, and can be defined as “visual and spatial displays that make relationships between related facts and concepts more apparent” (Dexter & Hughes, 2011, p. 51). Although graphic organizers are more commonly found in classrooms during reading and writing activities, these tools also can be used in mathematics instruction to help students understand and organize difficult concepts and represent their ideas visually (Ives, 2007; Zollman, 2009). This visual representation of abstract concepts can be very effective for students with ASD, given their strong preference for visual supports and a visual learning style (Grandin, 2007; Mayes & Calhoun, 2008). The graphic organizer used in this study, the K-N-W-S, is a strategy whereby students can plan, organize, and analyze a mathematical word problem. The K-N-W-S graphic organizer (Barton & Heidema, 2000) is comprised of the following four sections: (1) "What do I KNOW (K) from the information stated in this problem?" (2) "What information do I NOT need (N) 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?" This graphic organizer could provide the structure and concrete representations of thought that many students with ASD prefer (Grandin, 2007), and might address the challenge posed by the abstract thinking required in both higher level mathematics and the embedded nuances that are not as literal in word problems. The K-N-W-S graphic organizer has not yet been explored with SWD, nor has it been explored with students with ASD. This graphic organizer, when paired with strong teaching of mathematical concepts, may provide a bridge between constructivist learning approaches to teaching mathematics, such as the theory proposed by Piaget, which posits that students are active learners who must integrate their prior knowledge with new experiences (Siegler & Ellis, 1996), with the more direct instruction needed for some SWD, specifically for students with ASD (Flores et al., 2013).

The K-N-W-S graphic organizer (See Appendix A) could assist students with ASD for a number of reasons. Some researchers have suggested that the ability to produce visual-schematic representations may aid students in successfully understanding the text of a word problem and, consequently, accurately solving it (Boonen, van der Schoot, van Wesel, de Vries, & Jolles, 2013). The four steps of the K-N-W-S graphic organizer allow students with ASD to reorganize the language of a word problem in a structured, visual, and concrete way.

While students with ASD may benefit from this concrete, systematic representation of mathematical word problems, the use of graphic organizers in mathematics has not yet been explored deeply with this population. Thus, combining a visual approach with a graphic organizer may strengthen the intervention since video modeling has a much stronger evidence base for students with ASD.

Video modeling, a "technique that involves demonstration of desired behaviors through video representation of the behavior" (Bellini & Akullian, 2007, p. 266), is an evidence-based practice (EBP) for students with ASD (Bellini & Akullian, 2007). Researchers have primarily focused on the effects of VM on the acquisition of a wide variety of skills, including social, communication, and functional skills (Bellini & Akullian, 2007). 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). Taking into consideration the propensity that students with ASD have for visual learning and technology (Grandin, 2007; Mayes & Calhoun, 2008), as well as a strong, rich evidence base, one potential conduit for instruction of this strategy could be video modeling.

The videos used in this study are a form of video models, whereby the researcher taught the K-N-W-S strategy to a student avatar, instead of to a human student, in two, 10-minute videos. Student participants watched the videos of the researcher teaching to the student avatar in the TeachLivE™ virtual classroom, a mixed-reality teaching environment. The TeachLivE™

virtual classroom is comprised of a physical lab that an individual enters and a giant screen with five student avatars seated in a virtual classroom with whom the individual can interact. Immediately after watching one of the videos, student participants practiced using the K-N-W-S strategy independently with two word problems at their desks every day for nine days.

Statement of the Problem

The number of students with ASD in the U.S. who are served under the Individuals with Disabilities Act (IDEA) has been steadily increasing. As a result, more students with ASD are included in the general education classroom. Approximately 40% of students with ASD spent at least 80% of their school day inside the general education classroom in 2011 (U.S. Department of Education, 2014), as compared to 25% of students with ASD in 2002 (U.S. Department of Education, 2006). Researchers have sought to find the most effective interventions for this population of students to address their social, behavioral, and academic needs. However, limited research exists in the area of mathematical word problems, which are especially difficult for this population of students because of the abstract content and complex vocabulary.

Rationale

Students with disabilities, including students with ASD, struggle with solving mathematical word problems. This group of students especially needs to learn and apply effective strategies to assist them in accurately solving word problems. Students with ASD have strong visual skills and thrive on routine and consistency. Prior studies of interventions that work for other disability groups have not yet proven effective for students with ASD, and there is a paucity of research in this area. Graphic organizers, typically used as a reading comprehension tool, are a potentially viable way for students with ASD to solve word problems because they provide the structure, repetition, and concrete representation of the language of mathematical word problems, which is often where they struggle (Whitby & Mancil, 2009). Instruction delivered via video modeling is one avenue for teaching this strategy because of the strong preference students with ASD have for visual learning mechanisms (Grandin, 2007; Mayes & Calhoun, 2008).

Research Questions

The researcher utilized a quasi-experimental control group design in this study. The purpose of the large group design was to determine whether a difference exists between the effects of the intervention on three groups: SWD, students without disabilities, and students with ASD.

The guiding research questions were: (1) What are the effects of the K-N-W-S graphic organizer 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 (CBM)? (2) What are the effects of the K-N-W-S graphic organizer 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? and (3) Is there a difference in the effects of the K-N-W-S graphic organizer on the mathematical word problem solving ability between students with ASD, SWD, and their peers without disabilities?

Research Design

The researcher utilized a quasi-experimental design, in which *whole classes* were assigned to treatment or control groups. The purpose of the study was to examine the effects of the K-N-W-S graphic organizer intervention package on the word problem solving abilities of SWD, compared to their peers without disabilities, a subgroup of students with ASD, and students in the control condition, who were receiving their traditional mathematics word problem instruction, delivered through the *GO Math!* curriculum (Dixon, Larson, Leiva, & Adams, 2012).

Four inclusive classes participated in the study, totaling 84 students. However, 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) across two school sites. A total of 47 SWD, which included students with Section 504 Plans, 30 students without disabilities, and three students with ASD, participated in the study. A convenience sample was used, and whole classes were assigned to either the treatment or control group based on the percentage of SWD and students with ASD in the class.

Treatment Conditions

The intervention was implemented with two classes in the treatment group. Instruction took place for 20-30 minutes a day, every day for nine days, for a total of 180-270 minutes, or approximately three to three and a half hours per class. Prior to the intervention, the two classroom teachers were prepared for the intervention. A 15-minute orientation to the study included a summary of the instruction that would take place, how to field questions from students, and how to respond to comments from students. An explicit protocol and script were used (See Appendices B and C). Teachers were not made aware of the research questions; however, they were instructed not to teach or discuss the K-N-W-S strategy at any time other than when the researcher was in the classroom.

The teachers in both the treatment and control groups administered the pretest on Day One of the intervention, and ensured that the needs of students with testing accommodations were addressed. Following the pretest, on Day Two, the researcher used a standardized, validated, video-recorded session to teach the first two components of the K-N-W-S graphic organizer to the treatment classes – the "K" and the "N." The pre-recorded video, "Video One," included the researcher utilizing the "gradual release of responsibility" model of instruction (Fisher & Frey, 2008, p. 2), also known as "I do, we do, you do" model, in the TeachLivE™ lab with Sean, one of the student avatars. The TeachLivE™ virtual classroom is a mixed-reality teaching environment that consists of a virtual middle school classroom with five student avatars. For the purposes of the video, however, the researcher only taught the lesson to one student, Sean. The videos were played on the SmartBoard screens to entire classes. Both videos were approximately 10 minutes in duration. See Appendix D for the scripted video models.

Immediately following the video demonstration, the students engaged in independent practice with two word problems. During this independent practice component of the intervention, the researcher observed the students while the classroom teachers assisted students, redirected students to the task, provided explicit and corrective feedback, and answered questions from students.

On Day Three, the researcher instructed whole classes on the last two parts of the

K-N-W-S graphic organizer, the "W" and the "S," using a second standardized pre-recorded video, "Video Two," with Sean, the TeachLivE™ avatar. Again, students practiced the strategy with two word problems, while the teacher circulated to answer questions, provide feedback, and correct misconceptions. The researcher observed the students during this time and collected field notes.

On Days Four and Five, the researcher played a two-minute "refresher" video. This standardized, validated video consists of the researcher reviewing the components of the K-N-W-S graphic organizer, and allowed Sean to explain the four components in his own words. Students then applied the graphic organizer to two word problems, while the teacher circulated the classroom and the researcher observed.

Days Six through Ten followed the same format as Days Two through Five. On Day Six, the researcher replayed the first video in which she teaches the first two components of the K-N-W-S graphic organizer, the "K" and the "N," to the avatar, Sean. The students then applied the first two columns of the graphic organizer to two word problems, while the teacher circulated the classroom, and the researcher observed the students and collected field notes. On Day Seven, the researcher replayed the second video of herself teaching the last two components, the "W," and the "S," to the avatar, Sean. Then, students practiced using all four components of the graphic organizer with two word problems. The teacher circulated the classroom while the researcher observed. On Days Eight, Nine, and Ten, the researcher played the two-minute "refresher" video. Immediately afterwards, the students practiced the strategy with two word problems each day. The teacher attended to non-responders, answered all student questions, redirected students as necessary, and maintained normal classroom routines, while the researcher observed and collected field notes. On Days Eleven, Twelve, Thirteen, and Fourteen, no intervention took place. The students did not watch any of the videos. Instead, the students were provided with two word problems and the K-N-W-S graphic organizer each day, and practiced using the strategy. On Day Fifteen, the classroom teachers administered the posttest. The specific content of the daily word problems and the assessment were aligned with the fourth grade *Go Math!* National curriculum, Chapters 2, 3, and 4 (Dixon et al., 2012).

In the control group, the teachers administered the pretest and posttest; students did not receive any instruction on the K-N-W-S graphic organizer, but they did receive their traditional classroom mathematics instruction, *GO Math!* (Dixon et al., 2012).

Data Collection Procedures

The participating teachers administered a pretest with all students in the treatment and control groups, in whole class settings. Students with testing accommodations were provided with such during both the pretest and posttest. Classroom teachers and teaching assistants assisted with testing accommodations.

Following nine days of instruction on the K-N-W-S graphic organizer in the treatment group classrooms in 20-30 minute sessions, and four days of students spending 15 -20 minutes practicing the strategy on two word problems per day without any intervention, the teachers administered the final posttest.

Data Analysis

The researcher conducted several analyses on the pretest and posttest data, including both parametric statistics and non-parametric statistics. Dependent and independent t-tests were used to determine the following: (a) whether there was a mean difference in the mathematical word problem solving ability of students without disabilities as compared to SWD in the treatment group from pretest to posttest; and (b) whether there was a mean difference in the mathematical word problem solving ability of SWD in the treatment group as compared to SWD in the control group from pretest to posttest. The alpha level was set at the standard .05. To determine if a difference existed in the abilities of SWD in the treatment group, when compared to students without disabilities in the treatment group, and when compared to students with ASD in the treatment group, descriptive statistics were utilized. Due to the small sample size of the students with ASD group ($n = 3$), parametric statistics could not be utilized. In addition, individual test item analyses were performed to identify patterns in the data both between and within groups using the Wilcoxon Signed-Rank test and descriptive statistics, specifically focused on the group of students with ASD.

List of Terms, Acronyms, and Definitions

Autism spectrum disorder was defined by the diagnostic criteria set forth in the APA Diagnostic and Statistical Manual of Mental Disorders (DSM-V). Students with ASD exhibit "persistent deficits in social communication and social interaction across multiple contexts" and "restricted, repetitive patterns of behavior, interests, or activities" (APA, 2013, p. 50-51). For the purposes of this study, students who met the diagnostic criteria for the first two levels of severity, Level 1, or "Requiring support," (APA, 2013, p. 52) were included.

Avatars can be defined as "computer embodied virtual people that have a knowledge base and the ability to converse with humans in natural language" (Hopkins et al., 2011, p. 1544).

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" (p. 40). Cognitive Strategy Instruction 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" (p. 40).

Curriculum based measurement, or CBM, is a formative assessment and progress-monitoring tool, created from instructional materials and curriculum used in the classroom (Deno, 2003).

Graphic organizers are defined as "graphic arrangements of words, phrases, and sentences, and they may also include graphic elements such as arrows, and boxes" (Ives, 2007, p. 2). Graphic organizers are frequently used in reading and writing activities, but can also be used in mathematics instruction to help students understand and organize difficult concepts and represent their ideas visually.

Inclusion is defined as: "providing to all students, including those with severe disabilities, equitable opportunities to receive effective educational services, with supplementary aids and support services as needed, in age-appropriate general education classes in their neighborhood schools, toward the outcome of preparing all students for productive lives as full members of the society" (National Center on Educational Restructuring and Inclusion, p. 15).

An Individualized Education Program (IEP) is "a written statement for each child with a disability that is developed, reviewed, and revised" (20 U.S.C. § 614, p. 11). A child is eligible for an IEP under IDEA, which defines a child with a disability as one "(1) with mental retardation, hearing impairments…speech or language impairments, visual impairments…serious emotional disturbance…orthopedic impairments, autism, traumatic brain injury, other health impairments, or specific learning disabilities…(2) who needs special education and related services because of his or her disability or disabilities" (20 U.S.C. § 602, p. 9). The IEP includes the following: "(i) A statement of the child's present levels of educational performance; (ii) A statement of measurable annual goals, including benchmarks or short-term objectives; (iii) A statement of the special education and related services and supplementary aids and services to be provided to the child, or on behalf of the child, and a statement of the program modifications or supports for school personnel that will be provided for the child; (iv) an explanation of the extent, if any, to which the child will not participate with nondisabled children in the regular class and in the activities described in clause (iii); (v) a statement of any individual modifications in the administration of State or district-wide assessments of student achievement that are needed in order for the child to participate in such assessment; (vi) the projected date for the beginning of the services and modifications described in clause (iii), and the anticipated frequency, location, and duration of those services and modifications; (vii) (I) beginning at age 14, and updated annually, a statement of the transition service needs of the child under the applicable components of the child's IEP that focuses on the child's courses of study (such as participation in advanced-placement courses or a vocational education program); (viii) a statement of how the child's progress toward the annual goals described in clause (ii) will be measured; and how the child's parents will be regularly informed (by such means as periodic report cards), at least as often as parents are informed of their nondisabled children's progress, of (aa) their child's progress toward the annual goals described in clause (ii); and (bb) the extent to which that progress is sufficient to enable the child to achieve the goals by the end of the year" (20 U.S.C. § 602, pp. 54-55).

The K-N-W-S graphic organizer is a strategy whereby students can plan, organize, and analyze a mathematical word problem. The K-N-W-S consists of four steps:(1) "What do I KNOW (K) from the information stated in this problem?" (2) "What information do I NOT need (N) 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, 2000).

Mathematical word problems are mathematical tasks in which the majority of information is presented as text, rather than in mathematical notation (Verschaffel, Greer, & De Corte, 2000). Mathematical word problems, or story problems, differ from problem solving tasks. Problem solving in mathematics refers to "mathematical tasks that have the potential to provide intellectual challenges for enhancing students' mathematical understanding and development" (Cai & Lester, 2010, p. 1). Mathematical word problems can be categorized into several types. Multiplication and division word problems can be categorized into four main problem types: (a) Grouping and partitioning problems, which involve three quantities; (b) Rate problems, which also include three quantities, but "involve a rate instead of a number of objects"

(Carpenter, Fennema, Franke, Levi, & Empson, 1999, p. 46); (c) Price problems, which are a "type of rate problem in which the rate is a price per item" (p. 47); and (d) Multiplicative comparison problems, 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). All four of the problem types also have three sub-categories: (a) Multiplication problems, (b) Measurement division problems, and (c) Partitive division problems (Carpenter et al., 1999). The information presented in Table 1 provides examples of the different multiplication and word problems and their subtypes that students in the elementary grades may encounter in their daily mathematics curriculum. The types of word problems used in this study were one-step or multi-step grouping or partitioning word problems (including multiplication, partitive division, and measurement division problems), as well as rate problems.

Table 1: 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

Schema Based Strategy Instruction (SBI) is an instructional technique grounded in the schema theory of cognitive psychology (Jitendra & Star, 2011). Schema Based Strategy Instruction combines procedural instruction with conceptual knowledge and understanding (Jitendra et al., 2002), and is comprised of three strategies utilized for teaching the solution of mathematical word problems: visual representations, heuristics, and direct instruction.

A Section 504 Plan refers to Section 504 of the Rehabilitation Act of 1973. The goal of this legislation was to prevent discrimination against individuals with disabilities by organizations that receive federal funding, including schools. A broad, non-categorical model is used to determine a student's eligibility for a Section 504 plan. Eligibility is determined by the definition of disability outlined in the legislation as well as the functional impact of a physical or mental impairment, instead of just the need for special education, which would then be covered by IDEA (Smith, 2002).

Under 504, an individual with a disability is defined as someone who:

a) has a physical or mental impairment which substantially limits one or more of such person's major life activities, (b) has a record of such an impairment, or (c) is regarded as having such an impairment (Section 504 of the Rehabilitation Act, 1973).

A physical or mental impairment is defined in the following ways:

"1. any physiological disorder or condition, cosmetic disfigurement, or anatomical loss affecting one or more of the following body systems: neurological; musculoskeletal; special sense organs; respiratory, including speech organs; cardiovascular; reproductive; digestive; genito-urinary; hemic and lymphatic; skin; and endocrine;

2. any mental or psychological disorder, such as mental retardation, organic brain syndrome, emotional or mental illness, and specific learning disabilities" (Section 504 of the Rehabilitation Act, 1973, 29 U.S.C.§ 706(8)).

Strategy instruction in the field of special education refers to the instruction of learning strategies, which encompass a wide variety of methods for solving problems and completing academic tasks (Friend & Bursuck, 2012). For the purposes of this study, strategy instruction referred to instructional interventions used in the field of special education, such as CSI and SBI, whereby teachers directly instruct students in cognitive and metacognitive approaches to guide them through the process of completing a word problem. Conversely, in mathematics education, the term "strategy" is used to refer to a myriad of approaches.

TLE TeachLivE™, a "mixed-reality virtual environment" in which "human knowledge and technological knowledge are blended to create seemingly authentic interventions" (Dieker, Straub, Hughes, Hynes, & Hardin, 2014, p. 56), is a potential way to incorporate video modeling. It is comprised of a physical lab that an individual enters, and a giant screen with five avatars seated in a virtual classroom with whom the individual can interact.

Video modeling is a "technique that involves demonstration of desired behaviors through video representation of the behavior" (Bellini & Akullian, 2007, p. 266). Traditional video modeling involves a peer, adult, or sibling demonstrating a desired behavior, and an individual watching the video and imitating the demonstrated behavior. Another form of video modeling is video self-modeling, in which the individual watches him or herself successfully performing a targeted behavior (Bellini & Akullian, 2007).

CHAPTER TWO: LITERATURE REVIEW

Chapter Overview

In this chapter, the researcher presents a history of the education of students with disabilities (SWD), with a specific focus on students with autism spectrum disorders (ASD). A detailed description of the ASD diagnosis is provided, and characteristics of individuals with ASD are discussed. One area in particular, performance in mathematical word problem solving, is discussed in detail, with an emphasis on the potential reasons why this is an area of difficulty for SWD, and specifically, students with ASD. The researcher also provides a review of the literature on the use of graphic organizers and video modeling related to SWD and students with ASD in the area of mathematics.

The Education of Students with Disabilities

Prior to the passage of the landmark legislation P.L. 94-142, or the Education for all Handicapped Children Act (EAHCA) in 1975, the educational rights of SWD were extremely limited in three key ways. First, only 20% of SWD were served in public schools (Yell, Katsiyannis, & Bradley, 2011). In fact, in 1974, more than 1.75 million SWD did not receive educational services at all. Secondly, more than 3 million SWD who were permitted to attend public school did not receive an appropriate education that fit their specific needs (Katsiyannis, Yell, & Bradley, 2001). Furthermore, families of SWD, who had extremely limited options for their children, often had to secure services elsewhere, "often at great distance from their residence and at their own expense" (Yell & Katsiyannis, 2001, p. 83).

The landscape of education for SWD until 1975 was characterized by marked, consistent exclusion and unequal treatment of any student who exhibited different needs or characteristics. In the 19th century and on into the first half of the 20th century, SWD were typically placed into residential facilities or institutions where they were treated as less than human (Blatt & Kaplan, 1966). Several legal cases in the late 19th and early 20th centuries even upheld the exclusion of SWD in the public school system, including *Watson v. City of Cambridge* in 1893, which ruled that a child who was "weak in mind" could be expelled from public school, and *Beattie v. Board of Education* in 1919, whereby the judge ruled that school officials could exclude a student from the public school system because his facial contortions were a “bother” to the teachers and other students. Other court cases as recent as 1958, such as the *Department of Public Welfare v. Haas*, also upheld the right of the public school system to specifically exclude SWD (Yell, Rogers, & Rogers, 1998).

Prior to the passage of P.L. 94-142 in 1975, several events helped shape the legislation of current practices in special education, including: (a) the landmark legal case *Brown v. Board of Education* in 1954; (b) the Elementary and Secondary Education Act (ESEA) of 1965; (c) The Education of the Handicapped Act (EHA) of 1970; (d) Section 504 of the Rehabilitation Act; and (e) two landmark court cases that both occurred in 1972: *Mills v. Board of Education* (Mills) and *Pennsylvania Association for Retarded Children v. Commonwealth of Pennsylvania* (PARC).

The impetus for the shift in the education of SWD, which represented an even bigger social movement – the Civil Rights Movement - began in the 1950s with the Supreme Court case *Brown v. Board of Education* (1954). This historic case marked the end of segregation in the public school system. This case had lasting impacts for SWD because it strengthened the idea that *all* children have the same, equal right to receive a free and public education, regardless of race or disability (Yell et al., 2011). Chief Justice Earl Warren, who presided over this case, stated: “In these days, it is doubtful that any child may reasonably be expected to succeed in life if he is denied the opportunity of an education. Such an opportunity, where the state has undertaken to provide it, is a right that must be made available to all on equal terms” (*Brown v. Board of Education,* 1954, p. 493). *Brown v. Board of Education* was important because it laid the groundwork for inclusion of SWD in the public school system. As a result of this case, parental advocacy groups made the argument that if segregation by race was a denial of equal educational opportunity, then so was the exclusion of SWD (Yell et al., 2011).

As SWD began to be more accepted in schools and society, the most significant changes started occurring in the late 1960s and continued at an accelerated pace through the 1970's. This decade has been referred to by leaders in the field as the revolution of the field of special education (Yell & Katsiyannis, 2001). Although significant events have changed the face of education for SWD in a dramatic fashion over the last 40 years, including students with ASD, the most current estimates assert that approximately 95% of SWD are being served in public schools (U.S. Department of Education, 2012).

The first major piece of legislation that paved the way for the educational rights of SWD was the Elementary and Secondary Education Act (ESEA) of 1965. Although not specifically focused on SWD, this law marked the first effort to provide federal funding for education of the general population. The primary purpose of ESEA was to offer financial aid to states for students of poverty. However, this law also made federal money available to improve the education of SWD in state schools for the blind, deaf, and retarded (Huefner, 2000). The following year, an amendment to ESEA created the Bureau of Education for the Handicapped in the Department of Health, Education and Welfare, which later became the Office of Special Education Programs (OSEP).

The momentum of legislative actions continued when legislators created Section 504 of the Rehabilitation Act, passed in 1973, in order to protect the rights of individuals with disabilities in any federally funded programs or activities. This event was crucial to the field of special education and current educational practices, because the Section 504 regulation required a school district to provide a “free, appropriate, public education” (FAPE) to each qualified person with a disability in the school district’s jurisdiction, regardless of the nature or severity of the person’s disability. This Act also established due process procedures, by which parents of SWD have the right to challenge placement decisions for their child; it afforded parents other rights as well (Yell & Katsiyannis, 2001). Another important tenet of Section 504 was the concept of including SWD in the general education classroom, considered to be the least restrictive environment (LRE). This tenant is currently a best practice for SWD and, like FAPE, has been an integral component of special education legislation in the years that followed (Yell & Katsiyannis, 2001).

Another critical component of Section 504 was the principle of individualized education, and thus, the birth of Individualized Education Programs (IEPs). Once again, IEPs have been an important piece of special education legislation since their inception. A student’s IEP lays the foundation for effective and appropriate education for that student (Yell & Katsiyannis, 2001).

As a result of revisions to Section 504, two landmark court cases in 1972: *Mills v. Board of Education* (Mills) and *Pennsylvania Association for Retarded Children v. Commonwealth of*

Pennsylvania (PARC), created a wave of further momentum in the field for SWD. The Mills case was a class action lawsuit to protect the rights of students with a variety of disabilities, including students with behavioral difficulties, who were being excluded from public schools in the District of Columbia through expulsion, suspension, and reassignment (Yell et al., 2011). The PARC case involved the exclusion of students with mental retardation from the public school system. The resulting judgments of these two cases were significant for two reasons: first, they required that public schools provide access to education for SWD; and secondly, both cases resulted in the basic procedural rights of notice and hearing that must be extended to SWD before they could be placed in special education programs (*Mills v. Board of Education*, 1972; *Pennsylvania Association for Retarded Children (PARC) v. Commonwealth of Pennsylvania*, 1972; Yell et al., 2011).

Each of the abovementioned events in legal history began to shift the perceptions of society, prompting changes in the U.S. legal system with regards to the view of education and basic civil rights of SWD (Yell & Katsiyannis, 2001). These events and philosophical shifts led the way for the passage of EAHCA in 1975, which began a rapid wave of reform that further protected the rights of SWD in the public school system, specifically focused on FAPE and LRE.

The Education of the Handicapped Act (EHA) of 1970 was an outcome of the previous legislation, from *Brown v. Board of Education*, to Section 504 of the Rehabilitation Act, to the landmark legislative issues mentioned in the previous sections. This significant piece of legislation in the education of SWD was the first law that *exclusively* addressed SWD in a number of ways (Yell et al., 2011). First, EHA expanded the federal grant programs for SWD by offering grants to institutes of higher education in order to develop programs to prepare teachers of SWD. Further, a 1974 amendment to this law strengthened the educational rights of SWD by requiring that any states receiving federal funds must adopt the goal of "full educational opportunity for SWD" (Education Amendments of 1974). This law would later be amended to become the Education for All Handicapped Children Act (EAHCA, 1975).

The six major principles of EAHCA included: (a) right to FAPE; (b) the right of SWD to be educated in the LRE in which they can "succeed with support"; (c) the creation of the IEP; (d) right to nondiscriminatory evaluation; (e) due process procedures, protecting SWD and their families; and (f) the concepts of zero reject and child find (EACHA, 1975).

The EAHCA was amended in 1990 and renamed as The Individuals with Disabilities Act (IDEA). In 1997, IDEA was reauthorized. The leaders who revised this legislation further defined LRE as including SWD in the general education classroom to the "maximum extent appropriate" (20 U.S.C. § 602, p. 30). The definition in IDEA also included the provision that "special classes, separate schooling, or other removal of children with disabilities from the regular educational environment occurs only when the nature or severity of the disability is such that education in regular classes with the use of supplementary aids and services cannot be achieved satisfactorily" (20 U.S.C. § 602, p. 30). The principles of both FAPE and LRE led the way for what is currently referred to as inclusion.

In 2002, an additional piece of legislation that was passed by legislators to support and strengthen inclusion for SWD was the No Child Left Behind Act (NCLB; 2001), which reauthorized ESEA (Turnbull, 2005). The leaders of this legislation attempted to further protect the rights of SWD by requiring all students to have access to the general curriculum and participate in the same assessments as their general education peers (Crockett, 2011). The outcome of this legislation by advocates was the expectation that students with even more significant disabilities would have access to the same general education standards as their nondisabled peers and be included in assessments that determined the overall success of their learning within their school. This trend was a shift from excluding students in classrooms and schools to including them in classrooms, schools, curriculum, and assessment within the public school setting.

History of the ASD Diagnosis

In comparison to the historical overview of education for SWD, the education of students with ASD is relatively young. The first documented case of autism is believed to be Jean Itard's "Wild Boy of Aveyron" (Itard, Humphrey, & Humphrey, 1932). Itard, a French physician, discovered the boy, believed to be 11 or 12 years old, living on his own in the woods in 1798. Itard named him Victor. Victor displayed some characteristics of ASD, including repetitive behaviors, obsessions with certain objects, a unique memory, and a lack of speech (Itard et al., 1932). Despite this initial identification, this particular label of autism was ignored or misdiagnosed, until more recently in history.

Over the next century, between 1800 and 1940, most children like Victor, who might have been diagnosed with ASD in the present day, were instead placed into residential institutions and diagnosed with childhood schizophrenia, intellectual disabilities, emotional disturbances, or other mental disorders, because of their difficulties with social skills, the manifestation of repetitive, stereotypical behaviors, and deficits in communication and language (Sarrett, 2011; Simons, 1974; Verhoeff, 2013). The long-term outcomes for these individuals were bleak, as were the expectations for what they could accomplish. Given that many students with ASD did not receive an education, they spent most of their lives in institutions, unable to reach their full potential in school and society (Dicker & Bennett, 2011). The perception was that they could not function as a part of the school system, and that they may impede the learning of general education students (Wolff, 2004).

During the 1940s, a number of psychiatrists, including Leo Kanner, Eugen Bleuler, and Hans Asperger, began investigating some unique characteristics that they had observed in some of their young patients. These behaviors included “extreme autistic aloneness” (Kanner, 1943, p. 242), “excellent rote memory” (p. 243), monotonous, repetitive behaviors with an “obsessive desire for the maintenance of sameness” (p. 245), abnormal speech with echolalia, pronomial reversal, literalness, and an inability to use language for communication.

Although ASD had finally been discovered and named, it was not an official diagnosis yet (Dicker & Bennett, 2011). American psychiatrist Leo Kanner is credited with discovering the disorder in 1943 when he wrote a paper titled “Autistic disturbances of affective contact” (Kanner, 1943). Although Kanner is widely credited with discovering ASD, Eugen Bleuler, a Swiss psychiatrist, likely worked with children with ASD prior to Kanner’s work and coined the term “autistic thinking” (Bleuler, 1951; Wolff, 2004). In 1944, Dr. Hans Asperger also described four cases of “autistic psychopathy of childhood” (Wolff, 2004). These children were described as highly intelligent, some with gifts in very specific areas, like mathematics, but were lacking in social, emotional, communicative, and language skills (Wolff, 2004). Regardless of levels of intelligence, these children continued to be excluded from public education.

Following the publication of Kanner's paper in 1943, there was an explosion of theories related to the etiology of the disorder. In the 1960s, Bruno Bettleheim (1967) suggested that autism was caused by "refrigerator mothers." Kanner originally coined this term, but Bettleheim was responsible for spreading it as an accepted theory. Kanner and Bettleheim posited that autism was caused by mothers who were emotionally cold and did not express affection towards their children, and that the behaviors present in children with autism were a response to maternal rejection. Other theories postulated a relationship with schizophrenia or other psychological factors, in addition to psychogenic, biological, and a combination of factors (Verhoeff, 2013; Wolff, 2004).

During the time period from the 1960s to 1980s, the concept of ASD began to shift in tandem with increased attention and research. The most significant shift was related to what was considered to be the primary deficit of children with ASD, previously believed to be extreme withdrawal; researchers during this time period helped to clarify the diagnostic characteristics as core deficits in language, speech, and cognition (Frith, 1970; Rutter & Bartak, 1971; Verhoeff, 2013).

However, diagnosis and placement of students with autism in educational settings was not as progressive. During the 1970s, most medical practitioners and educators believed that students with ASD had very bleak outcomes. According to DeMyer and colleagues (1973), "Most autistic children remained educationally retarded and 42% were institutionalized.... (their findings) indicated the following prognosis in autism: 1– 2% recovery to normal, 5–15% borderline, 16–25% fair, and 60–75% poor" (p. 199). In fact, throughout the 1970s and early 1980s, most individuals with ASD were included only in separate classrooms or public institutions for students with severe intellectual disabilities or emotional disturbance. Whereas the rights of SWD were slowly expanding through legislation, the rights of individuals with ASD continued to be withheld.

The 1980s marked a significant turning point for the field of autism. In 1980, autism was added to the DSM-III (APA, 1980). The diagnostic criteria included: (a) a "pervasive lack of responsiveness to other people"; (b) "gross deficits in language development, and if speech is present, peculiar speech patterns such as immediate and delayed echolalia, metaphorical language, [and] pronominal reversal" and "bizarre responses to various aspects of the environment, e.g., resistance to change, peculiar interest in or attachments to animate or inanimate objects" (pp. 89-90). In the past 30 years, the diagnostic criteria has evolved, with the most current criteria delineating the disorder into three levels of severity, which differ based on the individual's "persistent deficits in social communication and social interaction across multiple contexts" and "restricted, repetitive patterns of behavior, interests, or activities" (APA, 2013, pp. 50-51).

Although the inclusion of autism into the DSM-III was an important turning point in the field, it was not until 10 years later that the educational rights of this population of students would be recognized and protected under the law. Autism was listed for the first time as one of the disorders under the definition of the term "children with disabilities" in the Individuals with Disabilities Act of 1990 (a reauthorization). The most recent amendment to IDEA, the Individuals with Disabilities Education Improvement Act (IDEIA) of 2004, *specifically* called for developing and improving programs to prepare special education teachers on the needs of children with ASD.

Over the last 20 years, practitioners in the field have seen huge increases in the prevalence of autism as well as the inclusion of students with ASD into the general education classroom. A 78% increase in the identification of students with ASD has occurred over the last decade (Centers for Disease Control and Prevention [CDC], 2012). The current prevalence rates estimate that 1 in every 68 children and 1 in every 48 boys will be diagnosed with the disorder; just ten years prior to that the rate was estimated at 1 in every 150 children (CDC, 2014). Currently, 38% of students with ASD are included in general education classroom settings for 80% of the day, compared to 58% of students with other disabilities (U.S. Department of Education, 2013). The most recent changes in the field of autism emerged with the release of the new DSM-V. In May 2013, the APA made significant changes to the diagnostic criteria for the ASD diagnosis in the Diagnostic and Statistical Manual-V. Asperger's syndrome was removed as a separate diagnosis, and now falls under the umbrella of ASD. In addition, three levels of severity of ASD were set forth: Level 1, Requiring support; Level 2, Requiring substantial support; and Level 3, Requiring very substantial support.

A more recent trend in the education of students with ASD is that of highly individualized instruction, as researchers have suggested that individualization may be the key for helping students with ASD to succeed in the inclusive classroom (Fava & Strauss, 2014; Stahmer, Schreibman, & Cunningham, 2011). Stahmer and colleagues explained, "the heterogeneity and developmental nature of the disorder make it unlikely that one specific treatment will be best for all children, or will work for any one child throughout his or her educational career" (p. 229).

Academic Characteristics of Students with ASD

Mathematics

Many students with ASD are highly successful when it comes to rote computational tasks in mathematics (Whitby & Mancil, 2009). However, mathematical word problems often present difficulties for students with ASD because of the abstract, complex, technical language, and the advanced cognitive and metacognitive skills necessary for effective word problem solving. A common and primary characteristic of individuals with ASD, especially students with high-functioning autism, is a difficulty understanding written and verbal language (Smith-Myles, Simpson, & Becker, 1995). 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). Additionally, almost one-quarter of students with ASD also are diagnosed with a mathematics learning disability (Mayes & Calhoun, 2008), compared with 3% to 14% of their peers (Gregoire & Desoete, 2009).

Comprehension of Spoken and Written Language

One of the primary factors that may influence the ability of students with ASD to successfully solve word problems in mathematics is the difficulty they face in the area of spoken and written language. In particular, students with ASD consistently struggle with comprehension of text (Chiang & Lin, 2007; Nation, Clarke, Wright, & Williams, 2006). These difficulties were first noted by Kanner (1943), who observed the following with regards to the reading ability of students with ASD: “reading skill is acquired quickly, but the children read monotonously, and a story or moving picture is experienced in unrelated portions, rather than in its coherent totality" (p. 250).

The number of studies related to the reading comprehension of students with ASD has increased over the last several decades as the prevalence of ASD and the inclusion of students with ASD in the general education classroom have continued to rise (CDC, 2012; Loiacono & Valenti, 2010; Southall, 2013; Williamson, Carnahan, & Jacobs, 2012). For example, Nation and colleagues (2006) conducted a study of the reading skills of students with ASD and found that 65% of their sample had poor reading comprehension skills; one-third of these students fell into the severely impaired category. In another related study, which involved the relationship between cognitive ability and reading comprehension in students with ASD, the researchers determined that a number of individuals with ASD were able to decode effectively; however, they struggled with comprehension (Carnahan et al., 2011). Brown, Oram-Hardy, and Johnson (2013) also found evidence that the reading comprehension of students with ASD often was impaired, especially in comparison to their peers without disabilities.

Several theories exist with regards to why comprehension of text is so difficult for students with ASD. O'Connor and Klein (2004) suggested that 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. Randi, Newman, and Grigorenko (2010) identified a trend in the empirical research on students with ASD and reading comprehension that suggested cognitive processing deficits in students with ASD, in addition to impairments in language, may be contributing factors in their struggles with comprehension. Griswold, Barnhill, Myles, Hagiwara, and Simpson (2002) also attributed cognitive and processing deficits to a difficulty with reading comprehension in students with ASD. Norbury and Nation (2011) found a relationship between reading comprehension, oral language abilities, and structural language competence; thus, it is possible that the speech and language impairments typically present in students with ASD also may be a factor in their difficulties with text comprehension. Yet another theory is that the skills of word recognition and reading comprehension develop independently of one another; thus, if a child with ASD has advanced decoding skills, it stands to reason that he or she will struggle with comprehension (Randi et al., 2010; Whalon & Hart, 2010).

Expository text is particularly difficult for SWD (Gersten, Fuchs, Williams, & Baker, 2001), including students with ASD (Williamson et al., 2012). The expository genre is typically characterized by complex, unpredictable, and inconsistent text structure (Carnahan & Williamson, 2013). Students with ASD thrive on predictability and routine; therefore, this inconsistency can be a challenge. Difficult and unfamiliar vocabulary is another characteristic; given the fact that students with ASD typically also have language impairments, they may not have the skills and tools necessary to manage unknown vocabulary words (Carnahan & Williamson, 2013). Finally, expository texts usually present a breadth of information with or without contextual supports, which can be problematic for students with ASD who may also have a cognitive impairment (Carnahan et al., 2011; Mason & Hedin, 2011). Furthermore, individual reader and text characteristics influence reading comprehension, such as a student's prior knowledge and ability to both access and connect that prior knowledge to the text (Carnahan et al., 2011). Students with ASD rarely access their prior knowledge, further complicating their ability to effectively comprehend text (O'Connor & Klein, 2004). In order to effectively solve a word problem, a student must possess strong reading comprehension abilities, yet co-morbidity among reading and math disabilities is common (Bottge, 2001; Capraro, Capraro, & Rupley, 2011; Fuchs, Fuchs, & Compton, 2013). According to Fuchs and colleagues (2013), "comorbidity is an especially prominent idea in mathematics" (p. 536). Researchers also have shown that reading comprehension ability has an effect on word problem solving performance (Vilenius-Tuohimaa, Aunola, & Nurmi, 2008).

Students with ASD and Word Problems in Mathematics

Accurately decoding, comprehending, interpreting, and applying a strategy to solve a mathematical word problem involves a number of complex cognitive abilities, especially when it comes to sophisticated expository text structures such as those found in mathematical word problems (Rockwell et al., 2011). The ability to solve mathematical word problems requires the synchronization of the following cognitive processes: (a) understanding text; (b) constructing a representation of the problem mathematically; (c) creating, planning, and monitoring solutions; (d) implementing the correct computational procedures necessary to find the solution; and (e) effectively interpreting the solution (Desoete, Roeyers, & De Clercq, 2003).

Other researchers have suggested that deficits in working memory and executive functioning, along with language impairments, may all factor into the academic difficulties of students with ASD (Barnhill, Hagiwara, Myles, & Simpson, 2000; Donaldson & Zager, 2010; Happe et al., 2006; Griswold et al., 2002). Furthermore, individuals with ASD frequently have difficulty with abstract concepts. Temple Grandin (2006), a well-known individual with ASD, commented that when she was in school, her academic skills were "uneven" (p. 229), subjects such as algebra were “impossible” (p. 229), and she exceled in areas in which she could utilize her strong visual thinking skills. When presented with a mathematical word problem, a student with ASD must be able to apply two processes that may be influenced by their deficits in abstract thinking and language: problem comprehension and problem solution (Hegarty, Mayer, & Monk, 1995; Lewis & Mayer, 1987; Mayer, 1985; Mayer & Hegarty, 1996). Problem comprehension is comprised of two steps: problem translation and problem integration. Problem translation is “the ability to translate the language that is imbedded in mathematics word problems into a coherent verbal representation, indicating that the solver has understood the problem” (Moran, Swanson, Gerber, & Fung, 2014, p. 98). Problem integration is “the ability to mathematically integrate the linguistic information into a mathematics structural representation” (p. 98).

Kintsch and Greeno (1985) proposed the concept of problem translation, a comprehension task in which the text from the word problem, which could be read orally or in writing, is used to build a text base. The ability to understand the text of a word problem in mathematics involves a number of processes involved in problem translation, including: “(1) a student recoding text or oral language into a phonological speech-based code, (2) a student incorporating contextual knowledge on the topic, (3) a student making links between successive propositions, (4) a student examining information for relevance, and (5) a student selecting and inhibiting information according to importance” (Moran et al., p. 98). The primary goal of problem translation is to convert each statement in the problem into a “proposition-based representation” (p. 98). In order to successfully solve a word problem, a student must successfully complete the problem translation process. Students with ASD may struggle with any or all of these processes.

Students with ASD often struggle with comprehension of text for a number of reasons. The difficulties they face with regards to cognition and language transfer to mathematics as well (Whitby, Travers, & Harnik, 2009), especially in word problems where the majority of information is presented in written text. Although students with ASD may have advanced computational and decoding skills (Whitby & Mancil, 2009), the complex language inherent in mathematical word problems makes it extremely difficult for students with ASD (Rockwell et al., 2011).

One fact well documented in the research for students with ASD is that, in both social and academic areas, they tend to be the most successful with literal, explicit, concrete activities and/or tasks (Kurth & Mastergeorge, 2010). This need for literal tasks often serves this population well in the procedural aspects of mathematics, such as computational skills (Whitby & Mancil, 2009). However, the ability to understand mathematics at a conceptual level in the context of language and situational learning can often be overwhelming for students who lack strong abstract thinking and language skills (Goldstein, Minshew, & Siegel, 1994).

Most children in the 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. Children who use this strategy utilize objects, such as counting cubes or blocks, to explicitly represent "each quantity in a problem, and the action or relationship involving these quantities before counting the resulting set" (p. 22). Many children use these strategies first. The second and more advanced level of mathematical thinking are counting strategies. Counting strategies are more efficient than direct modeling strategies, but they are also more abstract. When utilizing a counting strategy to solve a word problem, a child "essentially recognizes that it is not necessary to actually construct and count sets. The answer can be figured out by focusing on the counting sequence itself" (pp. 22-23). The most advanced strategy is number facts, in which children use number combinations, memorized facts, and "derived facts" (p. 24) to solve word problems. Derived facts demonstrate an understanding of relations between numbers. This developmental sequence begins with rote or concrete skills followed by more abstract applications of mathematical concepts.

Furthermore, children must use different strategies 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 the solution of those word problems. With some word problems, it is not possible to directly model the objects and actions in this problem type, or to use counting strategies to solve. Thus, a child must use the more advanced number facts strategy. Given that some students with ASD struggle to move past the concrete developmental level of direct modeling and may not acquire the more advanced levels of mathematical thinking, when presented with a problem to solve that requires the application of a number strategy, the task becomes extremely difficult.

Current Mathematical Word Problem Solving Instruction for SWD

Mathematics Standards, Curricula, and SWD

In addition to the complex nature of mathematics text, several issues exist with regards to the instruction of mathematics to SWD. The first issue relates to mathematics standards and curricula. Most of the current mathematics curricula have shifted over the last ten years (Jitendra, 2013), from a focus on teaching procedural skills to teaching conceptual understanding of complex mathematical concepts and more advanced reasoning and problem solving skills (Jitendra, 2013). In response to this shift, standards-based mathematics curricula also began to focus on "active student engagement, a focus on problem solving," and making "connections within mathematical strands as well as to real-life contexts" (Tarr et al., 2008, p. 248). The goal of current standards-based curricula is for students to "approach unknown problems by generating ideas and discussing multiple approaches to solve the problem" (Jitendra, 2013, p. 5). "Standards-based approaches for the 5% to 8% of school-aged children who experience some sort of mathematics learning disability, including students with ASD, may be challenging given their unique learner characteristics" (p. 5), such as working memory deficits, difficulty organizing information, limited knowledge of strategies and how to use them, and difficulty "manipulating numerical and linguistic information in mathematical word problems" (p. 5). As a result, considerable modifications may be needed for these students to participate in their standard grade level general education curriculum.

Teacher Preparation and Content Knowledge in Mathematics

In addition to the difficulties involved in teaching mathematical word problem solving skills to students with ASD, another major issue exists. Researchers who have studied teacher preparation programs have suggested that special education teachers do not have the appropriate knowledge for teaching mathematics to their students (Ball, Thames, & Phelps, 2008; Borko, 2004; Conference Board of the Mathematical Sciences, 2012; National Mathematics Advisory Panel, 2008). Yet, a strong correlation is noted between a teacher's content knowledge in the area of mathematics and their students' gains in mathematics (Faulkner & Cain, 2013; Hill, Rowan, & Ball, 2005). As a result, teachers who have a limited understanding of teaching and learning for the content areas, including mathematics, likely only teach procedural, lower-level skills to their SWD, resulting in both limited progress and underdeveloped conceptual understanding of mathematics (Boyd & Bargerhuff, 2009; Griffin, Jitendra, & League, 2009; Maccini & Gagnon, 2002; van Garderen, 2008). This limited level of teacher knowledge is often found in the field of special education and elementary education (Greer & Meyen, 2009).

Researchers have proposed a potential solution to this lack of knowledge, which is to improve the pedagogical content knowledge (PCK) of special education teachers in preparation programs and through professional development opportunities. The seminal work by Shulman (1986) introduced the term "specialized content knowledge" as the "missing paradigm in research on teaching and teacher knowledge" (p. 4). Shulman (1986) proposed seven major categories of teacher knowledge necessary for effectively teaching mathematics to *all* students: (a) general pedagogical knowledge; (b) knowledge of learners and their characteristics; (c) knowledge of educational contexts; (d) knowledge of educational ends, purposes, and values, and their philosophical and historical grounds; (e) content knowledge; (f) curriculum knowledge; and (g) pedagogical content knowledge, defined as "that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding" (p. 8).

Ball and colleagues (2008) further extended Shulman's work by proposing four domains of knowledge that teachers must know and be able to do in order to be effective teachers of mathematics, including: (a) common content knowledge, (b) specialized content knowledge, (c) knowledge of content and students, and (d) knowledge of content and teaching. Ball and colleagues explained the importance of this knowledge: "High-quality instruction requires a sophisticated, professional knowledge that goes beyond simple rules, such as how long to wait for students to respond" (p. 391).

While these frameworks proposed by Shulman and Ball are significant in that they outline the knowledge and skills necessary for effective mathematics instruction, several issues still remain. First, these types of teacher knowledge are extremely difficult to quantify and measure; teaching certification exams do not effectively measure this knowledge (Conference Board of the Mathematical Sciences, 2012; National Mathematics Advisory Panel, 2008; Rivkin, Hanushek, & Kain, 2005). A secondary issue is that special education teachers do not take as many mathematics methods courses as their peers in general education in their teacher preparation programs, which means they may not have the PCK necessary to be effective mathematics teachers when they graduate from their programs and begin teaching in their own classrooms (Maccini, 2006).

Performance in National Assessments

Mathematics continues to be an area of difficulty for many elementary school students. For SWD, this problem is even more evident, as shown by their performance on the National Assessment of Educational Progress (NAEP). Fewer than 20% of SWD are proficient in mathematics when they begin middle school, compared to 45% of their peers without disabilities, and 83% of SWD are performing at the basic or below basic level in mathematics in the fourth grade. By the time these SWD reach middle school, the outcomes are that only 8% of

SWD will be at the proficient level by the eighth grade (National Center for Educational Statistics [NCES], 2013). Approximately 378,000 of these SWD have been labeled as ASD (NCES, 2013).

In response to the need for improved word problem solving instruction in the U.S., especially for SWD, a panel of researchers conducted a meta-analysis of 38 studies that focused on mathematical word problem solving interventions for *all* students in grades 4-8, including SWD. As a result of the meta-analysis, Woodward and colleagues (2012) created a list of recommendations for the most effective problem solving instructional strategies, based on the What Works Clearinghouse (WWC) criteria for three levels of evidence (i.e., strong, moderate, and minimal evidence). Woodward and colleagues reviewed 38 studies and provided five recommendations for instructional practice that have the greatest potential for improving mathematical problem solving of students in grades 4-8, including: (1) "Prepare problems and use them in whole-class instruction," (2) "Assist students in monitoring and reflecting on the problem-solving process," (3) "Teach students how to use visual representations," (4) "Expose students to multiple problem-solving strategies," and (5) "Help students recognize and articulate mathematical concepts and notation" (p. 1). The recommendations with the strongest evidence were two and three, which have yet to have been explored directly with students with ASD.

Mathematical Word Problem Solving Interventions

Considering the difficulties that SWD face with regards to mathematics as well as the paucity of research in the area of mathematical word problem solving interventions, a need exists to enhance current practices in this area of mathematics. Furthermore, international peers consistently outperform mathematics students in the United States; effective word problem solving is a concern that encompasses both SWD as well as students with ASD. The recently implemented Common Core State Standards (CCSS), also referred to as College and Career Readiness Standards (CCRS), were an attempt to ensure high quality mathematics education (Schmidt, 2012). The result has been a major shift, from an emphasis on rote skills and procedural knowledge, to problem analysis, interpretation, and conceptual understanding of content (Cai & Lester, 2010). This shift in pedagogical theory appears to be a viable approach, but the impact of this higher level of thinking related to mathematical knowledge on SWD, and, more specifically, students with ASD, has yet to be realized.

Some solutions as to how the fields of mathematics education and special education might address these concerns with the shift are best to be examined from researchers who have begun to implement and investigate the effects of a number of academic interventions for students with ASD (Rockwell et al., 2011; Whitby, 2012). The current research has produced tools that have been both successful and unsuccessful for SWD; however, very few of these interventions have been applied to the population of students with ASD (see Appendix E).

The most commonly cited tools are schema based strategy instruction (SBI) and cognitive strategy instruction (CSI). In addition, graphic organizers (Dexter & Hughes, 2011) and video modeling (Bellini & Akullian, 2007) have been shown by researchers to potentially have a positive impact on SWD; however, that impact has been limited in research in the area of mathematics (Burton, Anderson, Prater, & Dyches, 2013). Currently though, most interventions in mathematics for SWD have focused on students with learning disabilities (LD) or students who are "at risk" for failure in mathematics (Zhang & Xin, 2012).

Schema-Based Strategy Instruction

Schema-based strategy instruction has been widely researched and has shown promise as a potentially viable practice for SWD, especially when compared to general strategy instruction, or GSI (Alter, Brown, & Pyle, 2011; Jitendra et al., 1998; Jitendra et al., 2002; Jitendra, Griffin, Deatline-Buchman, & Sczesniak, 2007; Jitendra & Star, 2012; Xin, Jitendra, & Deatline-Buchman, 2005). 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 et al., 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. "A schema consists of a mental problem-solution representation that allows an individual to efficiently solve a class of similar problems" (Rockwell et al., 2011, p. 88). The five addition and subtraction word problem types identified by Jitendra and Star (2011) are change, group or combine, compare, restate, and vary. Change problems involve an initial quantity that is either increased or decreased by an action to result in a different quantity at the end. Group or combine problems consist of two or more initial quantities that are combined to form a final quantity. Compare problems consist of two initial quantities that are compared to obtain a difference. Restate problems involve situations in which there is a relationship between two things, but the relationship must be restated in a way using different values. Vary problems are related to restate problems in that they also describe a relationship between two things, but in these types of problems, a student must determine how one thing affects the other.

The vast majority of research on SBI has focused on students with LD. Overall, researchers have found that SBI has the potential for improving the word problem solving abilities of students with LD in elementary and middle school grades. For example, Jitendra and colleagues (2007) implemented a randomized control trial study with 88 third graders in order to compare the effects of SBI to GSI with four types of addition and subtraction problems: change, group, compare, and two-step problems. Only 4 of the 88 students were identified as having learning disabilities. Students in the intervention group were matched with students in the comparison group; matching was based on each student's individual performance on the Stanford Achievement Test-9 (SAT-9) as well as their group status (i.e., disability diagnosis, ELL). Each pair of students was randomly assigned to either the intervention or comparison group, and then further assigned to one of three instructional groups, to create six groups. Three groups received SBI, and the other three groups received GSI, which included four strategies (i.e., using objects, drawing a diagram, writing a number sentence, and using data from a graph). The six classroom teachers who provided all of the instruction (i.e., five general education teachers and one special education teacher) were randomly assigned to the instructional groups, and were switched halfway through the study to teach the other condition. The researchers reported that at the end of the nine-week study, the SBI group significantly outperformed the GSI group, with a medium effect size of 0.69 for SBI when compared with GSI, based on student performance on a researcher-created word problem solving measure that consisted of 16 items, which was administered as a pretest, posttest, and generalization measure.

A similar experiment with 34 students with a range of disabilities, including LD, emotional behavior disorders, and intellectual disabilities in grades 2, 3, 4, and 5 also favored the

SBI group over the group of students who were receiving traditional instruction (Jitendra et al., 1998). The 34 students who participated in Jitendra and colleagues' study were selected from a pool of 75 students, based on their academic performance in mathematical word problem solving. The researchers administered a 15-item criterion assessment to all 75 students, and deemed 34 students eligible for participation in the study, based on their scores (60% or below) on the pretest. Students were then blocked by pretest scores, and randomly assigned to one of two treatment groups. The first group received SBI; the second group received traditional instruction, which was defined as "a guided discovery or general strategy" (p. 347), and consisted of a five-step word problem solving routine. The researchers also utilized a group of 24 third grade students without disabilities as another method of comparison; this group was used as a normative sample, and the students were only included for testing purposes. The assessments included five of each of three problem types: change, group, and compare. All of the word problems involved one-step addition or subtraction. A separate form of the test was created to assess generalization of the strategy.

Jitendra and colleagues (1998) used an ANCOVA with repeated measures to analyze the results of their study, which showed a statistically significant main effect for group, favoring the schema condition. While the students in both the schema and traditional groups showed an increase in scores from pretest to posttest (26% schema, 16% traditional), the students in the schema group showed a higher percentage of correctly solved word problems, with a 77% mean score on posttest as compared to the traditional group, whose mean score on the posttest was 65%. The students in the schema group made greater gains from pretest to the delayed posttest, or generalization probe, with a 34% increase. Both groups maintained their performance as measured by the delayed posttest, with the schema group scoring a mean of 81%, and the traditional group scoring a mean of 64%.

Jitendra and Hoff (1996) examined the effects of an instructional package that included SBI on the ability of students with LD to correctly solve one-step addition and subtraction word problems in mathematics. The three problem types were change, group, and compare. Three elementary-aged students with LD participated in five phases of this multiple probe study. All probe sets were parallel forms. The instructional package included scripted lessons, explicit instruction, modeling of the SBI strategy, guided practice, and corrective feedback. The SBI instruction included two discrete steps: recognize features of semantic relations in problem and design a solution strategy.

All three participants improved from baseline to the final phase, maintenance. One student improved from 20% correct to 97% correct on all three of the problem types, a second student improved from 31% to 95% correct, and the third participant improved from 26% to 95% correct. Researchers also implemented generalization probes, but the long-term effects of the intervention were not addressed in this study.

Jitendra and colleagues (2002) also employed a multiple probe design to study the effects of SBI on the word problem solving abilities of students with LD. The participants were four eighth grade students with LD. The special education teacher provided instruction to each student individually, in 35-40 minute sessions, after being trained by the researcher on the intervention procedures. The SBI intervention included two components: problem schemata identification and problem solution, and the participants applied this strategy to one-step multiplication and division word problems of two problem types – vary problems and multiplicative comparison. All four students improved in their mathematical word problem solving abilities from baseline (44%, 50%, 37%, and 29%) to intervention (all participants reached 100%), were able to maintain their levels five weeks after the study concluded (100% for all participants), and were able to generalize the strategy and apply it to solve other types of word problems (i.e., two-step problems) that were not addressed in this study.

In a similar study that extended Jitendra's earlier work on SBI interventions, Griffin and Jitendra (2008) implemented an experimental, between-subjects design with 60 third-grade students who were assigned to one of two treatment conditions, SBI or GSI. Students were matched based on their performance on the Mathematical Problem Solving subtest of the Stanford Achievement Test-9, and then randomly assigned to either treatment condition. The SBI condition included two phases of instruction on how to solve one and two-step problems: problem schema instruction and problem-solution instruction on three types of word problems (change, group, and compare). The GSI condition involved instruction on a four-step problem-solving procedure based on Polya's (1945/1990) model: (a) read and understand the problem, (b) plan to solve the problem, (c) solve the problem, and (d) look back or check. In addition, four commonly used word problem-solving strategies (using objects, acting it out or drawing a diagram, choosing an operation or writing a number sentence, and using data from a graph or table) were built in to the plan step of the problem-solving model.

The researchers employed a repeated measures ANCOVA in order to determine the differences between groups from pretest to posttest to delayed posttest (administered 12 weeks after the intervention), using the SAT-9 scores as a covariate. They found a statistically significant difference between groups ($p < .01$), favoring the SBI group at Time 1 only, with an effect size of .94 for SBI when compared to GSI (Griffin & Jitendra, 2008). However, in the long term, no statistically significant differences existed between students in the SBI and GSI condition in the solution of word problems, as students in both groups showed improvement in their ability to accurately solve word problems from pretest to posttest. Furthermore, students in both groups were able to maintain their performance across time, as measured by scores on the delayed posttest.

Xin and colleagues (2005) also compared the effects of SBI to GSI on the word problem solving abilities of SWD. The 22 student participants were diagnosed with LD ($n = 18$), emotional and behavioral disabilities ($n = 1$), or were labeled at risk ($n = 3$), and were placed into either the SBI or the GSI group based on their performance on a word problem solving pretest. Teachers were randomly assigned to the groups. Both groups were taught to apply the same four-step problem solving strategy to solve two types of word problems: multiplicative comparison and proportion. The difference in the instruction occurred at the second and third steps when it came to how to plan and solve the word problem. The SBI group was instructed in problem schemata identification and problem solution, while the GSI group utilized the more commonly used strategy of drawing a picture. Four parallel word problem-solving assessments were administered to students in both groups. The researchers used a repeated-measures ANOVA to assess the effects of SBI when compared to GSI; the researchers indicated statistically significant main effects for group ($p < .001$) and time of testing ($p < .001$). Additionally, post hoc analyses showed significant group differences on posttest ($p < .01$), maintenance test ($p < .001$), and follow-up test, ($p < .001$), all of which favored the SBI group.

In a more recent study, Jitendra and Star (2012) investigated the effects of SBI on the word problem solving abilities of 70 middle school students who were considered either high achieving or low achieving based on mathematics grades from the previous school year. Four classes of students were blocked by achievement level, and whole classes were randomly assigned to treatment or control conditions. The intervention classroom teachers were then trained on the SBI intervention. The researchers' primary goal was to assess the effects of SBI on high versus low achieving students' ability to solve mathematical word problems, and whether they could transfer the strategy to novel word problems. Students in the control group received their traditional math word problem solving instruction from a mathematics curriculum. Instruction focused on word problems involving fractions and percent. The treatment instruction included problem identification and representation, through direct modeling and scaffolded instruction. A four-step problem-solving heuristic, FOPS (Find the problem, Organize information using a diagram; Plan to solve the problem; Solve the problem) also was taught. A 14-item researcher created measure that included word problems from the 8^{th} grade Trends in International Mathematics and Science Study (TIMMS), National Assessment of Educational Progress (NAEP), and state assessments, was used as the dependent measure. Results from a two-factor ANCOVA with the pretest as a covariate indicated that the high-achieving students outperformed the low-achieving students in both conditions; however, this difference was statistically significant when comparing the mean problem solving scores for high-achieving students to the mean problem solving scores of low-achieving students in the SBI condition. Conversely, the mean problem solving scores for high-achieving students were not significantly different than the mean problem solving scores of low-achieving students (p = .85) in the control condition. Finally, the mean problem solving scores for high-achieving students who received SBI instruction were significantly greater than that of high-achieving students in the control condition.

Although all of the studies discussed in the previous section involved SWD, students who were at risk, or students who were considered low achievers, currently, only one research study has focused directly at the effects of SBI on the word problem solving ability of a student with ASD. Rockwell and colleagues (2011) investigated the effects of SBI 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 that used the mneumonic RUNS: (1) Read the problem, (2) Use a diagram, (3) Number sentence, and (4) State the answer. 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 that the study only focused on addition and subtraction problems, and that 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.

Cognitive Strategy Instruction

Another widely researched word problem solving intervention used with SWD in the area of mathematics word problems is CSI. According to Vaughn and Bos (2012), CSI "integrates ideas from behavioral, social, and cognitive learning theories and assumes that cognitive behavior (thinking processes), like observable behaviors, can be changed" (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). Montague created a mathematics word problem-solving curriculum based on CSI called *Solve It!,* which involves all of these features and is characterized primarily by the direct instruction of seven cognitive and metacognitive strategies provided to students during the problem solving process. These seven strategies include: (a) read, (b) paraphrase, (c) visualize, (d) hypothesize, (e) estimate, (f) compute, and (g) check. All of these strategies serve as a scaffold for students with ASD who have been reported to have issues with cognition and working memory (Barnhill et al., 2000; Donaldson & Zager, 2010; Griswold et al., 2002; Happe et al., 2006). In addition, the "visualize" strategy of the *Solve It!* program directly addresses the strong visual abilities of many students with ASD (Dettmer, Simpson, Myles, & Ganz, 2000; Myles, Grossman, Aspy, Henry, & Coffin, 2007; Odom et al., 2003; Odom, Collet-Klingberg, Rogers, & Hatton, 2010; Simpson, 2005).

A number of researchers have investigated the effects of CSI on the word problem solving skills of SWD, with mostly positive results across both large group and single subject designs (Hutchinson, 1993; Montague & Bos, 1986; Montague & Dietz, 2009; Montague et al., 2011). Montague and Bos (1986) investigated an eight-step cognitive strategy on the verbal math problem solving performance of six high school students with LD using a multiple baseline design. The eight steps included: "(1) Read the problem aloud, (2) Paraphrase the problem aloud, (3) Visualize, (4) State the problem, (5) Hypothesize, (6) Estimate, (7) Calculate, and (8) Self-check" (pp. 27-28). Five of the six students made "substantial progress after cognitive strategy training" (p. 39). The researchers acknowledged that although the results are promising, it is important for researchers and practitioners to consider the behavioral and cognitive characteristics of the students when designing cognitive strategy instruction for SWD.

Hutchinson (1993) employed a mixed methods study, with a multiple baseline design, and the use of a comparison group to test the effects of CSI on the ability of students with LD to solve three different algebra problem types (relational, proportion, and two variable, two-equation problems). Students were randomly assigned to either the single subject treatment group (n = 12), or to the control group (n = 8). Treatment sessions, which were conducted individually and lasted 40 minutes per session, included instruction on self-questioning for representing algebra problems and self-questioning for solving algebra problems, such as “Have I read and understood each sentence? Are there any words whose meaning I have to ask?” (Hutchinson, 1993, p. 39) and “Have I written an equation?” (p. 39). Transfer and generalization also were measured. Measures were scored on the students’ representation, solution, and numerical answers. Mastery was defined as four out of five problems correct on three consecutive assessments. Six students reached mastery on all three of the problem types, four students reached mastery on two problem types, and two students reached mastery on only the first problem type. Additionally, six weeks after post-testing, performance was maintained by 10 of the 12 students who had reached criterion on relational problems. For proportion problems, all 10 students who had reached criterion during intervention maintained their performance. Five of the six students who reached criterion for two-variable, two-equation problems maintained criterion performance. “In only 3 cases out of 28 did a student master a problem type during intervention and fail to maintain criterial performance six weeks later” (p. 45). Finally, when comparing the pretest and posttest data using Fisher’s Exact Test, Hutchinson found that there was a statistically significant difference between the two groups, which favored the CSI group on representation, solution, and answers for all three of the problem types.

Montague, Applegate, and Marquard (1993) used an experimental group design to compare the effects of three different treatments on students’ word problem solving ability. A total of 72 participants with LD and participants who were normally achieving (NA) were randomly selected from 100 students across four schools, and were then randomly assigned to one of the three treatment conditions across two cycles of treatment: (1) cognitive strategy instruction, (2) metacognitive strategy instruction, or (3) a combination of cognitive and metacognitive strategy instruction. Dependent measures were 6 tests of 10 problems, created from a pool of 400 one, two, and three-step math word problems from textbooks. A repeated measures ANOVA was used to determine if there were any differences between conditions; the researchers found that there were no significant differences among students' performance between the three treatment conditions. Further analysis revealed that NA students outperformed students with LD in all three of the treatment conditions.

One example of a more recent study that focused on problem solving interventions with SWD is Krawec and colleagues' (2012) investigation into the effects of *Solve It!* on the mathematical problem solving skills of middle school students with learning disabilities. Although this large group (n = 161), longitudinal, experimental study had statistically significant results (p = .001), and a moderate effect size of 0.52 (Cohen's *d)*, which shows promise for students with learning disabilities, a similar study with the same intervention on students with ASD demonstrated different results.

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. 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.

Although all three students improved their problem solving abilities in the short term, no maintenance of the strategies was secured (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 was not surprising, as students with ASD often have rigid thinking and have trouble communicating concepts in their own words.

While the results of the research on CSI are encouraging, a review of the research base indicated that CSI cannot yet be deemed an evidence-based practice (EBP) for SWD (Montague & Dietz, 2009), mainly due to a lack of sufficient detail in a number of the studies related to fidelity, reliability, and effect sizes. The researcher provides an overview of the studies on SBI and CSI, and the findings related to SWD in Appendix E.

Graphic Organizers in Mathematics

Although CSI and SBI are the most frequently cited and researched interventions in the literature, at this time, very few studies have focused on the effects of these interventions on students with ASD. However, another strategy in the literature that is not related to mathematics, but has shown to be effective for students with ASD, is video modeling (Bellini & Akullian, 2007). In addition, given the relationship between reading comprehension and the effective solution of word problems in mathematics, another strategy that might help students who struggle with the language of word problems is the use of graphic organizers (Sheriff & Boon, 2014; Zollman, 2011). In this section, the researcher discusses the literature related to interventions involving graphic organizers.

Given the difficulties that SWDs face when attempting to solve word problems in mathematics, and the lack of research related to EBPs in this area for students with ASD, new interventions must be examined and explored. One promising strategy that is rooted in the literature on reading comprehension, and might assist students struggling with comprehension, which includes students with ASD, in understanding the abstract concepts, relationships, and language of mathematical word problems is the use of graphic organizers (Alvermann & Swafford, 1989; Braselton & Decker, 1994; Friedland, McMillen, & Hill, 2011; Gill, 2008; Swafford & Alvermann, 1989). Graphic organizers are “graphic arrangements of words, phrases, and sentences, and they may also include graphic elements such as arrows, and boxes” (Ives, 2007, p. 2), or “visual and spatial displays that make relationships between related facts and concepts more apparent” (Dexter & Hughes, 2011, p. 51). The National Reading Panel (2000) recommended the use of graphic organizers as a strategy for improving reading comprehension, with a research base indicating that the use of graphic organizers is an effective practice for students with LD (Dexter & Hughes, 2011; Gajria, Jitendra, Sood, & Sacks, 2007; Ives, 2007; Kim, Vaughn, Wanzek, & Wei, 2004) and intellectual disabilities (Sheriff & Boon, 2014). Although most teachers have traditionally used graphic organizers to assist students in arranging their ideas during reading and writing activities, this tool also can be used in mathematics instruction to help students understand and organize difficult concepts and represent their ideas visually (Ives, 2007; Zollman, 2009). This visual representation of abstract concepts can be very effective for students with ASD given their strong preference for visual supports (Dettmer et al., 2000; Myles et al., 2007; Odom et al., 2003; Odom et al., 2010; Simpson, 2005).

Students with ASD and Graphic Organizers.

In tandem with the research base for SWD, researchers have found the use of graphic organizers for improving the expository reading comprehension of students with ASD can be beneficial in content areas, such as science and social studies (Knight, Spooner, Browder, Smith, & Wood, 2013; Schenning, Knight, & Spooner, 2013; Stringfield, Luscre, & Gast, 2011; Zakas, Browder, Ahlgrim-Delzell, & Heafner, 2013). Dexter and Hughes (2011) completed a meta-analysis on the use of graphic organizers in core content classes as an intervention for students with LD. The researchers found that graphic organizers had the largest effect in the content area of science (*ES* = 1.05), with moderate effect sizes in mathematics (*ES* = .59). However, this meta-analysis was focused on students with LD; there is a paucity of research on the use of graphic organizers as an intervention for students with ASD in solving mathematical word problems. Ives (2007) completed an experimental comparison study that examined the effects of graphic organizers on the ability of students with LD to complete word problems involving algebra. Ives (2007) found that the graphic organizer, which consisted of a two-by-three array of rectangular cells, helped students to organize and sequence the steps involved in solving linear equations. In another study on the effects of graphic organizers on word problem solving ability in mathematics, Sheriff and Boon (2014) utilized computer-based graphic organizers, created through *Kidspiration 3©* software, to assist three students with mild intellectual disabilities to solve one-step word problems. Results of their multiple-probe, single subject design indicated that all three participants improved in their ability to solve one-step word problems, from means of 2.75, 1.8, and 1.88 word problems solved correctly during baseline to means of 6.33, 6.67, and 6.67 word problems solved correctly during intervention. In a more recent, multiple-probe, single subject study, Strickland and Maccini (2014) combined the use of concrete manipulatives, sketches of manipulatives, and abstract notation with the support of a graphic organizer as an intervention for students with LD in multiplying two linear expressions. The three participants, all high school males, improved their problem solving accuracy from baseline to intervention; their scores ranged from 0% to 17% in baseline to a range of 78% to 93% after the intervention.

K-N-W-S Graphic Organizer

Building upon the literature from what is emerging from SBI and CGI, a graphic organizer could provide the structure and concrete representations of thought that many students with ASD prefer (Grandin, 2007) and address the challenge posed by the abstract thinking required in both higher level mathematics and the embedded nuances that are not as literal in word problems. The K-N-W-S graphic organizer, a strategy whereby students can plan, organize, and analyze a mathematical word problem, has not yet been explored with SWD. 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, including CSI and SBI, specifically for students with ASD (Flores et al., 2013).

The K-N-W-S strategy (see Appendix A) could assist students with ASD based upon other research findings. Some researchers have suggested that the ability to produce visual-schematic representations may aid students in successfully understanding the text of a word problem and, consequently, accurately solving it (Boonen et al., 2013). The K-N-W-S strategy consists of four steps: (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 first and second steps, the "K" and "N" require the student to reread the problem and clearly identify the important information from the unimportant information. This repetition and clear distinction between the information necessary to solve the problem and the superfluous, and often confusing, extra information may be particularly helpful for students with ASD. Because many students with ASD have language impairments, they are more likely to become confused by unnecessary information as they are trying to work through the language of a word problem (Rockwell et al., 2011). The third step, or the "W," allows students with ASD to identify the question the word problem is asking, again, reducing the language into smaller, comprehensible components. Finally, when completing the last step, or the "S," students with ASD must clearly identify the operation(s) necessary to solve the problem. An added benefit of using the K-N-W-S strategy is that teachers can analyze the graphic organizer to identify the exact step where their students are making errors (Braselton & Decker, 1994). In summary, the use of these four steps allows students with ASD to reorganize the language of a word problem in a structured, visual, concrete way. The K-N-W-S strategy falls under a field of strategies, including SBI and CSI, because it involves the same cognitive and metacognitive processes of understanding the problem, making a plan to solve it, applying a solution strategy, and monitoring solutions. Actual research of this strategy for students with ASD does not currently exist.

Video Modeling

Technology

One potential way to accommodate students with ASD in all facets of the curriculum to meet their diverse learning needs is through the use of visual supports, including those that are displayed via photographs or images (low-tech supports) as well as those that are displayed electronically (high-tech supports; Southall, 2013). Visual supports have been recognized as an EBP for students with ASD (Myles et al., 2007). Researchers indicate that visual supports, such as picture schedules, directly address the learning needs and characteristics of students with ASD, such as their strength of visual processing and their essential need for structure and routine (Carnahan, Williamson, & Haydon, 2009; Myles et al., 2007).

Information presented through electronic, high tech supports is often presented visually, which is appealing to students with ASD (Ramdoss et al., 2011). The benefits of high-tech supports for students with ASD, widely used as a tool for interventions in social skills, communication, and behavior, have strong potential to translate to academic endeavors. Computer-based instruction (CBI) can be customized, thus making it possible to meet the highly heterogeneic needs and abilities of students with ASD. Furthermore, students with ASD tend to respond well to technology, and actually even prefer a computer medium to more traditional learning mediums (Ramdoss et al., 2011; Southall, 2013). Schneps, O'Keeffe, Heffner-Wong, and Sonnert (2010) also suggested that the use of technology can be particularly helpful for SWD when reading about science, technology, engineering, and math (STEM) concepts because technology can provide tools to aid SWD in focusing their attention to the task at hand, as well as providing mechanisms that may compensate for any deficits in working memory by allowing the student to identify and process smaller pieces of information at one time.

Video Modeling and Students with ASD

Taking into consideration the propensity that students with ASD have for visual learning and technology, a conduit for instruction could potentially be video modeling. Video modeling is a "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). Video modeling is an EBP for students with ASD (Bellini & Akullian, 2007) in the acquisition of a wide variety of skills, including social, communication, and functional skills (Bellini & Akullian, 2007). Furthermore, there is some evidence suggesting that video modeling may be more effective than live, in-person modeling of behaviors or skills. 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 that video modeling "led to faster acquisition of tasks than in vivo modeling and was effective in promoting generalization" (p. 537). In this study, which employed a multiple baseline across participants design, five participants with ASD received both video modeling and in vivo modeling on a wide variety of target behaviors and tasks specific to each participant, including cooperative play, conversational speech, and self-help skills. Four of the five participants met criterion (100% correct) on their targeted skill with approximately half the amount of intervention sessions in the video modeling condition than the in vivo condition sessions.

Other researchers have expanded the use of video modeling to examine its effect on the academic performance of students with ASD. In a combined multiple baseline and multi-element study with three children with ASD, Marcus and Wilder (2009) compared the effects of peer versus video self-modeling in a novel letter-naming task. The researchers found that all three children with ASD were able to meet mastery (defined as 80% correct across three consecutive sessions) in the video self-modeling condition, while only one was able to meet mastery in the peer modeling condition.

Cihak, Fahrenkrog, Ayres, and Smith (2010) studied the effects of video self-modeling on improving the transition behaviors of four students with ASD, as measured by percentage of independent transitions through a single subject, A-B-A-B withdrawal design. The researchers observed 10 transitions per day, such as transitions from bus to classroom, classroom to cafeteria, classroom to playground, and cafeteria to classroom. When the student transitioned independently 100% of the time for three consecutive sessions, he or she was withdrawn from the intervention and moved into the next phase. All four students increased their percentage of independent transitions. Student one increased from a mean of 4% during baseline to a mean of 83% during the first intervention phase, decreased to a mean of 23% during withdrawal, and then increased to a mean to 93% in the second intervention condition. Student two increased from a mean of 6% during baseline, to a mean of 72% during the first intervention phase, then decreased to a mean of 27% during withdrawal, and increased to a mean of 82% in the second intervention condition. Student three increased from a mean of 8% during baseline to a mean of 79% during the first intervention phase, decreased to a mean of 47% during withdrawal, and increased to a mean of 88% in the second intervention phase. Finally, student four increased from a mean of 10% during baseline to a mean of 74% during the first intervention phase, decreased to a mean of 47% during withdrawal, and increased to a mean to 90% in the second intervention condition.

Burton and colleagues (2013) studied the effects of video self-modeling on the functional mathematical purchasing behaviors (e.g., estimating the amount of an item and the amount in change) of four adolescent males with autism and intellectual disabilities using a multiple baseline across participants design. The classroom teacher and two paraeducators implemented the intervention individually with each student twice a day, four days a week. The video models included the student completing a problem while following a seven-step procedure listed on a worksheet; the adult did not offer any instruction or feedback regarding the accuracy of the student's response. During the intervention phase, the students could rewind, replay, or fast forward the video on an iPad. The videos were edited to eliminate teacher prompts. One video was created for each of the five word problems, and the students played and replayed the corresponding video while completing each problem. The researchers also implemented a six-phase fading procedure in order to reduce the number of video models provided to the students. The students were required to complete one novel problem without a video model while gradually removing the model for previously solved problems. During the final phase, post intervention, students were asked to solve all five previously practiced problems without the use of the video models, although students were still provided with a visual prompt of the seven steps needed to complete each problem. The follow-up stage consisted of students completing three weekly probes without the use of video models. A visual analysis of the results indicated a functional relationship between video self-modeling and the ability of all four participants to accurately solve the functional mathematics problems. Criterion was defined as 80% accuracy across three consecutive sessions. Student one improved from a baseline mean of 24% to 98% during intervention and 100% during post-intervention. Student two improved from a baseline mean of 14% to 100% during intervention and 90% during post-intervention. Student three improved from a baseline mean of 0% to 98% during intervention and 86% during post-intervention. Student four improved from a baseline mean of 14% to 98% during intervention and 87% during post-intervention.

In another study involving the use of video modeling as an intervention for academic skills, Delano (2007) studied the effects of a writing intervention involving self-regulated strategy development on three adolescent students with Asperger syndrome. The three dependent measures were number of words written, number of functional essay elements (premises, reasons, conclusions, and elaborations), and duration of writing sessions. A multiple baseline across responses design was utilized. Each student watched a video of himself performing strategies to increase the number of words written. All three students increased their number of words written, number of functional essay elements, and duration in writing time from baseline to intervention, and were able to maintain their intervention levels 12 weeks after the intervention phase. Video modeling is considered an EBP for students with ASD (Bellini & Akullian, 2007).

TLE TeachLivE™

The TeachLivE™ virtual classroom is a potential way to incorporate virtual video modeling. TeachLivE™ is a "mixed-reality virtual environment" in which "human knowledge and technological knowledge are blended to create seemingly authentic interventions" (Dieker et al., 2014, p. 56). TeachLivE™ was created as a result of a collaborative effort between educators, computer scientists, and simulation technology experts, and was inspired by the simulation and mixed reality training that takes place with military personnel and in corporate training (Dieker et al., 2008). TeachLivE™ was developed primarily to create a mixed-reality environment that would help novice, pre-service teachers as well as practicing teachers hone their skills in any number of content areas, including instructional and classroom management skills (Dieker et al., 2014). The real-time, unscripted, authentic interactions are controlled by a human interactor, who orchestrates the classroom during each session. "With a human in the loop, the experience seems more realistic because the operator can quickly adapt to the context of the session and make references to such topical issues as sports, weather, and news issues" (Dieker et al., 2014, pp. 56-57).

Researchers who have utilized TeachLivE™ as an intervention have mainly focused on the effects of TeachLivE™ on teacher practices (Vince-Garland, 2012; Walker, 2012) and have found that four, 10-minute simulator sessions on a specific teaching practice can change at least one teaching behavior (Dieker et al., 2014). However, the mixed-reality training provided through TeachLivE™ also may be useful for SWD and more specifically, students with ASD, who may have anxiety about interacting with their human peers (Bellini & Akullian, 2007). In the TeachLivE™ virtual classroom, students can practice peer interactions without this anxiety, and perhaps can change their own behaviors in a similar fashion as the teachers who practice their skills in this setting.

Figure 1: TeachLivE Virtual Classroom

Chapter Summary of Literature Review

Students with ASD struggle with comprehension of text, especially expository text, for a number of reasons, including the nature of such text, which includes complex vocabulary and challenging language structures. Mathematical word problems are even more difficult because of the abstract nature of mathematical concepts and advanced cognitive and metacognitive processes necessary to successfully solve a word problem. The researcher incorporated several promising and evidence-based practices for students with ASD, including the use of 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.

CHAPTER THREE: METHODOLOGY

Introduction

In this chapter, the researcher provides an overview of a study that investigated the impact of the K-N-W-S graphic organizer intervention package on students with and without disabilities. The researcher begins the chapter by providing the research questions that frame the study. The researcher then describes the setting, participants, design, data collection procedures, instrumentation, and data analysis procedures.

Theoretical Framework

The theoretical framework that the researcher used as a foundation for this study is the generative model of learning theory. Wittrock (1974) proposed the generative model of learning theory with the fundamental premise that "people tend to generate perceptions and meanings that are consistent with their prior learning." The generative model of learning theory has been applied to the teaching of reading comprehension in content areas, such as science (Wittrock, 1991), as well as solving word problems in mathematics (Swanson, Moran, Lussier, & Fung, 2014). The fundamental principle of generative instruction theory is that in order for comprehension to take place, teaching and learning must focus on the relations between stored knowledge, memories of experience, and new information. Thus, "teaching for understanding is the generative process of building relations: (1) among the 'parts' (e.g., words, sentences, paragraphs, and larger units) of the subject matter, and (2) between student knowledge, belief, and experience, on the one hand, and the subject matter taught in schools, on the other hand" (Wittrock, 1991, pp. 169-170).

Generative strategy instruction (GSI), or generative strategy training, is rooted in the generative model of learning theory. Researchers propose that strategies such as GSI, that aid students in cognitive and metacognitive processing, advance a more profound understanding of content. Generative strategies require students to paraphrase content in written text into their own words, either verbally or in writing. In this proposed study, the student participant must be able to read a mathematical word problem and paraphrase the text into his or her own words to complete the K-N-W-S graphic organizer. The researcher proposes that the K-N-W-S graphic organizer strategy is a form of GSI. With this theoretical framework in mind, the researcher sought to develop an understanding of how students with ASD learn through GSI and whether or not this type of strategy did, in fact, increase comprehension of word problems in mathematics.

Research Questions

A quasi-experimental, control group design was used to answer the following research questions: (1) What are the effects of the K-N-W-S graphic organizer on the mathematical word problem solving abilities of fourth and fifth grade students with disabilities (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 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? and (3) Is there a difference in the effects of the K-N-W-S graphic organizer on the mathematical word problem solving abilities of students with ASD, SWD, and their peers without disabilities?

Research Hypotheses

Null hypothesis 1:

No statistically significant difference exists in the mathematical word problem solving abilities between SWD who do and do not learn to apply the K-N-W-S graphic organizer to mathematical word problems.

Null Hypothesis 2:

No statistically significant difference exists in the mathematical word problem solving abilities between SWD who learn to apply the K-N-W-S graphic organizer to mathematical word problems and students *without* disabilities who learn to apply the K-N-W-S graphic organizer to mathematical word problems.

Null Hypothesis 3:

No statistically significant difference exists in the mathematical word problem solving abilities between SWD who learn to apply the K-N-W-S graphic organizer to mathematical word problems, students without disabilities who learn to apply the K-N-W-S graphic organizer to mathematical word problems, and students with ASD who learn to apply the K-N-W-S graphic organizer to mathematical word problems.

Methodology

Setting

This study was conducted across two school sites in order to have access to a greater amount of students with ASD. A convenience sample was used, and whole classes were assigned to either the treatment or control group based on the population of SWD and students with ASD in the class. Classes with at least one student with ASD were included in the treatment group. 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 exceptionalities, including ASD, attention deficit disorder (ADD), specific learning disabilities (SLD), intellectual disabilities (ID), speech and language impairments (SLI), and emotional and behavioral disorders (EBD), as well as students with 504 Plans, are "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 One

The first school site was a public, tuition-free, charter school that serves approximately 200 students and employs approximately 25 teachers. 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 the students in the class. This school was a self-designated inclusive school, serving students from birth to Grade 5 with and without disabilities together in general education classroom settings. Approximately 22% of enrolled students were eligible for free and reduced lunch. The majority of students were white (47%), or Hispanic (37%). African American students represented 10% of the total enrollment, and Asian students represented 3% of enrollment. The school's focus was on the arts and technology. Each grade level faculty team consisted of a general education teacher, an exceptional education teacher, and teaching assistants. Due to the small, inclusive nature of the school, and the low student-to-teacher ratio, students were grouped into multi-age classes. Therefore, students in the treatment group were fourth grade students and students in the control group were fifth grade students. The researcher utilized one treatment group (fourth grade) and one control group (fifth grade) from this school site. 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.

The treatment group teacher who participated in the study was in her first year of teaching and holds a Masters degree in elementary education, and two Bachelors degrees in Communication Sciences and Disorders and Elementary Education. She held teaching certifications in Exceptional Student Education, Elementary Education Grades K-6, and had endorsements in reading and English for Speakers of Other Languages (ESOL). The control group teacher who participated in the study also was a first year teacher, who holds a Bachelor's degree in Early Childhood Education. She held teaching certifications in Exceptional Student Education, Early Childhood Education, Elementary Education Grades K-6, and had endorsements in reading and ESOL. Every day during the intervention, one teacher was leading the activities with the treatment group and one teaching assistant was helping students individually or in small groups.

School Two

The second school site was a public elementary school that received an "A" rating, from 2006 to 2014, and was named a national Blue Ribbon school by the U.S. Department of Education in 2010. At the time of the study, this elementary school served approximately 950 students and employs 65 teachers. Approximately 23% of enrolled students were eligible for free and reduced lunch. The majority of students were white (60%), or Hispanic (27%). African American students represented 5% of the total enrollment, as did Asian students. The researcher utilized one treatment group (fourth grade) and one control group (fourth grade) from this school site. The treatment group teacher who participated in the study is a female with 18 years of classroom experience. She held a Bachelor's degree in Elementary Education, and a certification in Elementary Education Grades K-6. The control group teacher who participated in the study has eight years of classroom experience and held a Master's degree in Exceptional Student Education. She had teaching certifications in Elementary Education Grades K-6 and Exceptional Student Education, with an endorsement in ESOL. During the study, the treatment group teacher was the only teacher in the classroom.

Due to the nature of conducting educational research in classrooms, a brief time lapse occurred related to starting the study due to spring break. Additionally, at school site one, the intervention sessions were conducted in the early morning, from 8:30 a.m. to 9:00 a.m., and at the second school site, the sessions were conducted in the late morning, from 11:00 a.m. to 11:30 a.m. Due to scheduling conflicts, these time slots were the only times during the day that were available for each of the two treatment classrooms.

Participants

Prior to the study, the researcher set forth the following inclusionary criteria for an *entire classroom* to be eligible to participate in the study: (1) an inclusive setting, whereby SWD were educated alongside their general education peers; (2) a minimum of three students in the class with disabilities, as determined by the presence of an Individualized Education Program (IEP); and (3) at least one student diagnosed with Level 1 ASD. 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 size of 80 students. One student left the school mid-study, two students missed more than 50% of the treatment sessions (more than five sessions) due to absences or lateness, and one student was excluded because he was unable to take the pretest prior to the start of the study. 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 three students with ASD participated in the study. Student demographic data can be found in Tables 2, 3, 4, and 5.

Table 2: Treatment and Control Groups

	Frequency	Percent	Valid Percent	Cumulative Percent
Treatment	41	51.2	51.2	51.2
Control	39	48.8	48.8	100.0
Total	80	100.0	100.0	

Table 3: Disability Status

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	ASD	3	3.8	3.8	3.8
	Other Disability	29	36.3	36.3	40.0
	General Education-No Disability	30	37.5	37.5	77.5
	504 Plan	18	22.5	22.5	100.0
	Total	80	100.0	100.0	

Table 4: Grade Level

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	4	60	75.0	75.0	75.0
	5	20	25.0	25.0	100.0
	Total	80	100.0	100.0	

Table 5: Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	31	38.8	38.8	38.8
	Male	49	61.3	61.3	100.0
	Total	80	100.0	100.0	

Characteristics of Student Participants with ASD

Throughout the course of the study, the researcher observed each of the students with ASD, and kept field notes of her observations of the students' behaviors, comments, and reactions to the intervention. The researcher provides a description of all three of the students with ASD in the section below, based on her observations and information provided to her by the classroom teachers.

Student One, or “Annie,” is a female who, at the time of the study, was a 10-year old diagnosed with Level 1 ASD, and in the fourth grade at a charter school. (Pseudonyms were used for all students to protect their identities). Annie’s teachers reported that she struggled in both core content areas of mathematics and reading. Annie also struggled with socialization and attention; the researcher observed these difficulties on an almost daily basis. Upon entering her class every morning, Annie would receive instructions to read a book of her choice until class started. Annie would often say, “I hate reading” or “I don’t want to read” and would sit at her desk with a closed book in front of her. She would frequently and repetitively ask her teachers (and often, the researcher): “What time is it?” The researcher observed Annie’s social difficulties on several occasions, during which she would tell a student sitting quietly nearby to “shut up” or “leave me alone.” During the intervention, Annie often received small group instruction from the teaching assistant along with two other students. She made attempts to use the K-N-W-S graphic organizer, but consistently used it incorrectly.

Student Two, or “Joey,” is a male who, at the time of the study, was a 10-year old diagnosed with Level 1 ASD. Joey attended a public school and was in the fourth grade. Joey’s teacher reported that he had been successful in all academic areas throughout the school year, but that he struggled with organizational tasks, such as packing up at the end of the school day. His teacher reported that Joey often forgot to pack his lunch box and other important items to bring home at the end of the day. Joey sat at a table with three other boys, including Bobby, the third student with ASD who participated in this study. Joey would engage in conversation with another male student, “Dean,” a general education student who sat at his table. Joey expressed his interest in video games to the researcher and would often draw scenes from video games on his daily work. Joey had the strongest academic abilities of the three student participants with ASD; however, he resisted using the K-N-W-S graphic organizer. Joey told the researcher on several occasions that the word problems were "easy" and he "didn't need to use" the graphic organizer.

Student Three, or "Bobby," is a male who, at the time of this study, was a 10-year old diagnosed with Level 1 ASD. Bobby attended a public school and was in the fourth grade. Bobby was in the same class as Joey, and they sat together at the same table. Bobby's teacher reported that he had social, emotional, behavioral, organizational, and academic difficulties throughout the school year, as well as difficulties paying attention and remaining on task. However, his teacher reported that Bobby had made significant progress in his behavior since the beginning of the school year. Bobby rarely spoke, and appeared to have difficulty completing the daily word problems. He often was the last one to turn in his work, and many times his work was incomplete. Bobby generally ignored the K-N-W-S graphic organizer and often just left it blank.

The three students with Level 1 ASD who participated in this study are very different from one another with regards to abilities, strengths, and needs; these differences clearly highlight the diversity and "spectrum" nature of autism, even with them all being considered to have a diagnosis of Level 1 ASD.

Research Design

The researcher used a quasi-experimental design in this study, in which whole classes were assigned to treatment or control groups based on the inclusionary criteria set forth by the researcher. The purpose of the study was to examine the effects of the K-N-W-S graphic organizer intervention package on the word problem solving abilities of SWD, when compared to their peers without disabilities, to a subgroup of students with ASD, and to students in the control condition, who received their traditional mathematics word problem instruction, delivered through the *GO Math!* curriculum (Dixon et al., 2012).

Intervention Package

The intervention package used in this study consisted of three pre-recorded, standardized, validated videos, as well as a packet of word problems for students to practice each day. Students were provided with two word problems per day, along with a copy of the K-N-W-S graphic organizer in order to rehearse the strategy.

Pre-recorded Video

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 "K" and the "N," in which students are asked to identify "What do I KNOW from the information stated in this problem?" and "What information do I NOT need in order to solve this problem?" The researcher utilized the gradual release of responsibility model of instruction, also known as the "I do, we do, you do" model, by demonstrating how she would begin to break down a word problem using the "K" and the "N" to Sean, the TeachLivE™ avatar, and then repeating the same steps with Sean for a second word problem.

The researcher followed an identical format in Video Two; she "taught" the last two components of the K-N-W-S graphic organizer, the "W" and the "S," in which students are asked to identify “WHAT exactly does this problem ask me to find?” and “What STRATEGY or operation will I use to solve this problem?” The researcher utilized the gradual release of responsibility model of instruction, also known as the “I do, we do, you do” model, by demonstrating how she would begin to break down a word problem using the “W” and the “S” to Sean, the TeachLivE^{TM} avatar, and then repeating the same steps with Sean for a second word problem.

The two-minute “refresher” video consisted of 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 includes the researcher briefly explaining each component as well as Sean explaining the components in his own words. The videos included “titles,” such as those shown in the image from Video One in Figure 2. These titles were similar to closed captions, and 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. All videos were also fully closed-captioned, but the captions were not used due to technical issues in the classrooms. The titles included in the images such as those seen in Figure 2 were shown on screen, but the closed captions were not, nor were they directly requested for any student with that accommodation in any of the classroom settings.

Daily Word Problems

The daily word problems packet consisted of two word problems per day (see Appendix F). All of the word problems were aligned with the types of word problems in the pre/post assessment and adapted from the *Go Math!* curriculum (Dixon et al., 2012), Florida State

Assessment (FSA), Partnership for Assessment of Readiness for College and Careers (PARCC) assessment, and Smarter Balanced Assessment Consortium (SBAC) assessment. Word problem types included one and multi-step multiplication and division grouping or partitioning and rate problems. Students were provided with assistance from their classroom teacher(s) while independently working on these word problems, but did not receive feedback or a grade on these word problems.

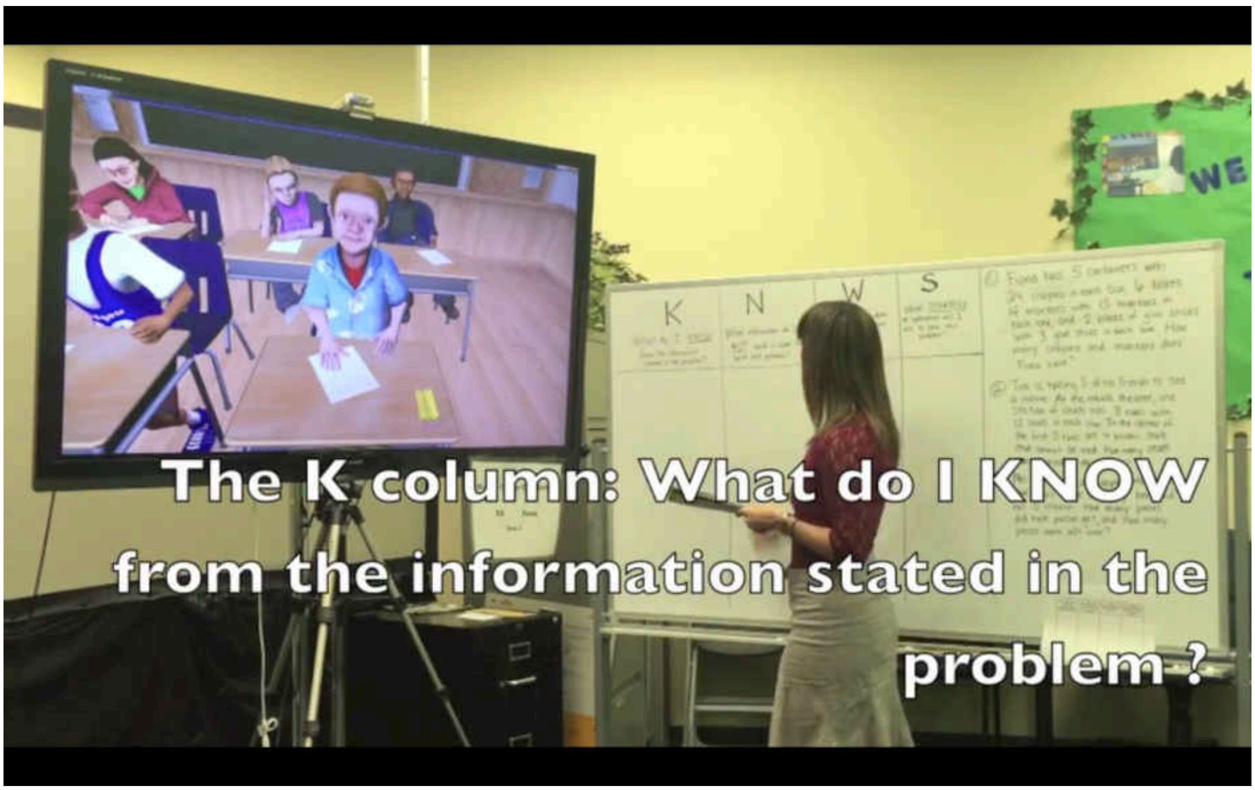


Figure 2: Video One in TeachLivE Virtual Classroom

Procedures

Upon receiving IRB approval from the University and the school district (See Appendix G), the researcher contacted the principals at both school sites. Both principals agreed to participate and recruited teachers via email. The researcher met with all potential teachers to identify whether or not each individual classroom met the inclusionary criteria. The classroom teachers in the treatment group were trained on the intervention, including what instruction would take place, how to field questions, and how to respond to comments from students. The researcher did not share the research questions with the teachers in either the treatment or control group. Furthermore, teachers in the treatment group were instructed not to teach or mention the K-N-W-S strategy during class time, other than when the researcher was in the room. An explicit protocol was used; this protocol is included in Appendix B.

The researcher, along with the teacher, implemented the intervention with the two classes in the treatment group. 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 sessions. Instruction took approximately 20-30 minutes a day, every day for nine days, for a total of 180-270 minutes, or approximately three to four and a half hours.

The researcher used three standardized, video-recorded sessions to teach each of the components of the K-N-W-S graphic organizer to the treatment classes. Three special education experts validated each of the three videos for content and clarity. See Appendix D for the video scripts. The pre-recorded video sessions included the researcher utilizing the "gradual release of responsibility" model of instruction, (Fisher & Frey, 2008, p. 2) also known as "I do, we do, you do" model. 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™ avatar, Sean. Using the simulated environment to show the strategy allowed for a scripted model and strict fidelity in showing students how to use the strategy.

Each day for nine days, students watched one of the three videos, and then worked on two word problems involving multiplication and/or division. The problem types were one-step or multi-step grouping or partitioning problems or rate problems. See Table 1 in Chapter One for further details on the word problem types. The specific content of the word problems was aligned to fourth-grade standards, and all student participants had already learned multiplication and division strategies at this juncture in the school year. All responses and corrections to daily word problems were recorded at the end of each session by the researcher to ensure consistency in the intervention and to aid in data analysis.

On Day One, the teacher began by administering the first pretest, and ensured that students' testing accommodations were provided as required by the Individualized Education Program (IEP). Following the pretest, on Day Two, the researcher showed the treatment group the first 10-minute video of herself teaching the "K" and "N" to Sean, using the gradual release of responsibility model. The video was played over the classroom SmartBoard. Students then practiced applying the "K" and "N" 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 the confound of researcher bias.

On Day Three, the researcher showed the treatment group the second 10-minute, standardized video of herself teaching the last two parts of the K-N-W-S graphic organizer, the "W" and the "S," to Sean, the TeachLivE™ avatar. Students then practiced all four steps of the graphic organizer with two different word problems while the teacher circulated to answer questions, provide feedback, and correct misconceptions.

On Day Four, students watched the third video, a two-minute "refresher" video that highlighted clips from the first two videos of the researcher explaining each part of the graphic organizer, as well as Sean explaining each component in his own words. Once again, students then applied the graphic organizer to two more word problems, while the researcher observed and the teacher circulated the classroom. On Day Five, students watched the two-minute "refresher" video again, and practiced the graphic organizer strategy with two more word problems.

The researcher followed the same format as the first five days on Days Six through Ten. On Day Six, the researcher showed the treatment group the first 10-minute video of herself teaching the "K" and "N" to Sean, using the gradual release of responsibility model, and students practiced only those first two parts with two mathematical word problems while the teacher circulated to answer questions, provide feedback, and correct misconceptions. On Day Seven, the researcher replayed the second standardized pre-recorded video of herself teaching the last two parts of the K-N-W-S graphic organizer, the "W" and the "S," to Sean for the treatment classes. The students practiced using all four steps of the K-N-W-S graphic organizer with two word problems while the teacher circulated to answer questions, provide feedback, and correct misconceptions. On Day Eight, students watched the two-minute "refresher" video, and then applied the graphic organizer to two word problems, while the teacher circulated the classroom. On Day Nine, students watched the two-minute "refresher" video, and applied the graphic organizer to two word problems. On Day Ten, students watched the two-minute "refresher" video for the final time, and then applied the graphic organizer to two word problems.

During the last four days of the study, Days Eleven through Fourteen, students only worked on two word problems per day; the researcher did not play any of the videos. Students were provided with the K-N-W-S graphic organizer each day, reminded of the special project they were working on in their mathematics class, and instructed to use the K-N-W-S to solve the two word problems. The researcher did not play the videos on these days, but did observe students during independent work, and collected and analyzed the student's daily word problem probes.

In the control group classes, the teachers delivered the pretest and posttest. Students did not receive any instruction on the K-N-W-S graphic organizer, but did receive their traditional classroom mathematics instruction, *GO Math!* (Dixon et al., 2012). See Appendix B for the detailed protocol, and Appendices C and D for the scripted, standardized lessons and video scripts.

Data Collection

The participating teachers began the study in Week One by collecting the pretest with all students in the treatment and control groups, in whole class settings. Students with testing accommodations were provided with such. During the final day of the study, the teachers administered the posttest. During this week, no intervention strategy was implemented. Daily word problems and K-N-W-S graphic organizers were also collected and scored in order to determine student use of the intervention as well as to provide the treatment group teachers with feedback on their students' performance.

Coding

All student data were de-identified by coding with the following system: school code (CH for charter school, and PU for public school), class number (1-4), treatment or control (A or B, respectively), grade level (4 or 5), student number (01-30), student disability status (A for students with autism spectrum disorder, B for SWD other than ASD, C for students without disabilities, and D for students with 504 Plans), and pretest or posttest (1 or 2, respectively). For example, the pretest for the first student in the treatment group in the charter school, classroom one, grade 4, without a disability, would be coded as follows: "CH1A401C1."

Social Validity Data

Following the collection of student posttest data, the researcher also collected social validity data from teachers. Teachers in the treatment group were asked to complete the *Intervention Rating Profile-15* (IRP-15; Martens, Witt, Elliott, & Darveaux, 1985) to indicate their level of satisfaction with the intervention. Teachers responded to 15 items about the intervention using a Likert-type scale in order to evaluate the teachers' perceptions of the acceptability of the intervention. Reliability of the instrument is .98 (Martens et al., 1985).

Table 6: Study Timeline

Day	Research Activity	Data Collection
Day One	• Teachers administer Pretest	• Pretest • Student IEP data
Day Two	• Researcher plays "K" and "N" video of herself teaching avatar and observes students • Students practice with two word problems • Researcher observes students during independent work	• Student Independent Work
Day Three	• Researcher plays "W" and "S" video of herself teaching avatar and observes students • Students practice with two word problems • Researcher observes students during independent work	• Student Independent Work
Day Four	• Researcher plays two-minute "refresher" video • Students practice with two word problems • Researcher observes students during independent work	• Student Independent Work
Day Five	• Researcher plays two-minute "refresher" video • Students practice with two word problems • Researcher observes students during independent work	• Student Independent Work
Day Six	• Researcher plays "K" and "N" video of herself teaching avatar • Students practice with two word problems • Researcher observes students during independent work	• Student Independent Work
Day Seven	• Researcher plays "W" and "S" video of herself teaching avatar • Students practice with two word problems • Researcher observes students during independent work	• Student Independent Work
Day Eight	• Researcher plays two-minute "refresher" video • Students practice with two word problems • Researcher observes students during independent work	• Student Independent Work
Day Nine	• Researcher plays two-minute "refresher" video • Students practice with two word problems • Researcher observes students during independent work	• Student Independent Work
Day Ten	• Researcher plays two-minute "refresher" video • Students practice with two word problems • Researcher observes students during independent work	• Student Independent Work
Day Eleven	• No intervention • Researcher observes students • Students practice with two word problems	• Student Independent Work

Day	Research Activity	Data Collection
Day Twelve	• No intervention • Researcher observes students • Students practice with two word problems	• Student Independent Work
Day Thirteen	• No intervention • Researcher observes students • Students practice with two word problems	• Student Independent Work
Day Fourteen	• No intervention • Researcher observes students • Students practice with two word problems • Researcher administers IRP-15 to teachers	• Student Independent Work • Social Validity Questionnaire
Day Fifteen	• Teachers administer Posttest • Researcher administers IRP-15 to teachers	• Posttest • Social Validity Questionnaire

Instrumentation

The researcher collected pretest and posttest data using a researcher-created curriculum-based measure (CBM). The use of CBMs has been viewed as an alternative to standardized testing (Deno, 1985), and can be defined as "a 'family' of assessment instruments that are designed first and foremost to assess student progress in the area of basic skills, reading, early literacy, mathematics, early numeracy, and written expression, including spelling" (Shinn, 1989, p.783). Curriculum-based assessments should be short, and only take 5-10 minutes to complete (Shinn, 1989). Therefore, the CBM consisted of ten questions, including one-step and multi-step multiplication and division word problems, which reflected content the students in both the treatment and control groups had already learned when the study was conducted. Two experts in the field validated the CBMs for content validity, including one of the *Go Math!* curriculum developers, who is also a mathematics education expert, as well as a special education expert. All students in both the control group and the treatment group completed the pretest and posttest to assess their ability to solve word problems in mathematics prior to and immediately following the intervention period.

The researcher created the CBM pretests and posttests for this study, using the *GO Math!* (Dixon et al., 2012) curriculum, FSA, PARCC, and SBAC assessments (see Appendix H). The researcher created the assessments by analyzing the chapters in *Go Math!* that taught multiplication and division (Chapters 2, 3, and 4 in the National curriculum), identifying the standards, goals, objectives, and concepts of each chapter, and creating a database of test questions. Next, each mathematics word problem was evaluated for readability; the Flesch-Kincaid grade level for each word problem was determined by using the readability tool in Microsoft Word. Any word problem that was deemed to be above grade level was discarded or rewritten to meet the grade level readability. This process continued until there were ten word problems. Each problem aligned with the concepts taught in each chapter and met the appropriate grade level for readability. The final reading level was determined to be 4.3, indicating it was appropriate for students in the fourth grade, month three of the school year. This study was conducted during months eight and nine of the school year.

Finally, the *Intervention Rating Profile-15* (IRP-15; Martens et al., 1985) was used with the treatment group teachers to determine the social validity of the intervention. The purpose of the social validity questionnaire was to ascertain the participating teachers' perceptions of the acceptability of the intervention, and whether they believed it was beneficial for their students to learn.

Measurement and Data Analysis

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. The first research question examines the difference between the SWD in the treatment group and the SWD in the control group. The second research question examines the differences in mathematical word problem solving ability between SWD in the treatment group and students without disabilities in the treatment group. Finally, the third research question examines the differences in mathematical word problem solving ability between SWD, students with ASD, and students without disabilities in the control group. The researcher conducted an a priori power analysis using G*Power software (Faul, Erdfelder, Buchner, & Lang, 2009). In order to have a moderate effect size (Cohen's *d*), there must be 44 students in each group.

The researcher performed several different analyses on the pretest and posttest data, including both parametric statistics and non-parametric statistics. Dependent and independent t-tests were used to determine the following: (a) whether a mean difference existed in the mathematical word problem solving abilities of students without disabilities as compared to SWD in the treatment group from pretest to posttest; and (b) whether a mean difference emerged in the mathematical word problem solving abilities of SWD in the treatment group as compared to SWD in the control group from pretest to posttest. The alpha level was set at the standard .05. In order to determine whether a difference was observed in the abilities of SWD in the treatment group, when compared to students without disabilities in the treatment group, and when compared to students with ASD in the treatment group, only descriptive statistics were used.

Only three students with ASD were involved in the study, which was not large enough to detect any statistical power. In addition, individual test item analyses were performed to identify patterns in the data between and within groups with regards to the different word problem types. The non-parametric Wilcoxon Signed-Rank test was used for these analyses.

Excluded Data

Given the sample size for the study, the researcher set forth the following five reasons for excluding student data from final analysis.

Reason 1: Any student who took a pretest but was unable to take a posttest (e.g., a student who has moved to a different school).

Reason 2: Any student who was unable to take a pretest prior to the start of the intervention.

Reason 3: Any student who was absent for more than 50% (5 or more) of the treatment sessions.

Reason 4: Any student who displayed fear or anxiety about the study or the pre/posttests.

Reason 5: Any student with ASD who did not meet the criteria for Level 1 diagnosis.

CHAPTER FOUR: RESULTS

Overview of Data Analysis

The purpose of this study was to investigate the effects of the K-N-W-S graphic organizer, delivered through video models of the researcher instructing a student avatar, on the mathematical word problem solving abilities of fourth and fifth grade students with and without disabilities. The research questions that guided the researcher in this study were:

(1) What are the effects of the K-N-W-S graphic organizer on the mathematical word problem solving abilities of fourth and fifth grade students with disabilities (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 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 on the mathematical word problem solving abilities of students with autism spectrum disorders (ASD), SWD, and their peers without disabilities?

In this chapter, the researcher presents the results of the data analyses for each of the research questions. 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. The researcher utilized the first dependent t-test to analyze the mean difference between pretest and posttest scores for the SWD in the treatment group. The researcher performed the second dependent t-test to analyze the mean difference between pretest and posttest scores for the 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.

Research question two was posed as an investigation of the differences between SWD and students *without* disabilities 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. The researcher analyzed the first dependent t-test to determine the mean difference between pretest and posttest scores for the SWD in the treatment group. For the second dependent t-test, the researcher analyzed the mean difference between pretest and posttest scores for the students without disabilities 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.

Research question three was an investigation of the differences between SWD, students without disabilities, and students with ASD who received the intervention. The researcher utilized descriptive statistics to compare the performance of students with ASD to their peers with and without disabilities. Given that there were only three students with ASD in the sample, even parametric statistics could not be performed.

The researcher also applied the three research questions to each of the individual test questions. These additional analyses were conducted to determine whether any patterns in the data related to student performance on the different types of word problems existed. The individual test item analyses were also disaggregated by disability group. The Wilcoxon Signed-Rank test, a non-parametric statistical test, was the primary analysis method for comparison across groups. The Wilcoxon Signed-Rank is considered the non-parametric version of a dependent t-test and is performed on ordinal data. This test ranks the median scores of a group of students on two dependent measures (Field, 2009). Finally, the researcher presents feedback from the treatment group teachers involved in the study to determine the social validity of the intervention package.

Instrumentation

A pretest/posttest curriculum-based measure (CBM) created by the researcher was used to look at student change based upon the intervention package. The CBM consisted of 10 word problems. A quantitative analysis of the dependent variable, word problem solving ability, was evaluated using the CBM. 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 graphic organizer 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. See Appendix H for the pretest-posttest CBM.

Student scores were analyzed first as a whole test, and then individually by question. However, individual test scores were ordinal level data, because the students could obtain either zero or 10 points for each question, so the item analyses consisted of descriptive and non-parametric statistics only.

Data Analysis Procedures

Data were entered into a Microsoft Excel spreadsheet and an SPSS Statistics (Version 20) spreadsheet for all students who completed a pretest, posttest, and a minimum of 50% of the intervention sessions, or at least five out of the nine sessions. A total of 80 out of 84 students completed all components of the study. One student was lost to attrition, because he left the school in the middle of the study, and three students were excluded because they either did not complete the pretest, the posttest, or missed five or more of the intervention sessions due to absences or lateness.

Two independent variables were: (a) treatment (intervention package of the K-N-W-S graphic organizer strategy taught through video models with the researcher and a student avatar, Sean, versus traditional instruction using the *Go Math!* curriculum (Dixon et al., 2012); and (b) student disability status (SWD or students without disabilities). Sample sizes of the disaggregated groups are presented in Table 7, below. An a priori power analysis conducted by the researcher indicated that there must be 44 students per group in order to have adequate statistical power; therefore, these smaller sample sizes affected the nature of the data analysis.

Table 7: Sample Sizes of Disaggregated Groups

Group	SWD, Treatment Group	Students without Disabilities, Treatment Group	SWD, Control Group	Students without Disabilities, Control Group	Students with ASD, Treatment Group
n	20	18	27	12	3

Overall Pretest to Posttest Analyses

Research Question 1

In order to answer research question (RQ) 1, whereby the researcher examined the difference in mathematical word problem solving ability between SWD in the treatment group and SWD in the control group from pretest to posttest, the researcher performed two dependent t-tests and an independent t-test. The first dependent t-test was aimed at examining any differences in the SWD treatment (n = 20) group performance from pretest to posttest. No statistically significant difference (t= -1.840, df = 19, p > .05) was found between the pretest scores (M = 32.25) and posttest scores (M = 39.00) for the SWD in the treatment group, indicating no significant change in mathematical word problem solving ability from pretest to posttest for SWD who received the K-N-W-S intervention package. Descriptive statistics for this group of SWD in the treatment group are presented in Table 8. The dependent t-test results are presented in Table 9.

Table 8: Descriptive Statistics for SWD in Treatment

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pretest Score	32.25	20	24.574	5.495
	Posttest Score	39.00	20	26.784	5.989

Table 9: Dependent t-test for SWD in Treatment

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pretest Score - Posttest Score	6.750	16.406	3.668	-14.428	.928	-1.840	19	.081

The second dependent t-test was calculated to examine differences in the SWD control group ($n = 27$) performance from pretest to posttest. No statistically significant difference ($t = -1.665$, $df = 26$, $p > .05$) was found between pretest scores ($M = 42.78$) and posttest scores ($M = 49.44$) for SWD in the control group, indicating no significant change in mathematical word problem solving ability from pretest to posttest for SWD in the control group. Descriptive statistics for this group of SWD in the control group are presented in Table 10. The dependent t-test results are presented in Table 11.

Table 10: Pre-Post Descriptive Statistics for SWD in Control

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pretest Score	42.78	27	29.559	5.689
	Posttest Score	49.44	27	27.816	5.353

Table 11: Dependent t-test for SWD in Control

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pretest Score - Posttest Score	6.667	20.801	4.003	-14.895	1.562	-1.665	26	.108

Next, the researcher compared the mean scores of SWD in the treatment group and SWD in the control group at posttest only by performing an independent t-test. 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), indicating no significant difference in mathematical word problem solving ability at posttest between SWD in the treatment group and SWD in the control group. Results of these analyses are presented in Tables 12 and 13.

Table 12: Post-test Descriptive Statistics

	Grouping	N	Mean	Std. Deviation	Std. Error Mean
Posttest Score	SWD, Treat	20	39.00	26.784	5.989
	SWD, Control	27	49.44	27.816	5.353

Table 13: Independent t-test Treatment vs. Control at Posttest

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	.753	.390	-1.293	45	.203	-10.444	8.079	-26.717	5.828
Equal variances not assumed			-1.300	41.929	.201	-10.444	8.033	-26.656	5.767

Research Question 2

In order to answer RQ 2, whereby the researcher examined the differences in mathematical word problem solving ability between SWD in the treatment group and students *without* disabilities in the treatment group, the researcher performed two dependent t-tests and an independent t-test. The first dependent t-test was aimed at examining differences in the scores of the SWD treatment group (n = 20) from pretest to posttest. No statistically significant difference (t = -1.859, df = 19, p > .05) was found between the pretest scores (M = 32.25) and posttest scores (M = 39.00) for the SWD in the treatment group, indicating no significant change in mathematical word problem solving ability from pretest to posttest for SWD who received the K-N-W-S intervention package. Descriptive statistics for this group of SWD in the treatment group are presented in Table 8. The dependent t-test results are presented in Table 9.

The second dependent t-test was aimed at examining any differences in the mathematical word problem solving ability of students *without* disabilities in the treatment group (n = 18) from pretest to posttest. Again, no statistically significant difference (t = -1.395, df = 17, p > .05) was found between pretest scores (M = 51.67) and posttest scores (M = 59.44) for students without disabilities in the treatment group, indicating no significant change in mathematical word problem solving ability from pretest to posttest for those students without disabilities in treatment. The researcher presents the results of these analyses in Tables 14 and 15.

Table 14: Descriptive Statistics for Students without Disabilities in Treatment

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pretest Score	51.67	18	26.844	6.327
	Posttest Score	59.44	18	29.600	6.977

Table 15: Dependent t-test for Students without Disabilities in Treatment

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pretest Score - Posttest Score	7.778	23.653	5.575	-19.540	3.985	-1.395	17	.181

Finally, an independent t-test was performed to further analyze any differences between SWD in the treatment group (n = 20) and students without disabilities (n = 18) in the treatment group at posttest only. A statistically significant difference (t = -2.236, df = 36, 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, indicating a significant difference between the mean scores of these two groups at posttest. The researcher presents the results of these analyses in Tables 16 and 17.

Table 16: Posttest Descriptive Statistics

	Student Group	N	Mean	Std. Deviation	Std. Error Mean
Posttest Score	SWD, Treatment	20	39.00	26.784	5.989
	SWoD, Treatment	18	59.44	29.600	6.977

Table 17: Independent t-test: SWD vs. Students without Disabilities

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Posttest Score	Equal variances assumed	.013	.909	-2.236	36	.032	-20.444	9.145	-38.992	-1.897
	Equal variances not assumed			-2.223	34.516	.033	-20.444	9.195	-39.120	-1.769

Research Question 3

Research Question 3 was aimed at examining the differences between SWD, students without disabilities, and students with ASD in the treatment group. Due to the small sample size of students with ASD, this RQ could not be answered with parametric statistics, if at all. Instead, the researcher examined the means at pretest and posttest of the students with ASD, and further analyzed the data by examining student performance across each individual test question 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). Individual test item analyses are discussed in depth. The null hypothesis could not be answered because parametric statistics were not a viable option given the sample sizes of the groups and lack of statistical power.

As previously mentioned, the researcher utilized descriptive statistics only when examining the performance of students with ASD. At pretest, Student One with ASD (Annie) scored a 20%, Student Two with ASD (Joey) scored an 80%, and Student Three with ASD (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%. The pre and posttest scores of all three students with ASD are displayed in Table 18.

Table 18: Comparison of Scores of Students with ASD from Pre-Posttest

	Pretest Score	**Posttest Score**	**Change**
Student One with ASD (Annie)	20%	30%	+10%
Student Two with ASD (Joey)	80%	70%	-10%
Student Three with ASD (Bobby)	45%	30%	-15%

Analyses by Individual Question

Additional analyses were performed in order to examine the differences in student performance by word problem type at both pretest and posttest. Due to the ordinal nature of the data, as well as the lack of statistical power when disability groups were further disaggregated, the researcher utilized non-parametric and descriptive statistics to investigate the differences in mathematical word problem solving ability between the treatment and control groups and between the groups of SWD and students without disabilities for each of the ten individual test questions at pretest and posttest. The Wilcoxon Signed-Rank test, a non-parametric statistical test, was the primary analysis method. The researcher presents the results of these analyses in Table 20.

Although every test question involved multiplication and/or division, the test questions were unique in that they assessed a few of the different types of word problems outlined in Chapter One, Table 1. Further, each problem had distinct characteristics such as the inclusion of extraneous information, or they required students to interpret a remainder in a division problem. Given the inconsistency of the overall pretest-posttest results by disability group, the researcher was interested in diving deeper into the individual test questions to determine whether any patterns in the data emerged (e.g., SWD in the treatment group showed improvement in one-step problems involving multiplication). In Table 19 below, the researcher outlines the details of each individual test question, including type of word problem, the text of the word problem, and any nuances associated with the word problem. Next, the researcher summarizes the performance of the SWD group who received the treatment, and the students without disabilities who received treatment. Finally, the researcher offers a more comprehensive analysis of the performance of students with ASD on the individual test items.

Table 19: Individual Test Question Details

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 exactly four students. How many teams of four can be made from the 27 students?	• Interpret the remainder • Multiple Choice

Q#	Word Problem Type	Steps	Text of Word Problem	Nuances of Word Problem
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
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 Item Analysis for SWD and Students without Disabilities

The researcher compared mean scores and results of the Wilcoxon Signed-Rank tests of three groups for each of the ten test questions, in order to determine any trends in the raw and descriptive data. Three Wilcoxon Signed-Rank tests were performed on each test question to investigate any differences from pretest to posttest for the following groups: (a) SWD in the treatment group; (b) SWD in the control group; and (c) Students without disabilities in the treatment group. The results of these individual item analyses and comparisons are presented in Table 20, and discussed in detail in the section below.

Question One

Question One is a one-step, three-digit by two-digit partitive division problem involving multiples of ten. In a partitive division problem, the total number of objects is known, and the number of groups is known, but the number of objects in each group is unknown. It is interesting to note that the mean scores increased for the SWD in the control group from pretest ($M = 3.70$) to posttest ($M = 7.03$) and the Wilcoxon Signed-Rank test was statistically significant ($p < .01$).

Question Two

Question Two is a multi-step, two-digit by two-digit multiplication (grouping) and addition problem. In a multiplication problem, the number of groups and number of objects per group is known, but the total number of objects is unknown. On Question Two, the largest increase in mean scores from pretest ($M = 3.33$) to posttest ($M = 6.11$) occurred for the students without disabilities in the treatment group, while scores increased slightly for the SWD in the control group from pretest ($M = 4.07$) to posttest ($M = 4.81$), and scores for the SWD in treatment group remained the same from pretest ($M = 4.00$) to posttest ($M = 4.00$). However, none of these changes in scores were statistically significant.

Question Three

Question Three is a multi-step, two-digit by one-digit partitive division problem, in which the number of objects per group is unknown. On Question Three, the mean scores increased the most for the SWD in the treatment group from pretest ($M = 1.50$) to posttest ($M = 3.00$). The mean scores increased only slightly for the SWD in the control group from pretest ($M = 4.07$) to posttest ($M = 4.44$), and the mean scores remained the same for the students without disabilities in the treatment group from pretest ($M = 5.00$) to posttest ($M = 5.00$). However, none of these changes in scores were statistically significant.

Question Four

Question Four is a one-step, two-digit by two-digit multiplication (rate) problem that included extraneous information not necessary to solve the word problem. On Question Four, the mean scores increased slightly from pretest ($M = 5.00$) to posttest ($M = 5.50$) for the SWD in the treatment group. The mean scores decreased for the SWD in the control group from pretest ($M = 6.29$) to posttest ($M = 5.55$) as well as the students without disabilities in the treatment group from pretest ($M = 8.88$) to posttest ($M = 6.66$). However, none of these changes in scores were statistically significant.

Question Five

Question Five is a one-step, two-digit by one-digit measurement division problem that required students to interpret the remainder. On Question Five, the mean scores increased for all three groups from pretest to posttest, but the only group that showed a statistically significant difference ($p < .05$) was the SWD in the control group, whose scores increased from a mean of 4.81 at pretest to a mean of 7.40 at posttest.

Question Six

Question Six is a multi-step, two-digit by one-digit partitive division and subtraction problem involving money (decimals). On Question Six, the mean scores either decreased or remained the same from pretest to posttest for all three groups. No statistically significant changes were found for any of the groups from pretest to posttest on this question.

Question Seven

Question Seven is a one-step, two-digit by one-digit partitive division problem that required students to interpret a remainder, similar to Question Five. Performance by student group was varied, as the SWD in treatment group showed a slight increase in mean scores, the SWD in the control group maintained their mean scores, and the students without disabilities in the treatment group showed an increase in mean scores. However, no statistically significant changes were found for any of the groups from pretest to posttest on this question.

Question Eight

Question Eight is a one-step, two-digit by two-digit multiplication problem that included extraneous information not necessary to the solution of the problem. Two groups demonstrated a statistically significant change: the SWD in the treatment group and the SWD in the control group. The SWD in the treatment group demonstrated an increase in scores from a pretest mean of 4.00 to a posttest mean of 7.00; furthermore, the Wilcoxon Signed-Rank test was statistically significant ($p < .05$). The SWD in the control group demonstrated an increase in scores from a pretest mean of 5.18 to a posttest mean of 7.03; furthermore, the Wilcoxon Signed-Rank test was statistically significant ($p < .05$).

Question Nine

Question Nine is a multi-step, two-digit by one-digit multiplication and addition problem involving money (decimals). On Question Nine, the mean scores decreased for two groups. The only group that demonstrated gains was the students without disabilities in the treatment group, who increased from a pretest mean of 6.11 to a posttest mean of 8.33. The Wilcoxon Signed-Rank test was statistically significant ($p < .05$). Conversely, the SWD in the treatment group decreased in mean scores from pretest to posttest; however, these changes were not statistically significant.

Question Ten

Question Ten is a multi-step, two-digit by one-digit multiplication, two by one-digit division, and addition problem that also required students to interpret a remainder. This question was the only one on the assessment that asked students to write in their own answers instead of choosing from four possible choices. Additionally, students were provided with the K-N-W-S graphic organizer for this question directly on the page. Overall, students scored the fewest number of points on this question in comparison to the other test questions. The mean scores decreased slightly from pretest ($M = 1.25$) to posttest ($M = 1.00$) for the SWD in the treatment group. The mean scores also decreased for the SWD in the control group from pretest ($M = 2.77$) to posttest ($M = 1.66$). The mean scores increased for the students without disabilities in the treatment group from pretest ($M = 2.77$) to posttest ($M = 5.55$). However, no statistically significant changes were found for any of the groups from pretest to posttest on this question.

Table 20: Item Analysis Across Groups

Question Type	Statistical Test	SWD in Treatment (20)	SWD in Control (27)	SWoD in Treatment (18)
One-step division problem	Wilcoxon Signed-Rank test Question 1 Pretest-Posttest Significance	1.00	.007	1.00
	Mean Score Question 1 Pretest	5.00	3.70	6.66
	Mean Score Question 1 Posttest	5.00	7.03	6.66
Multi-step multiplication problem	Wilcoxon Signed-Rank test Question 2 Pretest-Posttest Significance	1.00	.527	0.59
	Mean Score Question 2 Pretest	4.00	4.07	3.33
	Mean Score Question 2 Posttest	4.00	4.81	6.11
Multi-step division problem	Wilcoxon Signed-Rank test Question 3 Pretest-Posttest Significance	.083	.705	1.00
	Mean Score Question 3 Pretest	1.50	4.07	5.00
	Mean Score Question 3 Posttest	3.00	4.44	5.00
One-step multiplication problem	Wilcoxon Signed-Rank test Question 4 Pretest-Posttest Significance	.705	.527	.102
	Mean Score Question 4 Pretest	5.00	6.29	8.88
	Mean Score Question 4 Posttest	5.50	5.55	6.66
One-step division problem	Wilcoxon Signed-Rank test Question 5 Pretest-Posttest Significance	.096	.020	.480
	Mean Score Question 5 Pretest	2.00	4.81	4.44
	Mean Score Question 5 Posttest	4.50	7.40	5.55
Multi-step division problem	Wilcoxon Signed-Rank test Question 6 Pretest-Posttest Significance	.655	1.00	.257
	Mean Score Question 6 Pretest	3.00	2.22	5.00
	Mean Score Question 6 Posttest	2.50	2.22	3.33
One-step division problem	Wilcoxon Signed-Rank test Question 7 Pretest-Posttest Significance	.180	1.00	.317
	Mean Score Question 7 Pretest	2.00	3.33	2.77
	Mean Score Question 7 Posttest	3.50	3.33	4.44

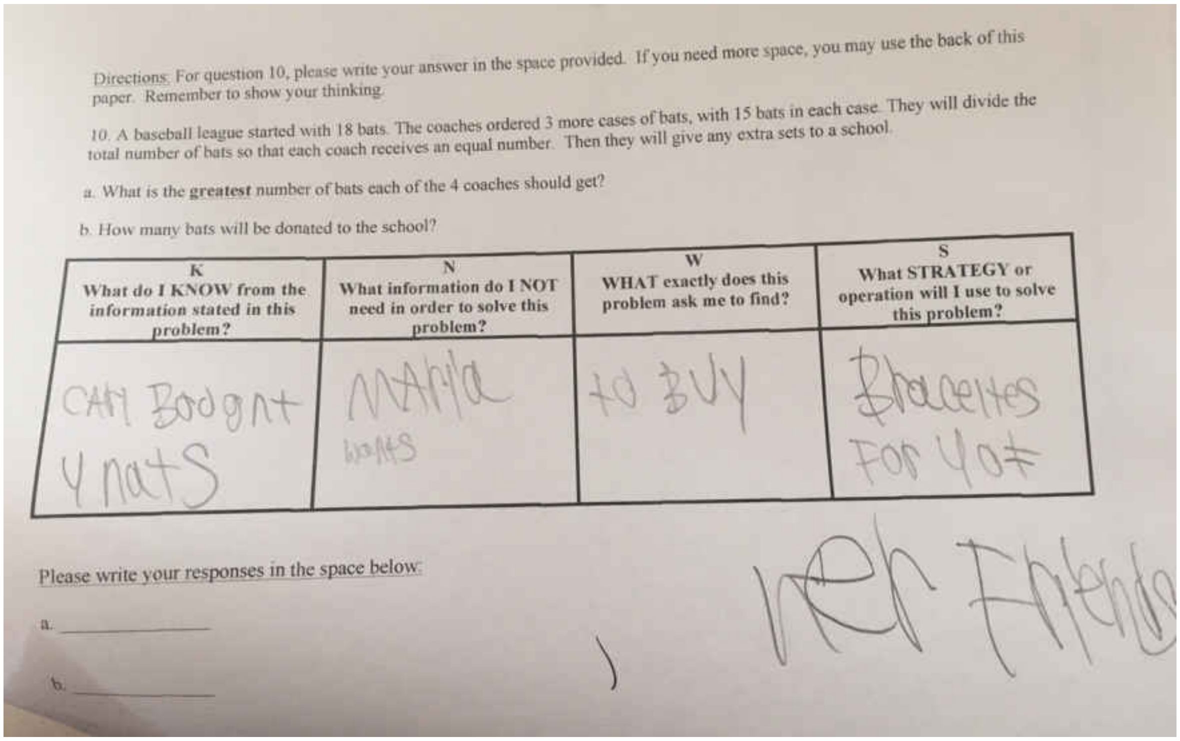
Question Type	Statistical Test	SWD in Treatment (20)	SWD in Control (27)	SWoD in Treatment (18)
One-step multiplication problem	Wilcoxon Signed-Rank test Question 8 Pretest-Posttest Significance	.014	.025	.180
	Mean Score Question 8 Pretest	4.00	5.18	6.11
	Mean Score Question 8 Posttest	7.00	7.03	7.77
Multi-step multiplication problem	Wilcoxon Signed-Rank test Question 9 Pretest-Posttest Significance	.317	1.00	.046
	Mean Score Question 9 Pretest	3.00	5.92	6.11
	Mean Score Question 9 Posttest	2.50	5.92	8.33
Multi-step multiplication and division problem	Wilcoxon Signed-Rank test Question 10 Pretest-Posttest Significance	.792	.194	.059
	Mean Score Question 10 Pretest	1.25	2.77	2.77
	Mean Score Question 10 Posttest	1.00	1.66	5.55

Results of the Item Analysis for Students with ASD

Due to the diversity amongst students with ASD, and the differences observed in the pretest-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. The test item analyses for the group of three students with ASD who received the treatment are discussed in detail below. In Table 21, the researcher provides a summary of the changes that occurred for the individual analyses for each of the students with ASD.

Student One Performance

Student One, or "Annie," scored a 20% on the pretest; her posttest score was 30%. With regards to use of the K-N-W-S graphic organizer, the researcher observed and noted in her field notes that Annie would use the tool when completing the daily word problems during the intervention phase, but would complete the sections incorrectly. A sample of Annie's work is included in Figure 3.



Directions: For question 10, please write your answer in the space provided. If you need more space, you may use the back of this paper. Remember to show your thinking.

10. 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?

K What do I KNOW from the information stated in this problem?	N What information do I NOT need in order to solve this problem?	W WHAT exactly does this problem ask me to find?	S What STRATEGY or operation will I use to solve this problem?
CAN Bodght 4 nats	MAria wants	to BUY	Bracelts For 40¢

Please write your responses in the space below:

a. ____________

b. ____________

Figure 3: Sample of Annie's Work

In Table 21 below, the researcher presents descriptive statistical data regarding Annie's performance on the pre-post assessment, compared to the performance of the other two students with ASD, Joey and Bobby. Annie showed improvement on Question Four (one-step multiplication, rate) and Question Six (multi-step division). On Question Four, both of Annie's peers answered this question correctly on both the pretest and posttest. Question Four was only one of two questions that all three students with ASD answered correctly on the posttest. On Question Six, Annie's peers either lost or maintained their scores for this question. On the pretest, Annie responded with the correct answer on Question Two, a multi-step word problem involving multiplication, but on the posttest, she responded incorrectly. In comparison, Annie's peers also lost or maintained their scores for this question.

Student Two Performance

Student Two, or "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." In Table 21, the researcher presents descriptive statistical data regarding Joey's performance on the pre-post assessment, compared to Annie and Bobby. Joey showed improvement on Question Two from pretest to posttest, a multi-step word problem involving multiplication. Alternatively, Joey responded correctly to Questions Six (multi-step, division) and Seven (one-step, division) on the pretest, but responded incorrectly to those questions on the posttest and therefore, lost points. A sample of Joey's work is included in Figure 4.

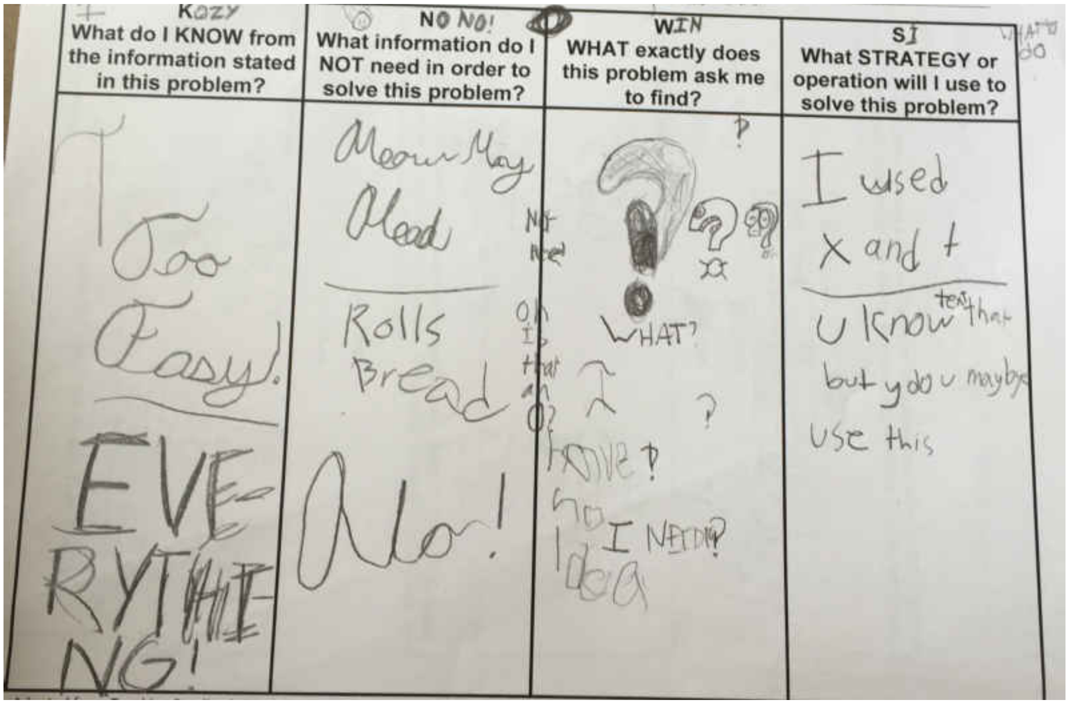
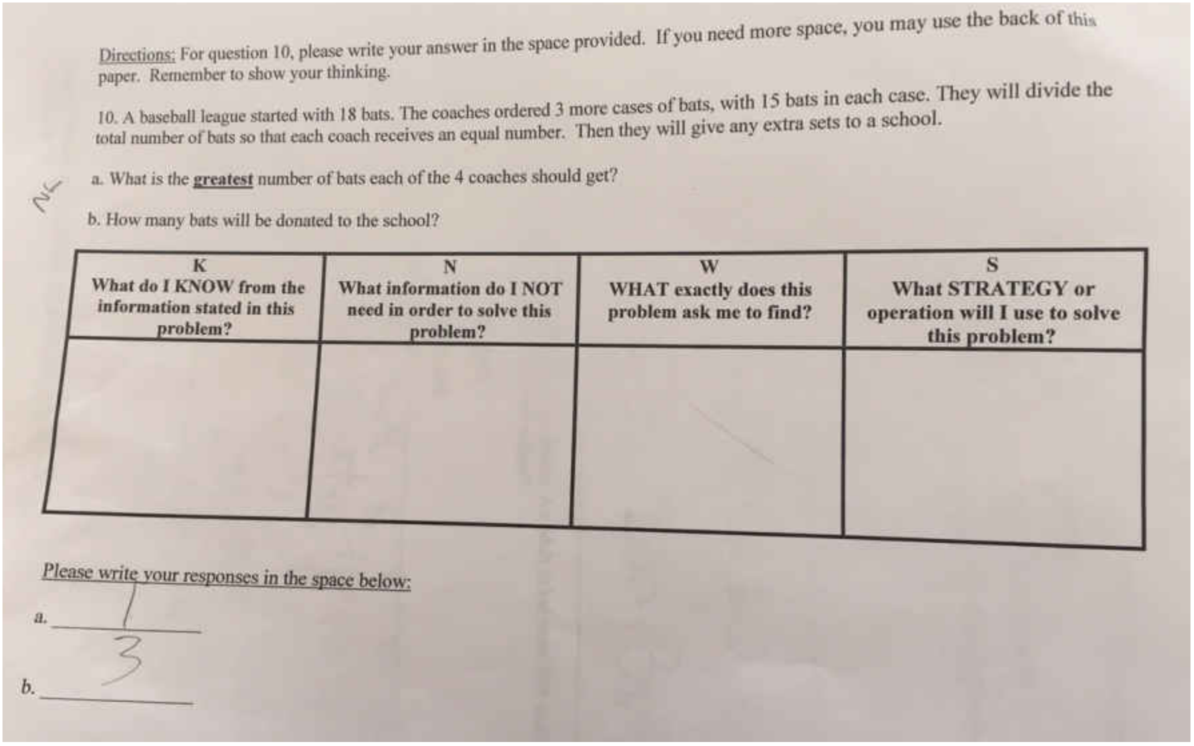


Figure 4: Sample of Joey's Work

Student Three Performance

Student Three, or “Bobby,” scored a 45% on the pretest and a 30% on the posttest. With regards to his usage of the K-N-W-S graphic organizer, Bobby rarely used it during the intervention when completing the daily word problems; he mostly just ignored the tool. In Table 21, the researcher presents descriptive statistical data regarding Bobby’s performance on the pre-post assessment as compared to the performance of the other students with ASD. The only word problem that Bobby showed improvement on from pretest to posttest was Question Five, a one-step division problem. On Questions Eight (one-step, multiplication) and Ten (multi-step, multiplication and division), Bobby lost points from pretest to posttest. A sample of Bobby’s work is included in Figure 5.



Directions: For question 10, please write your answer in the space provided. If you need more space, you may use the back of this paper. Remember to show your thinking.

10. 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.

NC 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?

K What do I KNOW from the information stated in this problem?	N What information do I NOT need in order to solve this problem?	W WHAT exactly does this problem ask me to find?	S What STRATEGY or operation will I use to solve this problem?

Please write your responses in the space below:

a. 1

b. 3

Figure 5: Sample of Bobby's Work

Table 21: Test Item Performance of Students with ASD

Q#	Type	Change in Scores for Student One with ASD "ANNIE"	Change in Scores for Student Two with ASD "JOEY"	Change in Scores for Student Three with ASD "BOBBY"
1	One-step division problem	**Neutral 0** Incorrect on Pretest; Incorrect on Posttest	**Neutral 0** Correct on Pretest; Correct on Posttest	**Negative -** Correct on Pretest; Incorrect on Posttest
2	Multi-step multiplication problem	**Negative –** Correct on Pretest; Incorrect on Posttest	**Positive +** Incorrect on Pretest; Correct on Posttest	**Neutral 0** Incorrect on Pretest; Incorrect on Posttest
3	Multi-step division problem	**Neutral 0** Incorrect on Pretest; Incorrect on Posttest	**Neutral 0** Correct on Pretest; Correct on Posttest	**Neutral 0** Correct on Pretest; Correct on Posttest
4	One-step multiplication problem	**Positive +** Incorrect on pretest; Correct on Posttest	**Neutral 0** Correct on Pretest; Correct on Posttest	**Neutral 0** Correct on Pretest; Correct on Posttest
5	One-step division problem	**Neutral 0** Correct on pretest; Correct on posttest	**Neutral 0** Correct on Pretest; Correct on Posttest	**Positive +** Incorrect on Pretest; Correct on Posttest
6	Multi-step division problem	**Positive +** Incorrect on pretest, Correct on posttest	**Negative -** Correct on Pretest; Incorrect on Posttest	**Neutral 0** Incorrect on Pretest; Incorrect on Posttest
7	One-step division problem	**Neutral 0** Incorrect on pretest; Incorrect on posttest	**Negative -** Correct on Pretest; Incorrect on Posttest	**Neutral 0** Incorrect on Pretest; Incorrect on Posttest
8	One-step multiplication problem	**Neutral 0** Incorrect on pretest; Incorrect on posttest	**Neutral 0** Correct on Pretest; Correct on Posttest	**Negative -** Correct on Pretest; Incorrect on Posttest

Q#	Type	Change in Scores for **Student One with ASD** "ANNIE"	Change in Scores for **Student Two with ASD** "JOEY"	Change in Scores for **Student Three with ASD** "BOBBY"
9	Multi-step multiplication problem	**Neutral 0** Incorrect on pretest; Incorrect on posttest	**Neutral 0** Correct on Pretest; Correct on Posttest	**Neutral 0** Incorrect on Pretest; Incorrect on Posttest
10	Multi-step multiplication and division problem	**Neutral 0** Incorrect on pretest; Incorrect on posttest	**Neutral 0** Incorrect on pretest; Incorrect on posttest	**Negative -** Scored 5 points out of ten for this question on pretest; scored zero points on posttest

Summary of Item Analysis for All Students

Interesting changes were noted from pretest to posttest on some of the individual test questions, but again, this summary has to be viewed with caution due to the limited sample size. Despite the limitations, an interesting change was with Question Eight (one-step, multiplication), 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 who did not receive the K-N-W-S intervention package also showed statistically significant differences on Question One (multi-step, division) and Question Five (one-step, division). However, these changes might be attributed to teacher effect or other variables not measured. The pretest to posttest changes of each group on each test item are outlined in Table 20, and the details of the individual word problem types are included in Table 19. 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 the students with ASD showed improvement in or a decline in their performance, and each student with ASD was observed demonstrating very different reactions to the use of the K-N-W-S graphic organizer.

Fidelity of Procedures

A number of measures were put in place to ensure that the study was implemented with fidelity. Two independent, graduate level researchers used a treatment protocol rubric to ensure fidelity of instruction for three out of the nine intervention sessions, or 33%. The treatment protocol rubric was aligned with the intervention treatment protocol and developed by the researcher to evaluate the fidelity of the researcher's instructional delivery (See Appendix I). The research assistants scored 25% of the pre/post assessments for interrater reliability.

Instructional Fidelity

The treatment protocol rubric contains 9 points of competency, with scores ranging from 0 to 1 for each component (see Appendix I). A total of 9 points can be earned. In order to confirm instructional fidelity, proficiency was established at 8 out of 9 points, which equates to 89% criteria. The researcher provided the two interobservers with an orientation prior to the research, which included a rationale for the intervention and an opportunity to practice the review of the evaluation rubric components and standards. Competency for instructional fidelity was established at 85%, and interobserver agreement (IOA) also was set at 85%. In addition, the interobservers were provided with materials in order to prepare them to evaluate the delivery of instruction, including: (1) a brief summary of the literature about the K-N-W-S graphic organizer and video modeling; (2) an overview of the methodology of the study; (3) a copy of the K-N-W-S graphic organizer; (4) the treatment protocol (script); and (5) the treatment protocol rubric.

Fidelity Checks During Intervention Phase

During the intervention phase, the interobservers assessed 33% of the researcher's instructional delivery. Each class received nine days of instruction; therefore, the interobservers assessed a total of three sessions per class. For instructional fidelity, point-by-point 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%.

Reliability of Scores

The researcher scored all assessments first. Then, an independent researcher scored 25% of the pretests and posttests for interrater reliability (IRR). The scores were compared with the researcher's original scores. Interrater agreement was calculated by dividing the number of agreements by agreements plus disagreements multiplied by 100 (Kazdin, 1982). Point-by-point IOA was used to ensure accuracy of scoring. The criterion for IRR was established at 95%. The final IRR was 99%.

Social Validity

The two treatment group teachers completed the Intervention Rating Profile (IRP)-15 (Martens et al., 1985), which ranges in scores from 15 to 90, immediately following the intervention. The Likert-type scale used in this social validity tool is included in Table 22. At this point in time, the teachers had been provided with data regarding student performance on the pretests, posttests, and daily word problems. Teacher One, a first year teacher at a charter school, slightly agreed with eight of the statements and agreed with seven of the statements, for a total score of 71. Teacher Two, an experienced teacher at a public school, strongly agreed with 13 of the statements, agreed with one of the statements, and slightly disagreed with the statement "This intervention is consistent with those I have used in classroom settings," for a total score of 86.

The researcher provides a summary of the teachers' responses in Table 23. Both teachers indicated a high preference for using this strategy (the intervention package, including the K-N-W-S graphic organizer and the video models) with students who were struggling with word problem solving in mathematics.

Table 22: IRP-15 Likert Scale

1	2	3	4	5	6
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree

Table 23: Social Validity Teacher Responses

Statement	**Teacher 1**	**Teacher 2**
"This is an acceptable intervention for the child's mathematical word problem solving ability"	Agree	Strongly Agree
"Most teachers would find this intervention appropriate for other problem solving interventions as well as the one identified"	Slightly Agree	Strongly Agree
"The intervention should prove effective in changing the child's mathematical word problem solving ability"	Slightly Agree	Strongly Agree
"I would suggest the use of this intervention to other teachers"	Slightly Agree	Strongly Agree
"The child's problem solving is severe enough to warrant the use of this intervention"	Slightly Agree	Agree

Statement	Teacher 1	Teacher 2
"Most teachers would find this intervention suitable for the mathematical word problem solving ability identified"	Slightly Agree	Strongly Agree
"I would be willing to use this intervention in the classroom setting"	Slightly Agree	Strongly Agree
"This intervention would not result in negative side-effects for the child"	Agree	Strongly Agree
"This intervention would be appropriate for a variety of children"	Agree	Strongly Agree
"This intervention is consistent with those I have used in classroom settings"	Agree	Slightly Disagree
"The intervention is a fair way to handle the child's mathematical word problem solving ability"	Slightly Agree	Strongly Agree
"This intervention is reasonable for the mathematical word problem solving ability identified"	Agree	Strongly Agree
"I like the procedures used in this intervention"	Agree	Strongly Agree
"This intervention is a good way to handle this child's mathematical word problem solving ability	Slightly Agree	Strongly Agree
"Overall, this intervention would be beneficial for the child"	Agree	Strongly Agree

(Martens et al., 1985)

Summary of Data Analysis

Overall, from pretest to posttest, when comparing mean scores, some changes occurred across the groups of SWD in the treatment group, the SWD in the control group, and the students without disabilities in treatment, but the results of the analyses must be interpreted with caution. Further analyses of the individual test questions were performed to identify patterns in the data. The results of these individual item analyses indicated variability across disability groups and individual students.

The researcher also observed differences among teachers' instructional abilities and pedagogical content knowledge (PCK) and noted some of these differences in her field notes. Since the teachers' practice was not a research question posed in this study, those differences were not discussed. However, the potential impact on student learning in mathematics and the use of the K-N-W-S graphic organizer were most likely impacted by the differences in classroom management, classroom environment (number of adults in the room), years of experience, and the mathematics instruction that occurred when the researcher was not in the classroom. This issue is discussed in Chapter 5 as a consideration for future research.

CHAPTER FIVE: DISCUSSION

Chapter Overview

In the past three decades since autism spectrum disorder (ASD) was included as a diagnosis in the Diagnostic and Statistical Manual of Mental Disorders (DSM III; APA, 1980), researchers in the medical and education fields alike have grown to understand more about the disability. As a result, there is greater knowledge about the core deficits, unique abilities, and educational needs of individuals with ASD. Additionally, as the prevalence of ASD began to explode, especially between 2000 and 2010, when the rates rose from 1 in 150 children to 1 in 68 children (Centers for Disease Control, 2014), researchers began to investigate practices, programs, and strategies that might meet the behavioral, social, communicative, and educational needs of this population. Students with ASD vary widely in ability (Thompson, 2013), hence the term "spectrum disorder," which implies a range of abilities and needs. These variances have made it difficult for researchers to identify evidence-based practices (EBPs) for students with ASD who are struggling academically. Although several approaches have been deemed EBPs for individuals with ASD, including Applied Behavior Analysis and Discrete Trial Training (Ryan, Hughes, Katsiyannis, McDaniel, & Sprinkle, 2011), very few practices have emerged as EBPs for students with ASD in academic areas such as mathematics (Burton et al., 2013; Flores, Hinton, & Strozier, 2014).

In fact, many students with ASD have particular difficulty with mathematics, for a wide variety of reasons, such as cognitive deficits, deficiencies in working memory and/or executive functioning, and difficulties with abstract tasks (Barnhill et al., 2000; Donaldson & Zager, 2010; Happe et al., 2006; Griswold et al., 2002). The inclusion of students with ASD in the general education classroom has increased since ASD was first added as a disability category to the Individuals with Disabilities Education Act (IDEA) of 1990. As a result of the increasing number of students with ASD in the general education classroom, combined with the shift to the Common Core State Standards (CCSS) and College and Career Readiness Standards (CCRS), the pressures placed on educators to find strategies to help their students succeed have increased. More recently, researchers have shifted their focus from finding EBPs for students with ASD, and are now suggesting that individualization is the key for this population (Fava & Strauss, 2014; Stahmer, Schreibman, & Cunningham, 2011). The results of this study are interesting in that they appear to support this theory that individualization, or customized, tailored interventions, is crucial to helping students with ASD to succeed in the general education classroom, and warrants further investigation.

In this chapter, the researcher discusses the topic of individualization and customization, and how it relates to this study, as well as implications for students with ASD in mathematics. Additionally, the researcher reviews the purpose of the study and the results in relation to current literature, provides recommendations based upon the results, and shares limitations of the research study. The discussion throughout this chapter is grounded in the implications of strategy instruction for students with ASD. Finally, the researcher offers suggestions for future research.

Purpose and Procedures of the Study

In this study, the researcher examined the effects of an intervention package, which included the K-N-W-S graphic organizer, which was delivered through video models with a student avatar, on the abilities of students with and without disabilities to solve mathematical word problems involving multiplication and division. The intervention designed by the researcher and utilized in this study combined instructional practices that have been found to be effective for students with disabilities (SWD): strategy instruction in mathematics (Jitendra & Star, 2012) and video modeling (Bellini & Akullian, 2007). The overarching goal of this study was to identify a practice that would potentially improve word problem solving for SWD, with a specific focus on the population of students with ASD.

Students with disabilities, including students with ASD, students with 504 Plans, and students with multiple disabilities, received an intervention package designed by the researcher, alongside their peers without disabilities in the general education classroom across two school sites. A total of 41 students in the two treatment group classes received nine days of instruction on the K-N-W-S graphic organizer, delivered through video models with the researcher and a student avatar from the TeachLivE^{TM} virtual classroom. Each day, after watching one of the three videos on the classroom SmartBoard, the students were provided with a paper copy of the K-N-W-S graphic organizer along with two word problems. The researcher used the same types of word problems on the daily word problems that were used on pretest/posttest assessment. See Table 24 for details regarding the daily word problems. The students had approximately 15-20 minutes to complete these word problems independently, while the teacher circulated the room to answer questions and provide assistance and the researcher observed and collected field notes. Following the nine days of intervention, the students spent five days rehearsing the strategy with two more word problems each day, without watching the videos beforehand.

The researcher analyzed the results of the pretests and posttests across and between groups via dependent and independent t-tests. The performance of students with ASD on the pretest and posttest was examined on an individual basis. Furthermore, distinct test item differences were explored through non-parametric and descriptive statistics in order to identify patterns related to word problem type and performance by disability and treatment groups. The results, as with any study, are grounded in a real school and classroom setting which created limitations that need to be considered when reviewing the data.

Table 24: Details of Daily Word Problems

Word Problem Type	Total Number of Questions
Multiplication (total number unknown)	16 questions
Measurement Division (number of groups unknown)	3 questions
Partitive Division (number of objects per group unknown)	5 questions
Rate	2 questions

The Current State of Mathematics Instruction

Currently, 60% of all SWD are included for 80% or more of the day in the general education class (U.S. Department of Education, 2013). Given that more SWD are being included in the general education classroom, more SWD are exposed to the same curriculum and expected to meet the same rigorous standards in mathematics as their peers without disabilities. However, SWD have consistently underperformed compared to their peers in mathematics (U.S. Department of Education, 2013). Further exacerbating this issue of disparity in the mathematics achievement of SWD as compared to their non-disabled peers, is the recent shift to the CCSS and CCRS. This shift has placed more of a focus on student acquisition of conceptual knowledge, rather than procedural knowledge in mathematics (Cai & Lester, 2010). The new standards and thus, new curricula, include more language in mathematics (Jitendra, 2013) and have increased the amount of academic rigor and expectations for all students.

Additionally, many special education teachers do not have the necessary knowledge to be effective mathematics teachers. Ball (2008), who expanded on the seminal work by Shulman (1986) related to critical teacher knowledge and skills, proposed that all teachers must possess four domains of knowledge to be effective mathematics teachers, including: (a) common content knowledge, (b) specialized content knowledge, (c) knowledge of content and students, and (d) knowledge of content and teaching. This issue is still pervasive in the field of special education, especially given the fact that every teacher has not and does not receive the same professional development on the new standards and curricula. The question continues to be, if a special education teacher is working across three grade levels, or three different content areas, what type(s) of professional development is necessary to ensure that these teachers have the skills needed to be effective, especially with this shift in the standards? Currently, general education and special education teachers' level of experience, knowledge, and skills in delivering effective mathematics instruction that is aligned with the CCSS and CCRS varies, and is dependent on their preparation (Powell, 2015). Throughout the intervention, the researcher observed and noted some differences between the intervention group teachers' content knowledge, teaching style, and instructional delivery, but teacher content knowledge was not a measured variable. The four teachers who participated in the study (two treatment, two control) had varying levels of experience and education. For example, the treatment group teacher at School One (charter school) was a first year teacher, had a number of certifications including exceptional student education (ESE), and had completed a Master's degree in elementary education. In comparison, the treatment group teacher at School Two (public school) had 18 years of classroom experience, was certified in elementary education, and had completed a Bachelor's degree. Furthermore, it is likely that since the study took place at two different schools (one charter and one public), there may have been variance in the amount and quality of mathematics professional development, especially with regards to the new CCSS and CCRS and how the standards have shifted. These differences may have been a factor in this study with regards to student performance from pretest to posttest and student performance on the different word problem types.

Implications for Strategy Instruction

Given this current climate of mathematics education for both elementary general education teachers and special education teachers, SWD, and especially students with ASD, will continue to fall even further behind if their teachers do not identify and implement strategies that help differentiate instruction for SWD to become successful in solving word problems in mathematics. Researchers have studied the effects of strategies such as schema-based strategy instruction (SBI) and cognitive strategy instruction (CSI) on the word problem solving abilities of SWD. Although the results of many of these studies are promising for SWD, very few studies have focused on the effects of these strategies on students with ASD (see Appendix E). Given this paucity of research, in tandem with the variability amongst different groups and individuals with disabilities, a need exists to identify strategies that can potentially assist all students who struggle with word problems to successfully access their grade level mathematics curriculum.

Implications for Students with Disabilities

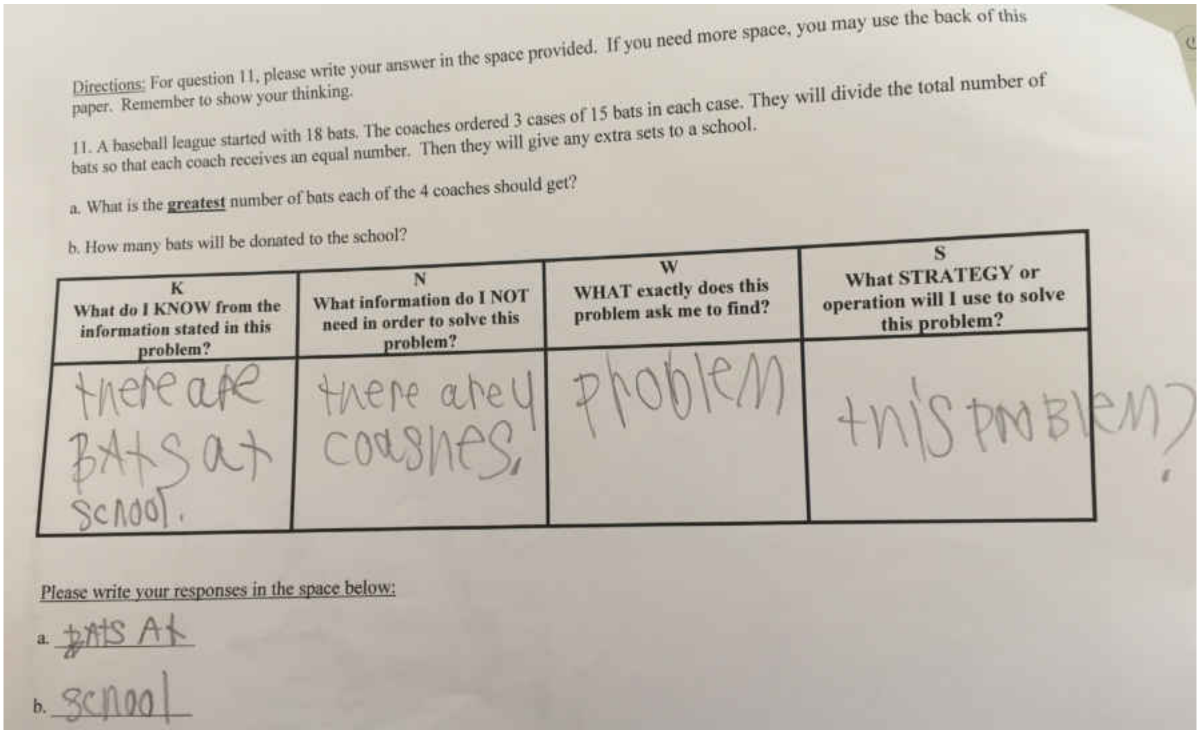
. Researchers in the field of special education have attempted to alleviate the issue of disparity in mathematics performance between SWD and their non-disabled peers by investigating and implementing strategy instruction interventions for students who are at risk of failure in mathematics, including SWD. Two of the most heavily researched interventions in mathematics designed to help students to effectively solve word problems are SBI and CSI. An extensive research base exists to suggest that strategy instruction, such as SBI and CSI, is beneficial to students who struggle with word problems in mathematics (see Appendix E). In a thorough review of approximately 20 studies, researchers found that strategy instruction can have a positive impact on the word problem solving abilities of SWD, especially students with LD (see Appendix E). However, as a result of the analyses conducted in this study, the researcher suggests that 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. For example, although the groups of SWD in the treatment group (n = 20), and students without disabilities in the treatment group (n = 18) both demonstrated an increase in their overall scores from pretest, when examining their mean scores on the individual test questions, there is wide variation in their performance on individual test questions. There doesn't appear to be a clear pattern related to the specific types of problems the students, as a group, showed increases in performance following the intervention. Perhaps this is because, at the individual level, some students improved on one question and different students improved on another question, depending on their individual needs, abilities, and level of mathematical thinking.

As a result of the outcomes of this study, the researcher suggests that strategy instruction may be beneficial for *some* SWD, but perhaps not all, and possibly only for certain types of word problems for students with very specific needs and abilities. When comparing the mean and median group scores, it is apparent that the K-N-W-S graphic organizer did not help every student on every type of word problem. This finding leads to a question that 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 that the individual needs of this population vary so widely from student to student. Traditionally, many students with ASD are more successful with computational tasks in mathematics than with solving word problems in mathematics, because word problems add a layer of complexity with language that is not present in straightforward computational problems (Braselton & Decker, 1994). Students with ASD struggle with spoken and written language; this is one of their core deficits (Smith-Myles et al., 1995). These deficits are apparent when examining the performance of students with ASD in reading comprehension tasks (Chiang & Lin, 2007; Nation et al., 2006), especially with expository text, including mathematics texts and mathematics word problems, which are language-based tasks.

All students must successfully navigate through a series of advanced cognitive processes in order to solve mathematical word problems: (a) understanding text; (b) constructing a representation of the problem mathematically; (c) creating, planning, and monitoring solutions; (d) implementing the correct computational procedures necessary to find the solution; and (e) effectively interpreting the solution (Desoete et al., 2003). Students with ASD tend to be more successful with literal, explicit, concrete activities and tasks (Kurth & Mastergeorge, 2010), and struggle to understand mathematics at a conceptual level, especially when language is involved (Goldstein et al., 1994). In this study, two of the students with ASD declined in their word problem solving performance after the intervention, and only one student improved from a score of 20% to 30%. Thus, it is likely that using the K-N-W-S graphic organizer 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 that none of the students with ASD used the graphic organizer correctly or consistently, with one student using it incorrectly (as evidenced in Figure 6), one student resisting the use of the tool, and one student ignoring it, it is likely that this was not a true visual strategy. These results correspond with the results of Whitby's (2012) study on the effects of CSI on the mathematical word problem solving abilities of three students with ASD. All three participants had trouble with the components of the intervention that required strong language skills: paraphrasing the word problem into their own words, and reading and rereading the problem until they understood it.



Directions: For question 11, please write your answer in the space provided. If you need more space, you may use the back of this paper. Remember to show your thinking.

11. A baseball league started with 18 bats. The coaches ordered 3 cases of 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?

K What do I KNOW from the information stated in this problem?	N What information do I NOT need in order to solve this problem?	W WHAT exactly does this problem ask me to find?	S What STRATEGY or operation will I use to solve this problem?
there are BATS at school.	there are coashes.	problem	this problem?

Please write your responses in the space below:

a. bats At

b. school

Figure 6: Sample of Annie's Work

Furthermore, when considering the three levels of word problem solving strategies: direct modeling, counting, and number facts (Carpenter et al., 1999), it is possible that two of the students with ASD in this study, Annie and Bobby, may have only been able to utilize the direct modeling strategy, and had not advanced to the more abstract levels of thinking. Considering that none of the students were provided with tools to concretely model the word problems, it is possible that for these two students in particular, the K-N-W-S graphic organizer, in addition to increasing the amount of language, also did not provide them with enough support that corresponded directly with their current level of mathematical thinking.

Additionally, it is a well-known fact that individuals with ASD vary widely from each other with regards to abilities and needs. There is a famous saying that states: “If you have met one person with autism, you have met *one* person with autism” (author unknown). Therefore, the researcher proposes that applying a “one-size fits all” approach to this particular population of SWD especially 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.

Although graphic organizers have a lot of support in the literature for having a positive effect on the achievement of SWD in a multitude of academic areas (Dexter & Hughes, 2011; Friedland et al., 2011; Gajria et al., 2007; Gill, 2008; Ives, 2007; Kim et al., 2004; Sheriff & Boon, 2014), the K-N-W-S graphic organizer was created during a time when procedural knowledge was more of a focus in the curriculum than conceptual knowledge, so it may be better suited to procedural tasks. Additionally, it increases the amount of language a student with ASD must decipher and make sense of when solving a word problem. Perhaps those students with ASD who have more significant language impairments struggled more with the K-N-W-S graphic organizer for this reason.

Moreover, students with ASD have very different academic needs than students with other disabilities, and they vary widely even from each other. Results of this study support this concept, as the overall pretest-posttest analyses and individual test item analyses suggest that the strategy instruction used in this study may not be helpful for all SWD, especially not for all students with ASD. Furthermore, it is also possible that these students did not yet possess the conceptual understanding of the mathematical concepts that were assessed in the pretest-posttest, and the K-N-W-S graphic organizer did not help to increase their conceptual understanding.

Implications for Mathematics Instruction

Implications for Students without Disabilities in Mathematics Instruction

As a whole, students *without* disabilities (in both the treatment and control groups) outperformed the other groups of SWD; this is not surprising and aligns with national data on student performance in mathematics (U.S. Department of Education, 2014). It does not appear that the treatment made a difference, as no statistical significance in mean scores from pretest (M = 51.67) to posttest (M = 59.44) were found for students without disabilities who received the intervention. This was a small group (n = 18), so the statistical analyses must be interpreted with caution; however, there was still an 8-point increase in the performance of students without disabilities who received the intervention in the treatment group. The SWD in the control group (n = 27) had higher pretest (M = 42.78) and posttest (M = 49.44) scores than their peers in the treatment group and also improved 7 points from pretest to posttest. It is difficult to compare the two groups given that the control group of SWD started out 10 points higher than the treatment group of SWD. It is also important to note that the students without disabilities in the treatment group started out with higher pretest scores (M = 51.67) than all of the other groups. These existing pretest differences could be attributed to teacher effects. We know that the teacher makes the biggest difference in a student's success in a classroom (Brophy, 1979) so it is possible that the treatment group teachers were more effective mathematics teachers, or more highly effective when teaching multiplication and division. It is also conceivable that group size, individual student abilities, or testing effects explained the differences between groups. Regardless of the cause, three groups of student participants improved slightly– including the group that did not receive the treatment – so it is not likely that it was the treatment alone that helped the students to improve in their word problem solving abilities. However, some patterns emerged where students did improve, and these findings provide something to consider for students who are resistant to respond to traditional mathematics instruction.

Implications for SWD in Mathematics Instruction

Students with disabilities who received the intervention varied in their performance by individual test question from pretest to posttest. On some of the test questions, SWD showed improvement; on others, they showed decline. The researcher suggests that as a result of these outcomes, strategy instruction, specifically in this case the use of the K-N-W-S graphic organizer combined with video models with an avatar may not be the best strategy for all SWD for all types of word problems. The researcher implemented this strategy to help SWD who struggle with mathematics to move through the cognitive processes necessary to solve a word problem, outlined by Desoete and colleagues (2003): (1) Understand the text ("K," "N," and "W"); (2) construct a mathematical representation of the problem ("S"); (3) plan a solution ("W" and "S"), and implement a correct computational procedure ("S"). However, there were no positive changes across all students or across all word problems, and this may be due to the fact that every student is different, and thus has different needs, skills, knowledge, and abilities. Perhaps, as educators, we need to scaffold when, where, how, and with whom we use strategy instruction, especially in mathematics where there is a paucity of research. The strategy that a teacher selects may not work for every student, for every word problem, and for every construct in mathematics.

Implications for Students with ASD in Mathematics Instruction

These recommendations and potential implications are especially applicable for students with ASD, who are known as a highly heterogeneous group. Every student is different from one another, so it does not make sense to apply a blanket strategy for this population, or any population of SWD. Traditionally, as researchers and educators, when we observe SWD, including students with ASD, struggling academically, we believe the best course of action is to identify and apply a strategy for that specific skill. In mathematics, especially related to word problem solving, some of these approaches have included CSI and SBI. Both strategies are highly language based. Only two studies have focused on the effects of these strategies on students with ASD (e.g., Rockwell et al., 2011; Whitby, 2012); both studies employed single subject designs, and results were mixed, suggesting that these may not be the best approaches for all students who struggle to solve word problems and who already have deficits related to language and communication.

The intervention used in this study combined the use of graphic organizers with video modeling. The researcher believed that the union of these two practices, both of which are highly visual, and both of which have a solid base in the literature, would be a potentially viable way to help students with ASD to improve their word problem solving abilities. Graphic organizers have been used successfully with SWD across content areas (Dexter & Hughes, 2011), including reading (Gajria et al., 2007; Gill, 2008; Kim et al., 2004) and mathematics

(Friedland et al., 2011; Ives, 2007; Sheriff & Boon, 2014). Although there is a dearth of research on the use of graphic organizers for students with ASD, the belief was that this particular graphic organizer would appeal to the visual preferences of students with ASD, especially when combined with the video models used in the study, and would help them to organize, analyze, and plan a solution to a mathematical word problem.

However, although the intention was to implement a visual strategy, the researcher still used a large amount of language in the intervention package. Additionally, the K-N-W-S graphic organizer may not be a true visual strategy due to the amount of language students must read and write in order to complete all four sections. Furthermore, in the two 10-minute video models with the student avatar, the researcher did the majority of the speaking; this large amount of oral language may have been overwhelming for some of the students, especially the students with ASD. The researcher observed, on most occasions, that the three students with ASD (and other students as well) were not attending to the videos the whole time; they seemed to lose interest after approximately five minutes.

The researcher observed and noted the reactions of the students with ASD during the intervention phase. One student with ASD, "Joey" was highly resistant to using the K-N-W-S graphic organizer in both the daily word problems and the assessments; he told both the researcher and his teacher that he "didn't need to use it" because the problems were "easy." Another student, "Annie" commented that it "took too long." The third student, "Bobby," said it was "a waste of time." It is interesting to note that all three of the students with ASD had difficulty with or were resistant to using the K-N-W-S graphic organizer.

Summary of Findings

The results of the research showed clear variation across groups with regards to the use and effectiveness of the K-N-W-S graphic organizer. Overall, increases in mean scores were observed for SWD in the treatment group from pretest to posttest, SWD in the control group, and students without disabilities in the treatment group, but a decrease in mean scores for the students with ASD. Furthermore, item analyses revealed individual differences by group and by test question. While the SWD in the treatment group showed an overall pretest-posttest improvement when mean scores were compared, they declined in performance on several of the individual test questions. Similarly, the students with ASD showed mixed results. One student increased in her pretest-posttest scores, while the other two declined from pretest to posttest. When examining the individual test item analyses, the students with ASD also showed variation in performance, with no clear patterns emerging individually or as a group.

The treatment group teachers had mixed reactions to the intervention. One teacher said that she believed that graphic organizers could be beneficial for SWD, but only if they had been learning and practicing with them since kindergarten. She also noted that the students seemed to improve in their ability to use the graphic organizer throughout the nine days of intervention, but was not certain if it was helping them to solve word problems.

Limitations of the Study

Several limitations related to this study are discussed, including testing effects, other limitations related to the dependent measure, the intervention package, statistical analyses, and timing of the intervention in the treatment group classes. The limitations are embedded in the challenges of access to classrooms and students, changes in procedures in the district where the study took place that caused delays of several weeks, and other delays related to statewide testing and school holidays.

Students were assessed on the same pre-post assessment. This procedure was intentional, as the researcher was interested in examining differences from pretest to posttest on the exact same questions. Although the existence of a control group limits the possibility of a testing effect, it is still possible that students showed improvement on the posttest because of their familiarity with the questions. Originally, the researcher had intended to implement several short curriculum-based measures (CBMs), but was concerned about the time the students would be away from their other classes and subjects, as well as testing fatigue. In fact, many of the students struggled to complete the 10-question pretest/posttest, so further testing likely would not have been realistic or beneficial to the students or the researcher. In future studies, it might be best to test students with two or three questions at a time, once a week, and vary the actual phrasing and numbers used in the questions, but still maintain the same types of questions in order to measure the change over time. However, that type of study and measures come with their own set of limitations as well.

Limitations of the study also were related to the dependent measure. Although two experts in the field validated the pretest-posttest for content validity, it was not possible to assess the reliability of the instrument due to time constraints and difficulties related to obtaining students who could take and retake the test. However, the tool used is an authentic CBM, as it was designed to align with the curriculum; test questions were drawn directly from the curriculum currently being used in classrooms. Authentic classroom assessments are not always valid and reliable. Additionally, although the test was designed to be a measure of word problem solving ability, students must still be able to compute effectively; therefore, it is possible that while some students were able to identify a correct solution strategy, they failed to calculate correctly.

Another primary limitation of this study is 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 became too small for any statistical power. (See Table 7 in Chapter 4 for sample sizes.) Therefore, the results of the statistical analyses should be interpreted with caution. Further, the researcher knowingly took a chance of committing Type II errors by conducting several t-tests to answer Research Questions 1 and 2. Finally, given the small sample sizes, the researcher had to use non-parametric tests, which are not as powerful as parametric statistics.

Although the researcher prepared the teachers for the study in a 15-minute orientation session, fidelity checks were not conducted prior to the study to ensure that the intervention group teachers were trained to 100% fidelity on the implementation of the intervention. The researcher suggests that future studies incorporate this fidelity check to ensure that teachers are proficient in the instructional strategy.

The video models created for and used in this study may not have been effective for a number of reasons. Although video modeling is a strategy that is deemed an EBP for SWD, particularly students with ASD (Bellini & Akullian, 2007), there is a paucity of research 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. For example, two of the videos used in this study were 10 minutes in length and incorporated an extensive amount of verbal and written language. Throughout the intervention portion of this study, the researcher noticed that after approximately five minutes, many of the students, including students with and without disabilities, were no longer looking at the video that was playing on the SmartBoard. It appeared that after this period of time, many of the students were no longer paying attention to the videos. Using shorter videos or showing short segments and then practicing the skill could be investigated in future research.

The final limitation is related to timing issues. First, the intervention only lasted nine days, which is a very short time frame. However, it was necessary for the researcher to be sensitive to the time constraints of the teachers. Secondly, although the researcher began the research approval process in early December, extreme delays occurred in obtaining the necessary permissions and security clearance from the local school district. The entire approval process took more than four months; thus, the researcher was not able to begin data collection at School Two until mid-March, which was a month later than expected. Further complicating the completion of the intervention were two events during which time the researcher was unable to enter the classroom: spring break and state testing. These activities delayed the study's completion another two weeks, and as a result, there was a two-week difference in the timing of the study between School One and School Two. Another issue related to timing was the time during the day when the intervention took place. In School One, the intervention took place at 8:30 a.m., as soon as the school day began, whereas in School Two, the intervention took place at 11:00 a.m. after students had been in school for several hours. Unfortunately, due to the realities of applied classroom research, it was not possible to control for this variable, and there may have been some effects on student performance as a result. For example, at School One, there were a number of students who entered class late, and missed all or part of the video(s), and while the researcher had planned to replay the videos for any students who missed it, there was not enough class time to do so. This issue of lateness never occurred in School Two, because the study took place later in the morning. Finally, given the differences in timing, there is a possibility that the different classes were working on different chapters in their *Go Math!* curriculum, which could have impacted student knowledge of the content assessed in this study.

Aside from these limitations, it is possible to examine patterns in the data and consider the potential implications of these patterns. In the section that follows, the researcher discusses her recommendations for future studies, which emerged as a result of the findings in this study.

Recommendations for Future Studies

Four overarching themes related to future studies emerged from this research: (a) the need for specificity related to type of word problem, disability category, and strategy; (b) research design; (c) instrumentation; and (d) timing. Recommendations for future studies will be discussed further in this section.

Considering the variability in student performance by test question, it might be beneficial that when designing future studies to utilize and assess very specific types of word problems. This analyses specifically related to students with ASD should focus on either only one or two types of word problems or problems that are identical in nature but with different “stories” and different numbers. Perhaps what is needed in the field is a deeper dive into the literacy skills and mathematical reasoning required for word problems, while simultaneously reflecting upon the complex nature and variety of skills and abilities students with ASD possess, to try and determine a pattern to the struggles and approaches for students in this population in word problems in mathematics. Future tools such as functional magnetic resonance imaging (fMRI) could begin to help educators understand the complexities of learning and potential patterns across or within the population of students with ASD as they learn mathematics.

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.

Given that the researcher had difficulty separating a student's computational ability from his or her word problem solving ability; that is, the ability to understand what the question is asking versus the ability to effectively calculate an answer, future researchers might focus on the creation of an instrument that measures both. One potentially viable way to assess these differences may be to use observations and a detailed rubric from the literature to filter out these differences between computational versus word problem solving difficulties (or, conceptual knowledge versus procedural knowledge). Furthermore, a mixed methods study that incorporates structured interviews with students is another viable method for addressing the issue of student mathematical knowledge and skills, as well as with the customization of interventions. These interviews could be tailored to meet the distinct needs of students with ASD by including checklists or other visuals for students to indicate mathematical thinking processes and preferences.

Due to time constraints and the realities of classroom research, this intervention was designed to be short, and to take the least amount of time away from the classroom teachers and their daily schedules. The researcher recommends that future studies should include a longer intervention phase and a maintenance probe, or multiple approaches to the length of intervention to determine the time needed for the greatest response to an intervention.

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. This research might include various TeachLivE™ student avatars and an investigation as to how students respond to each avatar. 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.

Conclusions

Simply put, students with ASD and all students, including SWD, have the right to access teachers and content at the highest level in mathematics, while the field continues to ensure individualized needs are met in inclusive settings. Inclusion is a civil right. *All* students, regardless of ability or disability, have the right to access the same standards and curriculum in the least restrictive environment. The inclusive education movement has been trending in the direction of more SWD being included in the general education classroom. Yet, without further in-depth research, especially in the area of mathematics, the field may not be meeting the individual and collective needs of SWD. Yes, SWD are being included more frequently, but are their needs being met if they are still so far behind their peers? Are all students prepared for college and careers if only 8% of eighth grade SWD are performing at the proficient or advanced level in mathematics as they enter high school, as compared to 39% of their peers (U.S. Department of Education, 2014)? And how will the most recent mathematics standards, which are more focused on acquisition of conceptual knowledge, further affect the performance of this population of students? The outcomes of this shift in mathematics standards have yet to be realized for SWD, and in many cases, for students in general education.

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 that 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.

APPENDIX A:
KNWS GRAPHIC ORGANIZER

K What do I KNOW from the information stated in this problem?	N What information do I NOT need in order to solve this problem?	W WHAT exactly does this problem ask me to find?	S What STRATEGY or operation will I use to solve this problem?

(Barton & Heidema, 2000)

APPENDIX B:
STUDY PROTOCOL

PRE-INTERVENTION PHASE			
	RESEARCHER	***INTERVENTION GROUP TEACHERS***	***CONTROL GROUP TEACHERS***
Prior to intervention	❒ Provide all teachers in treatment condition with: 1. Copies of K-N-W-S graphic organizer 2. Copies of pretest 3. Copy of Protocol and Scripted Lesson 4. Copies of daily word problems ❒ Collect grade level and disability information for each student in all classes (treatment and control) ❒ De-identify students with coding system ❒ Provide all teachers in control condition with: 1. Copies of pretest	❒ Provide researcher with student diagnoses ❒ For the lesson, make sure you have a copy for each student: 1. Pretest 2. K-N-W-S graphic organizer 3. Daily word problems **Researcher will provide you with copies of all the materials ** ❒ Be prepared to give the following to the researcher at the end of the first lesson: 1. Pretest	❒ For the lesson, make sure you have a copy of pretest for each student

INTERVENTION PHASE			
	RESEARCHER	***INTERVENTION GROUP TEACHERS***	***CONTROL GROUP TEACHERS***
Day One	❒ Collects pretests ❒ Codes pretests	❒ Provide an introduction to the pretest (follow script) ❒ Administer pretest ❒ Ensure proper testing accommodations	❒ Provide an introduction to the pretest (follow script) ❒ Administer pretest ❒ Ensure proper testing accommodations

	RESEARCHER	*INTERVENTION GROUP TEACHERS*	*CONTROL GROUP TEACHERS*
Day Two	❒ Plays Video One of herself teaching "K" and "N" in a lesson to avatar Sean ❒ Observes students during independent work ❒ Collects student work ❒ If any students are not in the room during the recorded lesson, researcher will replay the video ❒ Replay video for any students who request it	❒ Provide an introduction to the lesson (follow script) ❒ Explain that students will practice the strategy with two word problems after watching video (follow script) ❒ Ensure that all students have a copy of the K-N-W-S ❒ Circulate classroom and answer all student questions ❒ Maintain typical classroom routines ❒ Provide students with extra time to complete work ❒ Encourage students to "show their thinking" ❒ Attend to non-responders ❒ Answer all questions from students ❒ Provide corrective feedback to students ❒ Ensure that students are utilizing the K-N-W-S	

	RESEARCHER	***INTERVENTION GROUP TEACHERS***	***CONTROL GROUP TEACHERS***
Day Three	❒ Plays Video Two of herself teaching "W" and "S" in a lesson to avatar Sean ❒ Observes students during independent work ❒ Collects observational field notes ❒ Collects student work ❒ If any students are not in the room during the recorded lesson, researcher will replay the video ❒ Replay video for any students who request it	❒ Provide an introduction to the lesson (follow script) ❒ Explain that students will practice the strategy with two word problems after watching video (follow script) ❒ Ensure that all students have a copy of the K-N-W-S ❒ Circulate classroom and answer all student questions ❒ Provide students with extra time to complete work ❒ Encourage students to "show their thinking" ❒ Attend to non-responders ❒ Answer all questions from students ❒ Provide corrective feedback to students ❒ Ensure that students are utilizing the K-N-W-S ❒ Maintain typical classroom routines	

	RESEARCHER	***INTERVENTION GROUP TEACHERS***	***CONTROL GROUP TEACHERS***
Day Four	❒ Plays 2-minute "refresher" video ❒ Observes students during independent work ❒ Collects student work ❒ Collects observational field notes ❒ If any students are not in the room during the recorded lesson, researcher will replay the video ❒ Replay any of the video(s) for any students who request it	❒ Provide an introduction to the lesson (follow script) ❒ Explain that students will practice the strategy with two word problems after watching video (follow script) ❒ Ensure that all students have a copy of the K-N-W-S ❒ Circulate classroom and answer all student questions ❒ Provide students with extra time to complete work ❒ Encourage students to "show their thinking" ❒ Attend to non-responders ❒ Provide corrective feedback to students ❒ Ensure that students are utilizing the K-N-W-S ❒ Maintain typical classroom routines ❒ Ensure that students are utilizing the K-N-W-S to help them solve word problems	

	RESEARCHER	*INTERVENTION GROUP TEACHERS*	*CONTROL GROUP TEACHERS*
Day Five	❒ Plays 2-minute "refresher" video ❒ Observes students during independent work ❒ Collects observational field notes ❒ Collects student work ❒ If any students are not in the room during the recorded lesson, researcher will replay the video ❒ Replay any of the video(s) for any students who request it	❒ Provide an introduction to the lesson (follow script) ❒ Explain that students will practice the strategy with two word problems after watching video (follow script) ❒ Ensure that all students have a copy of the K-N-W-S ❒ Circulate classroom and answer all student questions ❒ Provide students with extra time to complete work ❒ Encourage students to "show their thinking" ❒ Attend to non-responders ❒ Provide corrective feedback to students ❒ Ensure that students are utilizing the K-N-W-S to help them solve word problems ❒ Maintain typical classroom routines ❒ Ensure that students are utilizing the K-N-W-S to help them solve word problems	

	RESEARCHER	***INTERVENTION GROUP TEACHERS***	***CONTROL GROUP TEACHERS***
Day Six	❒ Replays Video One of herself teaching "K" and "N" in a lesson to avatar Sean ❒ Observes students during independent work ❒ Collects student work ❒ Collects observational field notes ❒ If any students are not in the room during the recorded lesson, researcher will replay the video ❒ Replay video for any students who request it	❒ Provide an introduction to the lesson (follow script) ❒ Explain that students will practice the strategy with two word problems after watching video (follow script) ❒ Ensure that all students have a copy of the K-N-W-S ❒ Circulate classroom and answer all student questions ❒ Provide students with extra time to complete work ❒ Encourage students to "show their thinking" ❒ Attend to non-responders ❒ Provide corrective feedback to students ❒ Ensure that students are utilizing the K-N-W-S to help them solve word problems ❒ Maintain typical classroom routines ❒ Ensure that students are utilizing the K-N-W-S to help them solve word problems ❒ Maintain typical classroom routines ❒ Encourage students to "show their thinking"	

	RESEARCHER	***INTERVENTION GROUP TEACHERS***	***CONTROL GROUP TEACHERS***
Day Seven	❒ Replays Video Two of herself teaching "W" and "S" in a lesson to avatar Sean ❒ Observes students during independent work ❒ Collects observational field notes ❒ Collects student work ❒ If any students are not in the room during the recorded lesson, researcher will replay the video ❒ Replays video for any students who request it	❒ Provide an introduction to the lesson (follow script) ❒ Explain that students will practice the strategy with two word problems after watching video (follow script) ❒ Ensure that all students have a copy of the | K-N-W-S ❒ Circulate classroom and answer all student questions ❒ Provide corrective feedback to students ❒ Attend to non-responders ❒ Maintain typical classroom routines ❒ Provide students who request it with extra time to complete independent work ❒ Ensure that students are utilizing K-N-W-S to help them solve word problems ❒ Encourage students to "show their thinking" when completing daily word problems |	

	RESEARCHER	***INTERVENTION GROUP TEACHERS***	***CONTROL GROUP TEACHERS***
Day Eight	❒ Replays 2 minute "refresher" ❒ Observes students ❒ Collects observational field notes ❒ Collects student work ❒ If any students are not in the room during the recorded lesson, researcher will replay the video ❒ Replays any videos for student(s) who request it.	❒ Provide an introduction to the lesson (follow script) ❒ Explain that students will practice the strategy with two word problems after watching video (follow script) ❒ Ensure that all students have a copy of the K-N-W-S ❒ Circulate classroom and answer questions ❒ Provide students with extra time to complete work ❒ Encourage students to "show their thinking" ❒ Attend to non-responders ❒ Provide corrective feedback ❒ Ensure that students are utilizing the K-N-W-S ❒ Maintain typical classroom routines	

	RESEARCHER	***INTERVENTION GROUP TEACHERS***	***CONTROL GROUP TEACHERS***
Day Nine	❒ Replays 2 minute “refresher” video ❒ Observes students ❒ Collects observational field notes ❒ Collects student work ❒ If any students are not in the room during the recorded lesson, researcher will replay the video ❒ Replays any videos for student(s) who request it.	❒ Provide an introduction to the lesson (follow script) ❒ Explain that students will practice the strategy with two word problems after watching video (follow script) ❒ Ensure that all students have a copy of the K-N-W-S ❒ Circulate classroom and answer all student questions ❒ Provide students with extra time to complete work ❒ Encourage students to “show their thinking” ❒ Attend to non-responders ❒ Provide corrective feedback ❒ Ensure that students are utilizing the K-N-W-S to help them solve word problems ❒ Maintain typical classroom routines ❒ Encourage students to “show their thinking”	

	RESEARCHER	***INTERVENTION GROUP TEACHERS***	***CONTROL GROUP TEACHERS***
Day Ten	❒ Replays 2 minute "refresher" video ❒ Observes students ❒ Collects observational field notes ❒ Collects student work ❒ If any students are not in the room during the recorded lesson, researcher will replay the video ❒ Replays any videos for student(s) who request it.	❒ Provide an introduction to the lesson (follow script) ❒ Explain that students will practice the strategy with two word problems after watching video (follow script) ❒ Ensure that all students have a copy of the K-N-W-S ❒ Circulate classroom and answer all student questions ❒ Provide students with extra time to complete work ❒ Encourage students to "show their thinking" ❒ Attend to non-responders ❒ Provide corrective feedback ❒ Ensure that students are utilizing the K-N-W-S to help them solve word problems ❒ Maintain typical classroom routines ❒ Provide students with extra time to complete work	

	RESEARCHER	*INTERVENTION GROUP TEACHERS*	*CONTROL GROUP TEACHERS*
Day Eleven	❒ No intervention ❒ Observes students during independent work ❒ Collects observational field notes ❒ Collects student work	❒ Provide an introduction to the lesson (follow script) ❒ Ensure that all students have a copy of the K-N-W-S ❒ Circulate classroom and answer all questions from students ❒ Ensure that students are utilizing K-N-W-S to help them solve word problems ❒ Encourage students to "show their thinking"	
Day Twelve	❒ No intervention ❒ Observes students during independent work ❒ Collects observational field notes ❒ Collects student work	❒ Provide an introduction to the lesson (follow script) ❒ Ensure that all students have a copy of the K-N-W-S ❒ Circulate classroom and answer all questions from students ❒ Ensure that students are utilizing K-N-W-S to help them solve word problems ❒ Encourage students to "show their thinking"	

	RESEARCHER	*INTERVENTION GROUP TEACHERS*	*CONTROL GROUP TEACHERS*
Day Thirteen	❒ No intervention ❒ Observes students during independent work ❒ Collects observational field notes ❒ Collects student work	❒ Provide an introduction to the lesson (follow script) ❒ Ensure that all students have a copy of the K-N-W-S ❒ Circulate classroom and answer all questions from students ❒ Ensure that students are utilizing K-N-W-S to help them solve word problems ❒ Encourage students to "show their thinking"	
Day Fourteen	❒ No intervention ❒ Collects observational field notes ❒ Observes students during independent work ❒ Collects student work ❒ Administers social validity questionnaire (IRP-15) to teachers	❒ Provide an introduction to the lesson (follow script) ❒ Ensure that all students have a copy of the K-N-W-S ❒ Circulate classroom and answer all questions ❒ Ensure that students are utilizing K-N-W-S ❒ Encourage students to "show their thinking" ❒ Complete questionnaire	

	RESEARCHER	*INTERVENTION GROUP TEACHERS*	*CONTROL GROUP TEACHERS*
Day Fifteen	❒ Administers social validity questionnaire (IRP-15) to teachers ❒ Observes students in intervention group during posttest ❒ Collects observational field notes ❒ Collects posttests	❒ Administer posttest ❒ Ensure proper testing accommodations ❒ Complete questionnaire	❒ Administer Posttest ❒ Ensure proper testing accommodations

.

APPENDIX C:
SCRIPTED DAILY LESSONS

DAY ONE

Teacher: "Today we are going to begin a two week project during math class. In this project, we will begin using a new strategy for solving word problems in math. We will be using something called a graphic organizer. You have probably used graphic organizers to help you with reading and writing, but maybe not with math. Since we have to do some reading when we are working on word problems in math, we are going to use this graphic organizer to help us read through, make sense of, and then solve word problems in math.

Each day we will learn a different part of the graphic organizer, and there are four parts. The really fun part is that Mrs. Delisio is going to show you how she teaches this graphic organizer to our special friend named Sean to help him to solve word problems in math.

Today, we will start out by seeing what you know about how to solve word problems in math. Mrs. Delisio, a researcher from UCF, will be observing our class to see what strategies you already know and use to help you solve word problems. Mrs. Delisio is doing a scientific experiment. She is studying how students use this graphic organizer strategy.

The first thing we will do in this experiment is to take a quick pretest to see what you already know about solving word problems in math. I will give you the pretest and just ask that you do your best. If you can't figure out a problem, it is OK to leave it blank. This pretest will not count towards your grade in math or in this class – it is just to see what you know.

DAY TWO

Teacher: "Remember that we are working on a project in math class. Mrs. Delisio and our friend Sean will teach us how to use a tool to help us solve word problems in math. Your job is to pay attention to the video when Mrs. Delisio explains the first two parts of the graphic organizer today."

Researcher plays pre-recorded video of herself teaching the "K" and "N" to avatar Sean.

Teacher: Passes out first 2 daily math probes, and says, "Now you will practice the strategy with these two word problems. You will read the problem, and then ***only complete the first two columns***, the 'K' and the 'N' on the graphic organizer. Does anyone have any questions?"

Students practice using the K-N-W-S independently with two word problems.

DURING INDEPENDENT WORK:

Researcher observes, takes notes, and replays videos for any students who request it.

Teacher answers all questions from students, maintains normal classroom routines.

DAY THREE

Teacher: "Remember that we are working on a project in math class. Mrs. Delisio and our friend Sean will continue to teach us how to use a tool to help us solve word problems in math. Your job is to pay attention to the video when Mrs. Delisio explains the last two parts of the graphic organizer today."

Researcher plays pre-recorded video of herself teaching the "W" and "S" to avatar Sean.

Teacher: Passes out first 2 daily math probes, and says, "Now you will practice the strategy with these two word problems. Today you will use all four parts of the K-N-W-S to help you complete these two word problems. Please try to show your thinking when you're working on the word problems. Does anyone have any questions?"

Students practice using the K-N-W-S independently with two word problems.

DURING INDEPENDENT WORK:

Researcher observes, takes notes, and replays videos for any students who request it.

Teacher answers all questions from students and maintains normal classroom routines.

DAY FOUR

Teacher: "Remember that we are working on a project in math class. Mrs. Delisio and Sean have taught us how to use tool to help us solve word problems in math. Today, we are going to practice using this graphic organizer tool to help us solve two math word problems. First, Mrs. Delisio is going to play a short video to remind you what to do, and then you are going to practice all four steps of the graphic organizer – the K, N, W, and S – with two more word problems.

Researcher plays 2-minute "refresher" video with avatar Sean.

Teacher: Passes out daily math probes, and says, "Now you will practice the strategy with these two word problems. Today you will use all four parts of the K-N-W-S to help you complete these two word problems. Please try to show your thinking when you're working on the word problems. Does anyone have any questions?"

Students practice using the K-N-W-S independently with two word problems.

DURING INDEPENDENT WORK:

Researcher observes, takes notes, and replays videos for any students who request it.

Teacher answers all questions from students and maintains normal classroom routines.

DAY FIVE

Teacher: "Remember that we are working on a project in math class. Mrs. Delisio and Sean have taught us how to use tool to help us solve word problems in math. Today, we are going to practice using this graphic organizer tool to help us solve two math word problems. First, Mrs. Delisio is going to play a short video to remind us what to do, and then you are going to practice all four steps of the graphic organizer – the K, N, W, and S – with two more word problems.

Researcher plays 2-minute "reminder" video with avatar Sean.

Teacher: Passes out daily math probes, and says, "Now you will practice the strategy with these two word problems. Today you will use all four parts of the K-N-W-S to help you complete these two word problems. Please try to show your thinking when you're working on the word problems. Does anyone have any questions?"

Students practice using the K-N-W-S independently with two word problems.

DURING INDEPENDENT WORK:

Researcher observes, takes notes, and replays videos for any students who request it.

Teacher answers all questions from students and maintains normal classroom routines.

DAY SIX

Teacher: "Remember that we are working on a project in math class. Mrs. Delisio and Sean have taught us how to use tool to help us solve word problems in math. First, Mrs. Delisio is going to play the first video again, and then you are going to practice the K, and the N – with two more word problems.

Researcher plays pre-recorded video of herself teaching the "K" and "N" to avatar Sean.

Teacher: Passes out daily math probes, and says, "Now you will practice the strategy with these two word problems. Today you are only completing the first two columns, the 'K' and the 'N.'

Please try to show your thinking when you're working on the word problems. Does anyone have any questions?"

Students practice using the K-N-W-S independently with two word problems.

DURING INDEPENDENT WORK:

Researcher observes, takes notes, and replays videos for any students who request it.

Teacher answers all questions from students and maintains normal classroom routines.

DAY SEVEN

Teacher: "Remember that we are working on a project in math class. Mrs. Delisio and Sean have taught us how to use tool to help us solve word problems in math. First, Mrs. Delisio is going to play the second video again, and then you are going to practice all four steps of the graphic organizer – the K, N, W, and S – with two more word problems.

Researcher plays pre-recorded video of herself teaching the "W" and "S" to avatar Sean.

Teacher: Passes out daily math probes, and says, "Now you will practice the strategy with these two word problems. Today you will use all four parts of the K-N-W-S to help you complete these two word problems. Please try to show your thinking when you're working on the word problems. Does anyone have any questions?"

Students practice using the K-N-W-S independently with two word problems.

DURING INDEPENDENT WORK:

Researcher observes, takes notes, and replays videos for any students who request it.

Teacher answers all questions from students and maintains normal classroom routines.

DAY EIGHT

Teacher: "Remember that we are working on a project in math class. Mrs. Delisio and Sean have taught us how to use tool to help us solve word problems in math. First, Mrs. Delisio is going to play a short video to remind us what to do, and then you are going to practice all four steps of the graphic organizer – the K, N, W, and S – with two more word problems.

Researcher plays 2-minute "refresher" video with avatar Sean.

Teacher: Passes out daily math probes, and says, "Now you will practice the strategy with these two word problems. Today you will use all four parts of the K-N-W-S to help you complete these two word problems. Please try to show your thinking when you're working on the word problems. Does anyone have any questions?"

Students practice using the K-N-W-S independently with two word problems.

DURING INDEPENDENT WORK:

Researcher observes, takes notes, and replays videos for any students who request it.

Teacher answers all questions from students and maintains normal classroom routines.

DAY NINE

Teacher: "Remember that we are working on a project in math class. Mrs. Delisio and Sean have taught us how to use tool to help us solve word problems in math. First, Mrs. Delisio is going to play a short video to remind us what to do, and then you are going to practice all four steps of the graphic organizer – the K, N, W, and S – with two more word problems.

Researcher plays 2-minute "refresher" video with avatar Sean.

Teacher: Passes out daily math probes, and says, "Now you will practice the strategy with these two word problems. Today you will use all four parts of the K-N-W-S to help you complete these two word problems. Please try to show your thinking when you're working on the word problems. Does anyone have any questions?"

Students practice using the K-N-W-S independently with two word problems.

DURING INDEPENDENT WORK:

Researcher observes, takes notes, and replays videos for any students who request it.

Teacher answers all questions from students and maintains normal classroom routines.

DAY TEN

Teacher: "Remember that we are working on a project in math class. Mrs. Delisio and Sean have taught us how to use tool to help us solve word problems in math. First, Mrs. Delisio is going to play a short video to remind us what to do, and then you are going to practice all four steps of the graphic organizer – the K, N, W, and S – with two more word problems.

Researcher plays 2-minute "refresher" video with avatar Sean.

Teacher: Passes out daily math probes, and says, "Now you will practice the strategy with these two word problems. Today you will use all four parts of the K-N-W-S to help you complete these two word problems. Please try to show your thinking when you're working on the word problems. Does anyone have any questions?"

Students practice using the K-N-W-S independently with two word problems.

DURING INDEPENDENT WORK:

Researcher observes, takes notes, and replays videos for any students who request it.

Teacher answers all questions from students and maintains normal classroom routines.

DAY ELEVEN

Teacher: "Remember that we are working on a project in math class. You have watched some videos of Mrs. Delisio teaching the K-N-W-S graphic organizer to Sean. Today you are not going to watch the videos; instead, you will just practice all four steps of the graphic organizer – the K, N, W, and S – with two more word problems. Please try to show your thinking when you're working on the word problems.

Students practice using the K-N-W-S independently with two word problems.

DURING INDEPENDENT WORK:

Researcher observes, takes notes, and replays videos for any students who request it.

Teacher answers all questions from students and maintains normal classroom routines.

DAY TWELVE

Teacher: “Remember that we are working on a project in math class. You have watched some videos of Mrs. Delisio teaching the K-N-W-S graphic organizer to Sean. Today you are not going to watch the videos; instead, you will just practice all four steps of the graphic organizer – the K, N, W, and S – with two more word problems. Please try to show your thinking when you’re working on the word problems.

Students practice using the K-N-W-S independently with two word problems.

DURING INDEPENDENT WORK:

Researcher observes, takes notes, and replays videos for any students who request it.

Teacher answers all questions from students and maintains normal classroom routines.

DAY THIRTEEN

Teacher: “Remember that we are working on a project in math class. You have watched some videos of Mrs. Delisio teaching the K-N-W-S graphic organizer to Sean. Today you are not going to watch the videos; instead, you will just practice all four steps of the graphic organizer – the K, N, W, and S – with two more word problems. Please try to show your thinking when you’re working on the word problems.

Students practice using the K-N-W-S independently with two word problems.

DURING INDEPENDENT WORK:

Researcher observes, takes notes, and replays videos for any students who request it.

Teacher answers all questions from students and maintains normal classroom routines.

DAY FOURTEEN

Teacher: "Remember that we are working on a project in math class. You have watched some videos of Mrs. Delisio teaching the K-N-W-S graphic organizer to Sean. Today you are not going to watch the videos; instead, you will just practice all four steps of the graphic organizer – the K, N, W, and S – with two more word problems. Please try to show your thinking when you're working on the word problems.

Students practice using the K-N-W-S independently with two word problems.

DURING INDEPENDENT WORK:

Researcher observes, takes notes, and replays videos for any students who request it.

Teacher answers all questions from students and maintains normal classroom routines.

DAY FIFTEEN

Teacher: "Today you will be taking a quick assessment to see what you have learned about using this tool to help you solve word problems in math. I will give you the assessment and just ask that you do your best. If you can't figure out a problem, it is OK to leave it blank. This assessment will not count towards your grade in math or in this class – it is just to see what you know."

APPENDIX D:
VIDEO LESSON SCRIPTS

VIDEO ONE

Lauren: *(Faces camera)* Hi! I am Mrs. Delisio and I am here with my friend Sean, who is a 12-year old boy in the 7th grade. Your teacher has already explained to you that we are going to be learning a strategy to help us to solve word problems in math. For the next few minutes, I'm going to teach Sean how to use the first two parts of this graphic organizer to help him with some word problems in math. I want all of you to watch, and do your absolute best to pay attention to what I am teaching Sean, because afterwards, you are going to use this graphic organizer to help you with some word problems. *(Lauren turns to face Sean.)*

Lauren: So, Sean, have you ever used a graphic organizer before, maybe in reading, or writing?

Sean responds that he has, and gives an example of how he has used a graphic organizer.

Lauren: Thanks for that example, Sean. I'm glad you're familiar with graphic organizers. I actually use them all the time – I used them as a teacher, to help my students, and I have also used them to help me with my own schoolwork. Many students use graphic organizers during reading and writing, to help them organize thoughts or ideas. But today, we are going to use a graphic organizer to help us solve some word problems in math. This graphic organizer is going to help us make sense of all of the information in the word problem so that we can figure out what to do and how to solve it. How does that sound, Sean?

Sean: Replies positively (i.e. "Sounds great!")

Lauren: Today we are only going to learn about the first two columns. Sean, can you please look down at the paper on your desk? And class, (*turns to camera*) if you could also do the same – look at the paper you have on your desk. Today we are ONLY going to be learning about the first two columns. These columns have a "K" and an "N" at the top. The "K" stands for "What do I KNOW from the information stated in this problem?" The purpose of this question is to help you to figure out what information you already know from reading the problem, and how you can use that information to help you solve the problem. *(Lauren points to column on graphic organizer.)*

Now let's look at the second column, the "N" column. This column asks you "What information do I NOT need in order to solve this problem?" *(Lauren points to column on graphic organizer).* Sometimes, the people who write word problems add in parts that you don't need to solve the problem. This part of the graphic organizer will help you to figure out what those "not-needed" parts are. Those not-needed parts can trick you, so it's important to try and get rid of them so you don't get tricked! Sean, have you ever had trouble solving a tricky word problem?

Sean responds that he has; gives an example or elaborates, indicating that he feels that some word problems can be tricky and it helps to have a strategy or tool to help you.

Lauren: Thanks Sean – I agree that when you are trying to solve a tricky word problem in math, it is super helpful to have a strategy or tool – and that is exactly what this graphic organizer is. Sean, I am going to show you how I would use the graphic organizer to help me with a word problem, and then we will do one together. How does that sound?

Sean responds positively.

"I DO" – Direct Modeling

Lauren: OK Sean, lets look at the first word problem. It says "Fiona has 5 containers with 24 crayons in each, 6 boxes of markers with 15 markers in each box, and 2 boxes of glue sticks with 3 glue sticks in each box. How many crayons and markers does Fiona have?" OK Sean, this sounds like it might be a tricky one, so I am going to use our graphic organizer to help us. The first column asks me, "What do I KNOW?" Hmm… well, I know that first, Fiona has 5 containers – or boxes—of crayons. I know that there are 24 crayons in each box. *(Lauren writes "5 boxes, 24 crayons in each box" in K column)*. OK but wait, I'm not done here… there's more that I know. I also know that Fiona has 6 boxes of markers, and she has 15 markers in each box. (*Lauren writes "6 boxes, 15 markers in each box" in K column*). I know Fiona also has 2 boxes of glue sticks with 3 glue sticks in each box. (*Lauren writes "2 boxes, 3 glues sticks in each box" in K column*). Finally, I know that the problem is asking me to find out how many crayons and markers Fiona has left. (Lauren writes *"How many crayons and markers?" in K column).*

OK. I think that's it for what I know. Now, I will look at my second column. What information do I NOT NEED? Hmm. So I have to decide if there is any information in this word problem that is not important – any information that will NOT help me to solve the word problem. Let me reread. (*Lauren rereads word problem).* Hmm… the question asks me about crayons and markers ONLY – not glue sticks – so I don't think I need this information about how many glue sticks she has. So, I am going to cross that out in the K column, and move it over to the N column. This is NOT information I need to solve the problem and it's probably just there to trick me! *(Lauren crosses out in K column, and writes "2 boxes, 3 glue sticks in each" in N column).* Sean, did you see what I did? I read the problem a few times to figure out what information I KNOW and what information I do NOT NEED to help me solve this word problem.

Sean responds positively and repeats what Lauren said (read problem, figured out what she knew and what information was not important to solving the problem).

"WE DO" – Guided Practice

Lauren:
Sean, now we will try a word problem together. Remember we will be asking ourselves "What do we already KNOW?" and "What information do we NOT NEED?"

Let's look at another word problem together. This one says: "Tim is taking 5 of his friends to see a movie. At the movie theater, one section of seats has 8 rows with 12 seats in each row. In the center of the first 5 rows are 4 broken seats that cannot be used. How many seats can be used in the section?"

OK Sean, I'll get us started with the K column – what do we know? Well, we know Tim and his 5 friends – that's 6 people -- are going to the movies. *(Lauren writes "6 people going to movies" in K column).* Sean, what else do we know from reading the word problem?

Sean: We know there is a section of seats that has 8 rows. We know that each row has 12 seats.

Lauren: Great! I agree. Let's add that to the K column. (*Lauren writes "8 rows, 12 seats each row" in K column)*. What else do we know about that section of the movie theater, Sean?"

Sean: We know that some of the seats are broken—the first 5 rows had 4 broken seats.

Lauren: Thanks! Sean, is that 4 TOTAL broken seats, or 4 broken seats in EACH of the 5 rows?

Sean: *(Unsure, reads problem again*). Hmm, it wouldn't make sense if it was just 4 broken seats, because they wouldn't have said it was in 5 rows… so I think it's 4 broken seats in each of the 5 rows.

Lauren: Great job – I totally agree that it makes much more sense that it is 4 broken seats in each of the 5 rows. Sean, did you see why it's important to be really specific?

Sean: Yes – 4 total broken seats is a lot different than 4 broken seats in each of 5 rows.

Lauren: I agree. Great job figuring out the information we know from the problem, Sean! I'll add that information now. *(Lauren writes "4 broken seats in each of 5 rows").* Is there anything else?

Sean: Yes – we know that the problem is asking us how many seats can be used.

Lauren: I agree. So the problem is asking us how many seats are not broken. I'll add that. *(Lauren writes: "find out how many seats can be used -- are NOT broken.")*

Sean, what about the "N" column – what information do we NOT NEED??
I am wondering if we need the information about Tim and his 5 friends. What do you think? Is that information about 6 people going to the movies important? Do we need it to help us solve this word problem?

Sean: No, because the problem doesn't ask us about the people, it asks us about the seats.

Lauren: I agree! We should cross that out in the K column (*Crosses out in K column, then writes "Tim and 5 friends" in N column*).

Lauren: Well, Sean, we are finished for today. Thank you so much for your great work today, and for helping me teach this graphic organizer to some friends.

Sean: You're welcome!

Lauren: (*Turns to face camera*) "Class, today you watched me teach Sean about how to use the first two columns of this graphic organizer to help organize the important and NOT important information in a word problem. Now you will practice this exact same strategy on your own. **(VIDEO ENDS)**

VIDEO TWO

Lauren: *(Faces camera)*
Hello class! I am here again with our friend, Sean. In the last video, you watched me teach Sean about the first two columns in our graphic organizer, the "K" column and the "N" column. Remember? The "K" stands for "What do you KNOW?" and the N stands for "What information do I NOT need in order to solve this problem?"

For the next few minutes, I'm going to teach Sean how to use the last two parts of this graphic organizer to help him to solve word problems in math, and I want you to watch and do your absolute best to pay attention to what I am teaching Sean, because afterwards, you are going to use this graphic organizer to help you with some word problems. Remember, the reason we use a graphic organizer is to help us make sense of all of the information in the word problem so that we can figure out what to do and how to solve it. Sometimes word problems are tricky, and it helps to have a strategy or tool to help you. *(Lauren turns to face Sean.)*

Hi again Sean, how are you today?

Sean: Great!

Lauren: That is great to hear. Sean, can you tell what we did last time with this graphic organizer?

Sean responds yes, and repeats what he did in previous video.

Lauren: That's a great summary of what you learned Sean! Now, please look down at the paper on your desk? And class, (*turns to camera*) I would like you to do the same – look at the paper you have on your desk. Today I am going to teach you how to use the last two columns, the "W" column and the "S" column. The "W" column asks you "WHAT exactly does this problem ask me to find?" The purpose of this question is to help you to restate in your own words what the question is asking you to do. *(Lauren points to column on graphic organizer.)*

The S" column asks you, "What STRATEGY or operation will I use to solve this problem?" Now that you know what information in the problem is important, what information you do not need, and what the problem is asking you to do, now its time to figure out WHAT to do. HOW are you going to solve this problem? *(Lauren points to column on graphic organizer.)*

So, Sean, today I am going to show you how I would use the last two columns of the graphic organizer to help me to SOLVE the word problem, and then we will do one together. How does that sound?

Sean responds positively.

"I DO" – Direct Modeling

Lauren: OK Sean, lets look back at the first word problem from yesterday. It says "Fiona has 5 containers with 24 crayons in each, 6 boxes of markers with 15 markers in each box, and 2 boxes of glue sticks with 3 glue sticks in each box. How many crayons and markers does Fiona have left?"

I have already filled out the first two columns – let's read what I wrote:

In the K column I wrote:
5 boxes, 24 crayons in each box
6 boxes, 15 crayons in each box
How many crayons and markers?

In the N column I wrote
2 boxes, 3 glue sticks in each

Sean, remember that at first, I thought the information about the glue sticks belonged in the K column, but then after rereading it, I realized that that information wasn't important?

Sean responds positively and repeats what Lauren did.

Lauren: Now I will fill out the last two columns. OK, the W column asks me "WHAT exactly does this problem ask me to find?" Hmm… well it is asking me to find out how many total crayons AND markers Fiona has. OK, so that's what I will write. *(Lauren writes "how many crayons and markers?" in W column).*

The last column asks me "What STRATEGY or operation will I use to solve this problem?" OK, let me think, and look back at what I know. I know she has 5 boxes full of 24 crayons and 6 boxes of 15 markers. So first I have to find out how many crayons she has. To find out how many crayons she has, I will multiply 5 times 24 because she has 5 boxes and there are 24 in each *(Lauren writes: STEP ONE: 5 x 24 on board).* Then I have to find out how many markers she has. To find out how many markers she has, I will also multiply – this time its 6 x15.

(*Lauren writes: STEP TWO: 6x15).* OK, so 5x24 is 120, and 6 x15 is 90. But, I am not done-- the problem is asking me how many crayons AND markers Fiona had – so I have to add 110 crayons to 90 markers (Lauren writes: STEP THREE: 120+90=210) So, my answer is 210. *(Circles 210).* Phew, that was a tricky one – there were a lot of steps! It was a good thing I had my graphic organizer to help me to keep track of all that information.

Sean, did you see what I did?

Sean: Yes! (Sean repeats what I did, e.g., used the last 2 columns to figure out what problem is asking me to do, and what strategy to use).

WE DO – Guided Practice

Lauren: OK Sean, lets do one together. Remember the problem we worked on yesterday together? The one about Tim and his friends going to the movies?

Sean: Yes. The one with the broken seats.

Lauren: Great – that's the one – let's finish that problem today by using the last two columns of the graphic organizer to help us.

Remember we will be asking ourselves "WHAT exactly does this problem ask me to find?" and "What STRATEGY or operation will I use to solve this problem?"

Let's look back at the word problem, and what we already wrote in the first two columns:

"Tim is taking 5 of his friends to see a movie. At the movie theater, one section of seats has 8 rows with 12 seats in each row. In the center of the first 5 rows are 4 broken seats that cannot be used. How many seats can be used in the section?"

Sean, what did we write in the KNOW column?

Sean: We wrote
8 rows, 12 seats each row
4 broken seats in each of 5 rows

Lauren: I'll read what we wrote in the NOT NEED column – we wrote "Tim and 5 friends" – because we don't need this information to help us solve the problem. OK so now let's look at the W column – WHAT is this problem asking us to find? Hmmm… I think it's asking us to find how many seats can be used – or how many seats are NOT broken. Sean, do you agree?

Sean: Yes, I do.

Lauren: OK what about the S – what STRATEGY or operation will we use?

Sean: Well, first we have to find how many total seats there are. So if there are 8 rows with 12 seats in each row, I will multiply- 8x12, which is 96. *(Lauren writes STEP ONE: 8x12 = 96)*

Lauren: Great – is that it, or are there more steps?

Sean: Well next I have to find out how many seats are broken.

Lauren: I agree – but can you tell me why?

Sean: Yes – because in order to find out how many seats can be used, I have to find out how many total seats are broken, so I can subtract that number from the total number of seats.

Lauren: Great thinking, Sean. So first, you multiplied 8x12 to find the total number of seats, which was 96. What is the next step, Sean? How do I find out the total number of BROKEN seats?

Sean: You have to multiply again. There are 4 broken seats in 5 rows, so 4x5, which equals 20)

Lauren writes (STEP TWO: Multiply 4x5 = 20)

Lauren: And now, like you said, to find out how many seats are NOT broken, I have to subtract. 96 is the total number of seats, and 20 are broken. (*Lauren writes: STEP THREE: 96-20 = 76.)* Great job working that problem out Sean – that was another tricky one!

Lauren: Great job Sean -- we are finished for today. Thank you again for all of your great work, and for helping me to teach this graphic organizer to some friends.

Sean: You're welcome!

Lauren: (*Turns to face camera*) "Class, today you watched me teach Sean about how to use the last two columns of this graphic organizer to help figure out what the problems were asking us to find, and what strategy or operations we would use to solve the problems. Now you will practice this exact same strategy on your own.
(VIDEO ENDS)

APPENDIX E:
WORD PROBLEM SOLVING INTERVENTIONS FOR STUDENTS WITH DISABILITIES

Authors	**Disability Type**	**Intervention**	**Research Design**	**Grade Level or Age**	***n***	**Data Analysis**	**Outcomes**
Alter, Brown, & Pyle (2011)	EBD	SBI with cuing	Multiple baseline	Grades 1 and 4	3	Visual analysis	Improved in percentage of correctly solved word problems and time on task.
Case, Harris, & Graham (1992)	LD, low performing	Self-regulated strategy development (SRSD)	Multiple baseline across participants	Grades 5 and 6	4	Visual analysis	All four students improved in their ability to correctly solve addition and subtraction word problems, but only two of the students maintained these effects over time.
Fuchs et al. (2009)	Students with mathematics difficulty	Tutoring on number combinations (NC) with *Math Flash* and tutoring on word problems (WP) with *Pirate Math*.	Stratified Three group experimental design (control group, number combination tutoring group, word problem tutoring group)	Grade 3	133	ANCOVA	Statistically significant results in both tutoring conditions when compared with the control group. Compared with the control group, the effect size for NC tutoring was 0.55, and the effect size for WP tutoring was 0.62.

Authors	Disability Type	Intervention	Research Design	Grade Level or Age	*n*	Data Analysis	Outcomes
Hutchinson (1993)	LD	CSI	Two-phased study: Phase one was multiple baseline; Phase two was quasi-experimental control group design	Grades 8, 9, 10	12 & 30	Visual analysis & ANCOVA	Six students reached the 80% criterion in the single subject study on all four of the word problem types; four students reached criterion on two problem types, and two students reached criterion on one problem type. Statistically significant results favoring the treatment group.
Jitendra, DiPipi, & Perron-Jones (2002)	LD	SBI	Multiple probe across participants	Middle school	4	Visual analysis	All 4 participants increased in the number of correctly solved word problems and maintained their gains when tested 4 and 8 weeks post intervention. Students also generalized the strategy to other types of word problems.

Authors	**Disability Type**	**Intervention**	**Research Design**	**Grade Level or Age**	***n***	**Data Analysis**	**Outcomes**
Jitendra et al. (2007)	Intervention group and data analysis included 2 students with LD	SBI compared with general strategy instruction (GSI) which included a four step problem solving procedure, in addition to four other strategies: using objects, acting it out or drawing a diagram, choosing an operation, or using data from a graph or table.	RCT	Grade 3	88	ANOVA and ANCOVA	Statistically significant main effect for the SBI group; Medium effect size of 0.52 for SBI when compared to GSI. Statistically significant effect for group at maintenance; SBI group significantly outperformed the GSI group. A medium ES of 0.69 was found for SBI when compared with GSI.
Jitendra et al. (1998)	"Mild disabilities" including LD, ID, EBD, and "at risk"	SBI	Quasi-experimental control group design	Grades 2, 3, 4, 5	34	ANCOVA and ANOVA	Statistically significant main effects for group, favoring the schema group over the traditional instruction group (p =.02). Schema group made 34% increase from pretest to generalization as compared to traditional instruction group, which made a 14% increase. Effect sizes ranged from .65 to .88.

Authors	**Disability Type**	**Intervention**	**Research Design**	**Grade Level or Age**	***n***	**Data Analysis**	**Outcomes**
Jitendra & Hoff (1996)	LD	SBI	Multiple probe across participants	Grades 3 and 4	3	Visual analysis	All 3 students improved from baseline to intervention.
Jitendra, Hoff, & Beck (1999)	LD	SBI for one-step and two-step word problems	Multiple baseline across participants	Grades 6 and 7	4	Visual analysis	All 4 students showed improvement in their ability to solve one and two-step word problems; performance was better on one-step problems (mean of 85%) than two-step problems (54%).
Jitendra & Star (2012)	"Low achievers"	SBI	Quasi-experimental control group design	Grade 7	70	ANCOVA	SBI had a greater impact on high-achieving students' problem solving ability than low-achieving students, when implemented to solve proportion word problems.

Authors	**Disability Type**	**Intervention**	**Research Design**	**Grade Level or Age**	***n***	**Data Analysis**	**Outcomes**
Krawec et al. (2012)	LD	*Solve It!* (CSI)	RCT, pretest posttest	Grades 7, 8	161	ANOVA	Statistically significant main effects on strategy use of students in the treatment group when compared to students in the control group (p = .001).
Levingston, Neef, & Cihon (2009)	ASD	Precurrent behaviors (identification of label, operation, larger numbers, and smaller numbers)	Multiple baseline across behaviors	Age 10	2	Visual analysis	For both participants, correct responses for label, operation, and larger increased following training, as well as the percentage of correctly solved word problems.
Montague (1992)	LD	Cognitive and metacognitive instruction	Multiple baseline across participants	Middle school	6	Visual analysis	Mixed results; No maintenance of strategy over time.
Montague, Applegate, & Marquard (1993)	LD and students without disabilities	CSI	Quasi-Experimental design; three treatment groups (no control group)	Grades 7,8,9	72	Factorial ANOVA and Repeated measures ANOVA	Students with LD improved significantly over time.

Authors	**Disability Type**	**Intervention**	**Research Design**	**Grade Level or Age**	***n***	**Data Analysis**	**Outcomes**
Montague & Bos (1986)	LD	CSI	Multiple baseline across participants	High school, ages 15-18	6	Visual analysis	Four out of the six participants increased by 5-6 of correctly solved word problems.
Montague, Enders, & Dietz (2011)	LD	*Solve It!* Cognitive Strategy Instruction	Cluster randomized design	Middle school	779	Multilevel modeling	Students in treatment group showed greater growth in math problem solving ability as compared to comparison group, including students with LD
Rockwell, Griffin, & Jones (2011)	ASD	Schema-based instruction (SBI)	Single case, multiple probes across behaviors design	Grade 4	1	Visual analysis	Participant improved in ability to solve all types of one-step addition and subtraction word problems; participant was also able to generalize the strategy to different types of problems.
Swanson, Orosco, & Lussier (2014)	Students with and without math difficulties	Strategy instruction 5 conditions: (1) materials + verbal strategies, (2) materials + verbal + visual strategies, (3) materials + visual strategies, (4) materials only, and (5) untreated control condition	Covariate design	Grade 3	193	ANOVA, HLM, ANCOVA	Posttest scores for students with math difficulties in the Materials + Verbal + Visual and the Materials were significantly higher than the posttest scores of the students with math difficulties in the control condition.

Authors	Disability Type	Intervention	Research Design	Grade Level or Age	*n*	Data Analysis	Outcomes
Whitby (2012)	ASD	*Solve It!* Cognitive Strategy Instruction	Multiple RCT with 4 groups/ conditions and a control group baseline	Middle school; Ages 13-14	2	Visual analysis	Mixed results: Student 1 improved from a mean of 35% of correctly solved word problems to 84%. Student 2 improved from a mean of 50% of correctly solved word problems to a mean of 88%. Student 3 improved from a mean of 60% of correctly solved word problems to 96%. However, there was no maintenance of the strategies (35%, 80%, 60%), and each of the students struggled with different aspects of *Solve It!*
Xin, Jitendra & Deatline-Buchman (2005)	LD, EBD, "at risk"	SBI compared to general strategy instruction	RCT; Pretest-posttest comparison group design	Middle school (grades 6, 7, 8)	22	ANOVA	Statistically significant main effects for group ($p < .001$), and time of testing ($p < .001$), favoring the SBI group. SBI group outperformed GSI group on measures of acquisition, maintenance and generalization. Effect sizes ranged from 0.89 to 2.72

APPENDIX F:
DAILY MATHEMATICS WORD PROBLEM PROBES

Name: ____ Date: ________________

Mathematics Word Problems: Daily Probes

Day One

1. Gardeners at the Seed Store are planting seeds in 12-row seed trays. They plant 12 seeds in each row. How many plants will there be in each tray if all the seeds grow?

A. 22 C. 120

B. 220 D. 144

Show your thinking:

2. John's grade has 3 classrooms. Each classroom has 14 tables. Two students sit at each table. About how many students are there in all?

A. 84 C. 28

B. 17 D. 31

Show your thinking:

Day Two

3. The city of Orlando is having a festival. The city of Orlando wants to order 12 loaves of bread and 18 dozen bagels from Orange City Bakery. How much will the city of Orlando have to pay Orange City Bakery?

Baked Goods	Price
Loaf of bread	$10
Bagels	$12/dozen
Rolls	$14/dozen

A. $30.00

C. $336.00

B. $120.00

D. $36.00

Show your thinking:

4. Matt is selling candy bars to raise money for his baseball team. He has 22 boxes of chocolate bars to sell. There are 15 chocolate bars in each box. If Matt sells 3 boxes of chocolate bars, how many more chocolate bars does he have left to sell?

A. 330 bars

C. 37 bars

B. 228 bars

D. 19 bars

Show your thinking:

Day Three

5. George buys 5 gallons of orange juice. He also buys 30 cartons of 18 eggs for a pancake breakfast. How many total eggs does he buy?

A. 340

C. 460

B. 354

D. 540

Show your thinking:

6. There are 126 students who signed up to learn how to play basketball. If there are 6 students in each group, how many groups are there?

A. 12

C. 21

B. 20

D. 120

Show your thinking:

Day Four

7. Ian is saving money for a new bicycle by saving all of his change. So far, Ian has collected 40 quarters. How much money has Ian saved so far?

A. $4.00

B. $10.00

C. $16.00

D. $40.00

Show your thinking:

8. An art teacher has 15 boxes of 64 colored pencils each. In 12 of the boxes, 28 of the colored pencils have **not** been used. All of the rest have been used. How many of the colored pencils have **not** been used?

A. 960

B. 336

C. 40

D. 79

Show your thinking:

Day Five

9. Section 100 in the Amway arena has 20 rows. Each row has 15 seats. Tickets for a concert cost $18 each. If all the seats are sold, how much money will the arena collect for Section 100?

A. $540

C. $300

B. $5,400

D. $1,440

Show your thinking:

10. A bakery has 4 trays with 16 muffins on each tray. The bakery has 3 trays of cupcakes with 24 cupcakes on each tray. If 15 cupcakes are sold, how many muffins and cupcakes are left?

K **What do I KNOW from the information stated in this problem?**	**N** **What information do I NOT need in order to solve this problem?**	**W** **WHAT exactly does this problem ask me to find?**	**S** **What STRATEGY or operation will I use to solve this problem?**

Please write your answer in the space below:

Day Six

11. Chad draws 17 dogs on each of 4 posters. He draws 21 cats on each of 6 other posters. If he draws 5 more dogs on all of the posters with dogs, how many dogs and cats does he draw?

A. 88

B. 126

C. 38

D. 214

Show your thinking:

12. A garden contains only cucumber plants and tomato plants. There are 6 rows of cucumber plants and 7 rows of tomato plants. Each row of cucumber plants has 14 plants. Each row of tomato plants has 15 plants. What is the total number of plants in the garden?

A. 189

B. 42

C. 84

D. 105

Show your thinking:

Day Seven

13. Jimmy wants to buy the same number of hats for 4 of his friends. He has $60 dollars, and each hat costs $5. What is the largest number of hats that Jimmy buys for each friend?

A. 5

B. 6

C. 2

D. 3

Show your thinking:

14. The Publix bakery uses 52 pounds of flour every day. It orders flour every 25 days. How many pounds of flour does Publix need to order every 25 days?

A. 77

B. 1,300

C. 625

D. 50

Show your thinking:

Day Eight

15. Mrs. Jensen is teaching a card game to 6 of her students. She has 52 cards. She passes out one card to each of the 6 students until all of the cards are gone. How many students get exactly 9 cards?

A. 2

C. 5

B. 4

D. 6

Show your thinking:

16. Alicia has 32 stickers. She wants to give all of her stickers away to some of her friends. She gives each friend exactly 8 stickers each. How many friends did Alicia give her stickers to?

A. 128

C. 24

B. 8

D. 4

Show your thinking:

Day Nine

17. A school bought 50 cartons of pencils for the first week of school. Each carton of pencils costs $48. Pencils come in cartons of 24 boxes. How much did the school spend on pencils?

A. $240

B. $1,200

C. $2,400

D. $4,800

Show your thinking:

18. A restaurant has 156 chairs. There are 12 chairs at each table. How many tables are there?

A. 12

B. 13

C. 168

D. 144

Show your thinking:

Day Ten

19. Marina burns 97 calories each time she plays fetch with her dog. She plays fetch with her dog twice a day. How many calories will Marina burn playing fetch with her dog in 25 days?

A. 194
B. 4,850
C. 2,375
D. 2,000

Show your thinking:

20. John wants to use the Rock Climbing club's money to buy each member new climbing shoes. There are 12 members of the club. The new shoes cost $42 per pair. The club has $450. Is this enough money to buy each member a new pair of climbing shoes? If not, how much more money is needed?

Please write your response in the space below:

Day Eleven

21. Annie did 168 sit-ups in 12 minutes. How many sit-ups did she do in one minute?

A. 14
C. 168
B. 180
D. 12

Show your thinking:

22. The city of Orlando is building a new school. The new school has some classrooms. There are 24 desks in each classroom. Altogether there are 312 desks. How many classrooms are there in the new school?

A. 312
C. 288
B. 24
D. 13

Show your thinking:

Day Twelve

23. Allie can do 65 pushups in 5 minutes. How many pushups can she do in 1 minute?

A. 13

B. 65

C. 325

D. 70

Show your thinking:

24. A teacher wants to give 3 markers to each of her 25 students. Markers come in packages of 8. How many packages will the teacher need?

A. 8

B. 9

C. 10

D. 11

Show your thinking:

Day Thirteen

25. Audrey started her sticker collection with 18 stickers. Her mom ordered 3 more pages of stickers for Audrey, with 15 stickers on each page. Audrey will divide the total number of stickers between herself and her two sisters so that they each receive an equal number of stickers. How many stickers will each of the 3 sisters get?

A. 6

B. 18

C. 5

D. 21

Show your thinking:

26. Lou stocks shelves at Publix. He puts 35 cans of tomato sauce on each shelf. The shelf has 4 equal rows and another row with only 3 cans. How many cans are in each of the equal rows?

A. 6

B. 7

C. 8

D. 9

Show your thinking:

Day Fourteen

27. Lauren has some DVDs. She can fit 32 on each shelf, and there are 5 shelves. How many DVDs does Lauren have?

A. 32 C. 160

B. 37 D. 150

Show your thinking:

28. There are 132 projects at the science fair. If 8 projects can fit in a row, how many full rows of projects can be made? How many projects are in the row that is not full?

K **What do I KNOW from the information stated in this problem?**	**N** **What information do I NOT need in order to solve this problem?**	**W** **WHAT exactly does this problem ask me to find?**	**S** **What STRATEGY or operation will I use to solve this problem?**

Please write your responses in the space below:

Number of projects in full rows: ______________________________

Number of projects in row that is not full:_______________________

APPENDIX G:
UCF IRB LETTER OF APPROVAL

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Exempt Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Lauren Delisio**

Date: **January 26, 2015**

Dear Researcher:

On 01/26/2015, the IRB approved the following activity as human participant research that is exempt from regulation:

Type of Review:	Exempt Determination
Project Title:	Effects of a mathematics graphic organizer and peer-mediated instruction with an avatar on the word problem solving abilities of students
Investigator:	Lauren Delisio
IRB Number:	SBE-14-10816
Funding Agency:	
Grant Title:	
Research ID:	N/A

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Signature applied by Joanne Muratori on 01/26/2015 01:49:19 PM EST

IRB Coordinator

APPENDIX H:
PRETEST/POSTTEST
CURRICULUM-BASED MEASURE

Directions: For questions 1-10, please circle your answer, and show your thinking.

1. Mr. Rogers bought 420 pencils for the school. If there are 10 pencils in a box, how many boxes of pencils did he buy?

A. 42

B. 420

C. 4,200

D. 42,000

Show your thinking:

2. 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?

A. $630

B. $1,302

C. $672

D. $1,202

Show your thinking:

3. 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?

A. 2

B. 3

C. 4

D. 5

Show your thinking:

4. Louis bikes 20 miles in a week. Louis also jogs 10 miles in a week. How far will he have jogged in 26 weeks?

A. 30 miles

B. 200 miles

C. 260 miles

D. 520 miles

Show your thinking:

5. There are 27 students in a gym class. The gym teacher wants to make teams for a race. Each team must have exactly four students. How many teams of four can be made from the 27 students?

A. 3

B. 4

C. 6

D. 7

Show your thinking:

6. 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?

A. 56

B. 99

C. 560

D. 990

Show your thinking:

7. 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?

A. 16 cards each, with 4 cards left over

B. 17 cards each, with 1 card left over

C. 25 cards each, with 2 cards left over

D. 26 cards each, with no cards left over

Show your thinking:

8. 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?

A. 56

B. 66

C. 768

D. 32

Show your thinking:

9. 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?

A. $20.00

C. $27.00

B. $66.00

D. $62.00

Show your thinking:

Directions: For question 10, please write your answer in the space provided. If you need more space, you may use the back of this paper. Remember to show your thinking.

10. 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?

K **What do I KNOW from the information stated in this problem?**	**N** **What information do I NOT need in order to solve this problem?**	**W** **WHAT exactly does this problem ask me to find?**	**S** **What STRATEGY or operation will I use to solve this problem?**

Please write your responses in the space below:

a. ________________

b. ________________

APPENDIX I:
TREATMENT FIDELITY OBSERVATION FORM

K-N-W-S Graphic Organizer Fidelity Observation Form

Teacher:_____________________________ Observer: ____________________________

Date:______________ Time: _____________ Student: _____________________________

Grade(s):____________ Fidelity Rating:_________ IRR*: Yes__No__

Please write the number that best describes your observation of the use of each instructional behavior. Assign 0 points if the behavior was not observed, and 1 point if it was observed. The observation should last through the entire lesson. Space is provided below each item for written comments. You may continue on the back if necessary.

Teacher Action	**Completed? Yes/No** **0= NO** **1=YES or N/A for that day**	**Comments/Concerns**
1. Teacher follows script for that specific day. (All days)		
2. Teacher allows brief period for clarifying questions from students. *The teacher or researcher can replay the video upon student request. (All days)		
3. Teacher circulates classroom during independent work and attends to non-responders (Days 2-14)		
4. Teacher encourages students to “show their thinking” on daily word problems (Days 2-14)		
5. Teacher answers all questions from students (Days 2-14)		
6. Teacher ensures that students are applying the K-N-W-S to daily word problems (Days 2-14)		
7. Teacher provides corrective feedback to students (Days 2-14)		

Researcher Action	Completed? Yes/No 0= NO 1=YES or N/A for that day	Comments/Concerns
8. Researcher plays standardized videos of herself with avatar Sean and replays videos when necessary or requested by a student.		
9. Researcher only observes students during independent work; does not offer any help to students; does not answer questions from students.		

LIST OF REFERENCES

Alter, P., Brown, E. T., & Pyle, J. (2011). A strategy-based intervention to improve math word problem-solving skills of students with emotional and behavioral disorders. *Education and Treatment of Children*, *34*(4), 535–550.

Alvermann, D. E., & Swafford, J. (1989). Do content area strategies have a research base? *Journal of Reading*, *32*(5), 388-394.

American Psychiatric Association. (1980). *Diagnostic and statistical manual of mental disorders: DSM-3.* Washington, D.C.: American Psychiatric Association.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders: DSM-5*. Washington, D.C.: American Psychiatric Association.

Ball, D. L, Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education*, *59*(5), 389–407.

Bandura, A. (1977). *Social learning theory.* Englewood Cliffs, NJ: Prentice Hall.

Barnhill, G., Hagiwara, T., Myles, B. S., & Simpson, R. L. (2000). Asperger syndrome: A study of the cognitive profiles of 37 children and adolescents. *Focus on Autism and Other Developmental Disabilities, 15*(3), 146-153.

Barton, M. L., & Heidema, C. (2000). *Teaching reading in mathematics: A supplement to teaching reading in the content areas teacher's manual* (2nd Ed.). Aurora, CO: Mid-Continent Research Association.

Beattie v. Board of Ed. of Antigo, 169 Wis. 231, 232, 172 N. W. 153 (1919). Education Amendments of 1974.

Begeny, J. C. (2011). Effects of the Helping Early Literacy with Practice Strategies (HELPS) reading fluency program when implemented at different frequencies. *School Psychology Review, 40*(1), 149-158.

Begeny, J. C., Laugle, K. M., Krouse, H. E., Lynn, A. E., Tayrose, M. P., & Stage, S. A. (2010). A control-group comparison of two reading fluency programs: The helping early literacy with practice strategies (HELPS) program and the Great Leaps K-2 reading program. *School Psychology Review*, *39*(1), 137-155.

Bellini, S., & Akullian, J. (2007). A meta-analysis of video modeling and video self-modeling interventions for children and adolescents with autism spectrum disorders. *Exceptional Children*, *73*(3), 264-287.

Bellini, S., & Ehlers, E. J. (2009). Video modeling interventions for youth with autism spectrum disorders: Practical suggestions for clinicians and educators. *Journal of Assistive Technology Outcomes and Benefits, 6*, 56–69.

Bettelheim, M. (1967). *The empty fortress*. New York: The Free Press.

Blatt, B., & Kaplan, F. M. (1966). *Christmas in purgatory: A photographic essay on mental retardation*. Boston: Allyn & Bacon.

Bleuler, E. E. (1951). Autistic thinking. In D. Rapaport (Ed.), *Organization and pathology of thought: Selected sources* (pp. 399-437). New York: Columbia University Press.

Boonen, A. J, van der Schoot, M., van Wesel, F., de Vries, M. H., & Jolles, J. (2013). What underlies successful word problem solving? A path analysis in sixth grade students. *Contemporary Educational Psychology*, *38*(3), 271–279.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher*, *33*(8), 3-15.

Bottge, B. (2001). Reconceptualizing mathematics problem solving for low-achieving students. *Remedial and Special Education*, *22*(2), 102–112.

Boyd, B., & Bargerhuff, M. E. (2009). Mathematics education and special education: Searching for common ground and the implications for teacher education. *The Practice of Mathematics Education, 11,* 54–67.

Braselton, S., & Decker, B. C. (1994). Using graphic organizers to improve the reading of mathematics. *The Reading Teacher, 48*(3), 276-281.

Brophy, J. (1979). Teacher behavior and student learning. *Educational Leadership, 37*, 33-38.

Brown v. Board of Education, 347 U.S. 483 (1954). Retrieved from http://caselaw.lp.findlaw.com/scripts/getcase.pl?navby=case&court=us&vol=347&page=483

Brown, H., Oram-Cardy, J., & Johnson, A. (2013). A meta-analysis of the reading comprehension skills of individuals on the autism spectrum. *Journal of Autism and Developmental Disorders, 43*(4), 932-955.

Burton, C. E., Anderson, D. H., Prater, M. A., & Dyches, T. T. (2013). Video self-modeling on an iPad to teach functional math skills to adolescents with autism and intellectual disability. *Focus on Autism and Other Developmental Disabilities, 26*(2), 67-77.

Cai, J., & Lester, F. K. (Eds.). (2010). *Why is teaching with problem solving important to student learning?* Reston, VA: National Council of Teachers of Mathematics.

Campbell, K. U. (1998). *Great Leaps Reading* (4th Ed). Micanopy, FL: Diarmuid, Inc.

Capraro, R. M., Capraro, M. M., & Rupley, W. H. (2011). Reading-enhanced word problem solving: A theoretical model. *European Journal of Psychology of Education*, *27*(1), 91–114.

Carnahan, C. R., & Williamson, P. S. (2013). Does compare-contrast text structure help students with autism spectrum disorder comprehend science text? *Exceptional Children, 79*(3), 347-364.

Carnahan, C. R., Williamson, P., & Haydon, T. (2009). Matching literacy profiles with instruction for students on the spectrum: Making reading instruction meaningful. *Beyond Behavior*, *19*(1), 10-16.

Carnahan, C. R., Williamson, P. S., & Christman, J. (2011). Linking cognition and literacy in students with autism spectrum disorder. *Teaching Exceptional Children, 43*(6), 54-62.

Carpenter, T. P., Fennema, E., Franke, M. L., Levi, L., & Empson, S. B. (1999). *Children's mathematics: Cognitively guided instruction.* Portsmouth, NH: Heinemann

Case, L. P., Harris, K. R., & Graham, S. (1992). Improving the mathematical problem-solving skills of students with learning disabilities: Self-regulated strategy development. *Journal of Special Education*, *26*(1), 1-19.

Centers for Disease Control and Prevention. (2012). *Prevalence of autism spectrum disorders – Autism and developmental disabilities monitoring network, 14 sites, United States, 2008.* Retrieved from http://www.cdc.gov/mmwr/pdf/ss/ss6103.pdf

Centers for Disease Control and Prevention. (2014). *Prevalence of autism spectrum disorder among children aged 8 years — Autism and developmental disabilities monitoring network, 11 sites, United States, 2012.*

Charlop-Christy, M. H., Le, L., and Freeman, K. A. (2000). A comparison of video modeling with in vivo modeling for teaching children with autism. *Journal of Autism and Developmental Disorders, 30(6),* 537- 552.

Chiang, H., & Lin, Y. (2007). Reading comprehension instruction for students with autism spectrum disorders. *Focus on Autism and Other Developmental Disabilities,* 22(4), 259-267.

Cihak, D., Fahrenkrog, C., Ayres, K. M., & Smith, C. (2010). The use of video modeling via a video iPod and a system of least prompts to improve transitional behaviors for students with autism spectrum disorders in the general education classroom. *Journal of Positive Behavior Interventions, 12*(2), 103-115.

Conference Board of the Mathematical Sciences. (2012). *The mathematical education of teachers II.* Providence, RI: American Mathematical Society.

Crockett, J. B. (2011). Policy and leadership in the administration of special education. In J. M. Kauffman & D. P. Hallahan (Eds.). *Handbook of Special Education* (pp. 349-362). New York: Routledge.

Delano, M. E. (2007). Improving written language performance of adolescents with Asperger syndrome. *Journal of Applied Behavior Analysis, 40*(2), 345-351.

DeMyer, M. K., Barton, S., DeMyer, W. E., Norton, J. A., Allen, J., & Steele, R. (1973). Prognosis in autism: A follow-up study. *Journal of Autism and Developmental Disorders*, *3*(3), 199-246.

Deno, S. L. (1985). Curriculum-based measurement: The emerging alternative. *Exceptional Children, 52,* 219–232.

Deno, S. L. (2003). Developments in curriculum-based measurement. *Journal of Special Education*, *37*(3), 184-192.

Department of Public Welfare v. Haas, 154 N.E. 2nd 265 (Ill. 1958).

Desoete, A., Roeyers, H., & De Clercq, A. (2003). Can offline metacognition enhance mathematical problem solving? *Journal of Educational Psychology, 95*(1), 188-200.

Dettmer, S., Simpson, R. L., Myles, B. S., & Ganz, J. B. (2000). The use of visual supports to facilitate transitions of students with autism. *Focus on Autism and Other Developmental Disabilities, 15*(3), 163-170.

Dexter, D. D., & Hughes, C. A. (2011). Graphic organizers and students with learning disabilities: A meta-analysis. *Learning Disability Quarterly, 34*(1), 51-72.

Dicker, S., & Bennett, E. (2011). Engulfed by the spectrum: The impact of autism spectrum disorders on law and policy. *Valparaiso University Law Review, 45*(2), 415-455.

Dieker, L. A., Straub, C. L., Hughes, C. E., Hynes, M. C., & Hardin, S. (2014). Learning from virtual students. *Educational Leadership, 71*(8), 54-58.

Dixon, J. K., Larson, M., Leiva, M. A., & Adams, T. (2012). *GO Math!* Orlando, FL: Houghton Mifflin Harcourt.

Donaldson, J. B., & Zager, D. (2010). Mathematics interventions for students with high functioning Asperger's syndrome. *Teaching Exceptional Children, 42*(6), 40-46.

Education Amendments of 1974, 88 Stat. 484, Pub. L. 93–380. (1974).

Education Commission of the States. (1999). *Wilson Reading System.* Retrieved from http://files.eric.ed.gov/fulltext/ED447439.pdf

Education for All Handicapped Children Act of 1975, 20 U.S.C. § 1400 *et seq* (1975).

Education of the Handicapped Act of 1970, Pub. L. No. 92-230, 84 Stat. 175, Part B. (1970).

Elementary and Secondary Education Act of 1965, Pub. L. No. 89-10, 70 Stat. 27 (1965).

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*, 1149-1160.

Faulkner, V. N., & Cain, C. R. (2013). Improving the mathematical content knowledge of general and special educators: Evaluating a professional development module that focuses on number sense. *Teacher Education and Special Education, 36*(2), 115-131.

Fava, L., & Strauss, K. (2014). Response to early intensive behavioral intervention for autism: An umbrella approach to issues critical to treatment individualization. *International Journal of Developmental Neuroscience, 39*, 49-58.

Field, A. (2009). *Discovering statistics using SPSS*. (3rd Ed.) London: Sage Publications.

Fisher, D., & Frey, N. (2008). *Better learning for better teaching.* Alexandria, VA: Association for Supervision and Curriculum Development.

Flores, M. M., Nelson, C., Hinton, V., Franklin, T. M., Strozier, S. D., Terry, L., & Franklin, S. (2013). Teaching reading comprehension and language skills to students with autism spectrum disorders and developmental disabilities using direct instruction. *Education and Training in Autism and Developmental Disabilities, 48*(1), 41-48.

Flores, M. M., Hinton, V. M., & Strozier, S. D. (2014). Using the Concrete-Representational-Abstract sequence and the strategic instruction model to teach computation to students with autism spectrum disorders and developmental disabilities. *Education and Training in Autism and Developmental Disabilities*, *49*(4), 547-554.

Friedland, E. S., McMillen, S. E., & Hill, P. (2011). Collaborating to cross the mathematics-literacy divide: An annotated bibliography of literacy strategies for mathematics classrooms. *Journal of Adolescent and Adult Literacy*, *55*(1), 57-66.

Friend, M., & Bursuck, W. (2012). *Including students with special needs* (6th Ed.). Boston, MA: Pearson.

Frith, U. (1970). Studies in pattern detection in normal and autistic children: Reproduction and production of color sequences. *Journal of Experimental Child Psychology*, *10,* 120-135.

Fuchs, L. S., Fuchs, D., & Compton, D. L. (2013). Intervention effects for students with comorbid forms of learning disability: Understanding the needs of nonresponders. *Journal of Learning Disabilities*, *46*(6), 534–548.

Fuchs, L. S., Powell, S. R., Seethaler, P. M., Cirino, P. T., Fletcher, J. M., Fuchs, D., … Zumeta, R. O. (2009). Remediating number combination and word problem deficits among students with mathematics difficulties: A randomized control trial. *Journal of Educational Psychology*, *101*(3), 561–576.

Fuchs, L. S., Zumeta, R. O., Schumacher, R. F., Powell, S. R., Seethaler, P. M., Hamlett, C. L., & Fuchs, D. (2010). The effects of schema-broadening instruction on second graders' word-problem performance and their ability to represent word problems with algebraic equations: A randomized control study. *The Elementary School Journal*, *110*(4), 446–463.

Gajria, M., Jitendra, A., Sood, S., & Sacks, G. (2007). Improving comprehension of expository text in students with LD: A research synthesis. *Journal of Learning Disabilities*, *40*(3), 210–225.

Gersten, G., Fuchs, F. S., Williams, J. P., & Baker, S. (2001). Teaching reading comprehension strategies to students with learning disabilities: A review of research. *Review of Educational Research, 71*(2), 279-320.

Gill, S. (2008). The comprehension matrix: A tool for designing comprehension instruction. *Reading Teacher*, *62*(2), 106-113.

Goldstein, G., Minshew, N. J., & Siegel, D. J. (1994). Age differences in academic achievement in high-functioning autistic individuals. *Journal of Clinical and Experimental Neuropsychology, 16*(5), 671-680.

Grandin, T. (2006). Perspectives on education from a person on the autism spectrum. *Educational Horizons*, *84*(4), 229–234.

Grandin, T. (2007). Autism from the inside. *Educational Leadership, 64*(5), 29-32.

Greer, D. L., & Meyen, E. L. (2009). Special education teacher education: A perspective on content knowledge. *Learning Disabilities Research and Practice, 24*(4), 196–203.

Grégoire, J., & Desoete, A. (2009). Mathematical disabilities: An underestimated topic? *Journal of Psychoeducational Assessment*, *27*(3), 171-174

Griffin, C. C., & Jitendra, A. K. (2008). Word problem solving in inclusive third-grade mathematics classrooms. *The Journal of Educational Research, 102*(3), 187-201.

Griffin, C. C., Jitendra, A. K., & League, M. B. (2009). Novice special educators' instructional practices, communication patterns, and content knowledge for teaching mathematics. *Teacher Education and Special Education*, *32*(4), 319-336.

Griswold, D. E., Barnhill, G. P., Myles, B. S., Hagiwara, T., & Simpson, R. L. (2002). Asperger syndrome and academic achievement. *Focus on Autism and Other Developmental Disabilities, 17*(2), 94-102.

Happe, F., Booth, R., Charlton, R., & Hughes, C. (2006). Executive function deficits in autism spectrum disorders and attention-deficit/hyperactivity disorder: Examining profiles across domains and ages. *Brain and Cognition, 61*(1), 25-39.

Harris, K. R. (1985). Conceptual, methodological, and clinical issues in cognitive behavior assessment. *Journal of Abnormal Child Psychology, 13*(3), 373-390.

Hart, J., & Whalon, K. (2008). Promote academic engagement and communication of students with autism spectrum disorder in inclusive settings. *Intervention in School and Clinic*, *44*(2), 116-120.

Hegarty, M., Mayer, R. E., & Monk, C. A. (1995). Comprehension of arithmetic word problems: A comparison of successful and unsuccessful problem solvers. *Journal of Educational Psychology*, *87*(1), 18–32.

Hill, H. C., Rowan, B., & Ball, D. L. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal*, *42*(2), 371–406.

Hopkins, I., Gower, M., Perez, T., Smith, D., Amthor, F., Casey Wimsatt, F. F., & Biasini, F. (2011). Avatar Assistant: Improving social skills in students with an ASD through a computer-based intervention. *Journal of Autism & Developmental Disorders*, *41*(11), 1543-1555.

Huefner, D. (2000). The risks and opportunities of the IEP requirements under IDEA '97. *Journal of Special Education*, *33*(4), 195-204.

Hutchinson, N. L. (1993). Effects of cognitive strategy instruction on algebra problem solving of adolescents with learning disabilities. *Learning Disability Quarterly*, *16*(1), 34-63.

Individuals with Disabilities Education Act of 1990, 20 U.S.C. § 1400 et seq. (1990). Retrieved from http://uscode.house.gov/statutes/pl/101/476.pdf

Individuals with Disabilities Education Improvement Act of 2004, 20 U.S.C. § 1400 et seq (2004).

Itard, J. M., Humphrey, M. M., & Humphrey, G. (1932). *The wild boy of Aveyron: Rapports et mémoires sur le sauvage de l'Aveyron.* New York: The Century Co.

Ives, B. (2007). Graphic organizers applied to secondary algebra instruction for students with learning disorders. *Learning Disabilities Research and Practice, 22*(2), 110–118.

Jitendra, A. K. (2013). Understanding and accessing standards-based mathematics for students with mathematics difficulties. *Learning Disability Quarterly, 36*(1), 4-8.

Jitendra, A. K., DiPipi, C. M., & Perron-Jones, N. (2002). An exploratory study of schema-based word-problem solving instruction for middle school students with learning disabilities: An emphasis on conceptual and procedural understanding. *The Journal of Special Education*, *36*(1), 23–38.

Jitendra, A. K., Griffin, C. C., Deatline-Buchman, A., & Sczesniak, E. (2007). Mathematical word problem solving in third-grade classrooms. *The Journal of Educational Research*, *100*(5), 283–302.

Jitendra, A. K., Griffin, C. C., Haria, P., Leh, J., Adams, A., & Kaduvettoor, A. (2007). A comparison of single and multiple strategy instruction on third-grade students' mathematical problem solving. *Journal of Educational Psychology*, *99*(1), 115–127.

Jitendra, A. K., Griffin, C. C., McGoey, K., Gardill, M. C., Bhat, P., & Riley, T. (1998). Effects of mathematical word problem solving by students at risk or with mild disabilities. *The Journal of Educational Research*, *91*(6), 345–355.

Jitendra, A., & Hoff, K. (1996). The effects of schema-based instruction on the mathematical word-problem-solving performance of students with learning disabilities. *Journal of Learning Disabilities*, *29*(4), 422-431.

Jitendra, A. K., Hoff, K., & Beck, M. M. (1999). Teaching middle school students with learning disabilities to solve word problems using a schema-based approach. *Remedial and Special Education*, *20*(1), 50–64.

Jitendra, A. K., & Star, J. R. (2011). Meeting the needs of students with learning disabilities in inclusive mathematics classrooms: The role of schema-based instruction on mathematical problem-solving. *Theory Into Practice*, *50*(1), 12–19.

Jitendra, A. K., & Star, J. R. (2012). An exploratory study contrasting high- and low-achieving students' percent word problem solving. *Learning and Individual Differences*, *22*(1), 151–158.

Kanner, L. (1943). Autistic disturbances of affective contact. *The Nervous Child: Quarterly Journal of Psychopathology, Psychotherapy, Mental Hygiene, and Guidance of the Child*, *2,* 217-250.

Katsiyannis, A., Yell, M., & Bradley, R. (2001). Reflections on the 25th anniversary of the Individuals with Disabilities Act. *Remedial and Special Education, 22*(6), 324-334.

Kazdin, A. E. (1982). *Single-case research designs: Methods for clinical and applied settings*. New York, NY: Oxford University Press.

Kim, A., Vaughn, S., Wanzek, J., & Wei, S. (2004). Graphic organizers and their effects on the reading comprehension of students with LD: A synthesis of research. *Journal of Learning Disabilities*, *37*(2), 105–118.

Kintsch, W., & Greeno, J. G. (1985). Understanding and solving word arithmetic problems. *Psychological Review*, *92,* 109-129.

Knight, V. F., Spooner, F., Browder, D. M., Smith, B. R., & Wood, C. L. (2013). Using systematic instruction and graphic organizers to teach science concepts to students with autism spectrum disorders and intellectual disability. *Focus on Autism and Other Developmental Disabilities*, *28*(2), 115–126.

Krawec, J., Huang, J., Montague, M., Kressler, B., & Melia de Alba, A. (2012). The effects of cognitive strategy instruction on knowledge of math problem-solving processes of middle school students with learning disabilities. *Learning Disability Quarterly*, *36*(2), 80–92.

Kroesbergen, E. H., & Van Luit, J. (2003). Mathematics interventions for children with special educational needs: A meta-analysis. *Remedial and Special Education*, *24*(2), 97-114.

Kurth, J. A., & Mastergeorge, A. M. (2010). Academic and cognitive profiles of students with autism: Implications for classroom practice and placement. *International Journal of Special Education*, *25*(2), 8-14.

Levingston, H. B., Neef, N. A., & Cihon, T. M. (2009). The effects of teaching precurrent behaviors on children's solution of multiplication and division word problems. *Journal of Applied Behavior Analysis*, *42*(2), 361-367.

Lewis, A., & Mayer, R. (1987). Students' miscomprehension of relational statements in arithmetic word problems. *Journal of Educational Psychology*, *79,* 363-371.

Loiacono, V., & Valenti, V. (2010). General education teachers need to be prepared to co-teach the increasing number of children with autism in inclusive settings. *International Journal of Special Education, 25*(3), 24-32.

Maccini, P. (2006). Mathematics instructional practices and assessment accommodations by secondary special and general educators. *Exceptional Children, 72*(2), 217–234.

Maccini, P., & Gagnon, J. C. (2002). Perceptions and application of NCTM standards by special and general education teachers. *Exceptional Children, 68*(3), 325-244.

Marcus, A., & Wilder, D. A. (2009). A comparison of peer video modeling and self video modeling to teach textual responses in children with autism. *Journal of Applied Behavior Analysis, 42*(2), 335-341.

Martens, B. K., Witt, J. C., Elliott, S. N., & Darveaux, D. (1985). Teacher judgments concerning the acceptability of school based interventions. *Professional Psychology: Research and Practice, 16,* 191–198.

Mason, L. H., & Hedin, L. R. (2011). Reading science text: Challenges for students with learning disabilities and considerations for teachers. *Learning Disabilities Research and Practice, 26*(4), 214-222.

Mastropieri, M. A., & Scruggs, T. E. (2010). *The inclusive classroom: Strategies for effective differentiated instruction.* Upper Saddle River, NJ: Pearson Education, Inc.

Mayer, R. E. (1985). Mathematical ability. In R. J. Sternberg (Ed.), *Human abilities: An information processing approach* (pp. 127-150). New York: Freeman.

Mayer, R. E., & Hegarty, M. (1996). The process of understanding mathematical problems. In R. J. Sternberg, T. Ben-Zeev (Eds.), *The nature of mathematical thinking* (pp. 29-53). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Mayes, S., & Calhoun, S. L. (2008). WISC-IV and WIAT-II profiles in children with high-functioning autism. *Journal of Autism and Developmental Disorders*, *38*(3), 428-439.

Meichenbaum, D. (1977). *Cognitive-behavior modification: An integrative approach.* New York: Plenum.

Mills v. Board of Education, 348 F. Supp. 866. (1972, D.D.C).

Minshew, N. J., Goldstein, G., Taylor, H. G., & Siegel, D. J. (1994). Academic achievement in high functioning autistic individuals. *Journal of Clinical and Experimental Neuropsychology, 16,* 261-270.

Montague, M. (1992). The effects of cognitive and metacognitive strategy instruction on the math problem solving of middle school students with LD. *Journal of Learning Disabilities*, *25*(4), 230–248.

Montague, M., Applegate, B., & Marquard, K. (1993). Cognitive strategy instruction and mathematical problem-solving performance of students with learning disabilities. *Learning Disabilities Research and Practice, 8*(4), 223-232.

Montague, M., & Bos, C. (1986). The effect of cognitive strategy training on verbal math problem solving performance of learning disabled adolescents. *Journal of Learning Disabilities*, *19,* 26-33.

Montague, M., & Dietz, S. (2009). Evaluating the evidence base for cognitive strategy instruction and mathematical problem solving. *Exceptional Children, 75*(3), 285–302.

Montague, M., Enders, C., & Dietz, S. (2011). Effects of cognitive strategy instruction on math problem solving of middle school students with learning disabilities. *Learning Disability Quarterly*, *34*(4), 262-272.

Moran, A. S., Swanson, H., Gerber, M. M., & Fung, W. (2014). The effects of paraphrasing interventions on problem-solving accuracy for children at risk for math disabilities. *Learning Disabilities Research and Practice*, *29*(3), 97-105. doi:10.1111/ldrp.12035

Myles, B. S., Barnhill, G. P., Hagiwara, T., Griswold, D. E., & Simpson, R. L. (2001). A synthesis of studies on the intellectual, academic, social/ emotional and sensory characteristics of children and youth with Asperger syndrome. *Education and Training in Mental Retardation and Developmental Disabilities*, *36*(3), 304-311.

Myles, B. S., Grossman, B. G., Aspy, R., Henry, S. A., & Coffin, A. B. (2007). Planning a comprehensive program for students with autism spectrum disorders using evidence-based practices. *Education and Training in Developmental Disabilities, 42*(4), 398-409.

Myles, B. S., & Simpson, R. L. (2002). The complexities of Asperger syndrome: What we know and what we have yet to learn. *Educational Horizons*, *81*(1), 38-44.

Nation, K., Clarke, P., Wright, B., & Williams, C. (2006). Patterns of reading ability in children with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 36*(7), 911-919.

National Center for Education Statistics (2013). Digest of education statistics. Retrieved from http://nces.ed.gov/programs/digest/d13/tables/dt13_204.30.asp

National Center on Educational Restructuring and Inclusion. (1994). *National study of inclusive education.* New York, NY: City University of New York.

National Mathematics Advisory Panel. (2008). *Foundations for success: The final report of the National Mathematics Advisory Panel.* Washington, D.C.: U.S. Department of Education.

National Reading Panel. (2000). *Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction*. National Institute of Child Health and Human Development: Bethesda, MD. Retrieved from http://www.nichd.nih.gov/publications/pubs/nrp/Documents/report.pdf

No Child Left Behind Act of 2001, 20 U.S.C. § 6301 et seq. (2002).

Norbury, C., & Nation, K. (2011). Understanding variability in reading comprehension in adolescents with autism spectrum disorders: Interactions with language status and decoding skill. *Scientific Studies of Reading*, *15*(3), 191–210.

O'Connor, I. M., & Klein, P. D. (2004). Exploration of strategies for facilitating the reading comprehension of high-functioning students with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 34*(2), 115-127.

Odom, S. L., Brown, W. H., Frey, T., Karascu, N., Smith-Canter, L. L., & Strain, P. S. (2003). Evidence-based practices for young children with autism: Contributions for single-subject design research. *Focus on Autism and Other Developmental Disorders, 18*(3), 166-175.

Odom, S. L., Collet-Klingberg, L., Rogers, S. J., & Hatton, D. D. (2010). Evidence-based practices in interventions for children and youth with autism spectrum disorder. *Preventing School Failure, 54*(4), 275-282.

Pennsylvania Association for Retarded Children (PARC) v. Commonwealth of Pennsylvania, 334 F. Supp. 1257. (1972, E.D. PA).

Powell, S. (2015). Connecting evidence-based practice with implementation opportunities in special education mathematics preparation. *Intervention in School and Clinic*. Advance online publication. doi: 10.1177/1053451215579269

Ramdoss, S., Mulloy, A., Lang, R., O'Reilly, M., Sigafoos, J., Lancioni, G., … El Zein, F. (2011). Use of computer-based interventions to improve literacy skills in students with autism spectrum disorders: A systematic review. *Research in Autism Spectrum Disorders*, *5*(4), 1306–1318.

Randi, J., Newman, T., & Grigorenko, E. L. (2010). Teaching children with autism to read for meaning: Challenges and possibilities. *Journal of Autism and Other Developmental Disorders*, *40*(7), 890-902.

Rivkin, S. G., Hanushek, E. A., & Kain, J. E. (2005). Teachers, schools, and academic achievement. *Econometrica, 73*(2), 417-458.

Rockwell, S. B., Griffin, C. C., & Jones, H. A. (2011). Schema-based strategy instruction in mathematics and the word-problem solving performance of a student with autism. *Focus on Autism and Other Developmental Disabilities*, *26*(2), 87–95.

Rutter, M., & Bartak, L. (1971). Causes of infantile autism: Some considerations from recent research. *Journal of Autism and Childhood Schizophrenia*, *1*(1), 20-32. doi:10.1007/BF01537740

Ryan, J. B., Hughes, E., Katsiyannis, A., McDaniel, M., & Sprinkle, C. (2014). Research-based educational practices for students with autism spectrum disorders. *Teaching Exceptional Children*, *47*(2), 94-102.

Sarrett, J. C. (2011). Trapped children: Popular images of children with autism in the 1960s and 2000s. *Journal of Medical Humanities*, *32*(2), 141-153.

Schenning, H., Knight, V., & Spooner, F. (2013). Effects of structured inquiry and graphic organizers on social studies comprehension by students with autism spectrum disorders. *Research in Autism Spectrum Disorders*, *7*(4), 526–540.

Schmidt, W. H. (2012). At the precipice: The story of mathematics education in the United States. *Peabody Journal of Education, 87*(1), 133-156.

Schneps, M. H., O'Keeffe, J. K., Heffner-Wong, A., & Sonnert, G. (2010). Using technology to support STEM reading. *Journal of Special Education Technology*, *25*(3), 21-33.

Section 504 of the Rehabilitation Act of 1973, 34 C.F.R. Part 104.

Sheriff, K. A., & Boon, R. T. (2014). Effects of computer-based graphic organizers to solve one-step word problems for middle school students with mild intellectual disability: A preliminary study. *Research in Developmental Disabilities, 35*(8), 1828-1837.

Shinn, M. R. (1989). *Curriculum-based measurement.* New York: Guilford.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(4), 4-14.

Siegler, R. S., & Ellis, S. (1996). Piaget on childhood. *Psychological Science*, *7*(4), 211-215. doi:10.1111/j.1467-9280.1996.tb00361.x

Simons, J. M. (1974). Observations on compulsive behavior in autism. *Journal of Autism and Childhood Schizophrenia, 4*(1), 1-10.

Simpson, R. L. (2005). Evidence-based practices and students with autism spectrum disorders. *Focus on Autism and Other Developmental Disorders, 20*(3), 140-149.

Smith, T. E. (2002). Section 504: What teachers need to know. *Intervention in School and Clinic, 37*(5), 259-366.

Smith-Myles, B., Simpson, R., & Becker, J. (1994). An analysis of characteristics of students diagnosed with higher-functioning autistic disorder. *Exceptionality, 5*(1), 19-30.

Southall, C. (2013). Use of technology to accommodate differences associated with autism spectrum disorder in the general curriculum and environment. *Journal of Special Education Technology, 28*(1), 23-34.

Stahmer, A. C., Schreibman, L., & Cunningham, A. B. (2011). Toward a technology of treatment individualization for young children with autism spectrum disorders. *Brain Research, 1380*, 229-239.

Strickland, T. K., & Maccini, P. (2014). The effects of the Concrete–Representational–Abstract integration strategy on the ability of students with learning disabilities to multiply linear expressions within area problems. *Remedial and Special Education, 34*(3), 142-153.

Stringfield, S., Luscre, D., & Gast, D. L. (2011). Effects of a story map on accelerated reader postreading test scores in students with high-functioning autism. *Focus on Autism and Other Developmental Disabilities*, *26*(4), 218–229.

Swafford, J., & Alvermann, D. E. (1989). Postsecondary research base for content reading strategies. *Journal of Reading*, *33*(3), 164-169.

Swanson, H. L., Moran, A., Lussier, C., & Fung, W. (2014). The effect of explicit and direct generative strategy training and working memory on word problem-solving accuracy in children at risk for math difficulties. *Learning Disabilities Quarterly, 37*(2), 111-123.

Swanson, H., Orosco, M. J., & Lussier, C. M. (2014). The effects of mathematics strategy instruction for children with serious problem-solving difficulties. *Exceptional Children*, *80*(2), 149-168.

Tarr, J. E., Reys, R. E., Reys, B. J., Chavez, O., Shih, J., & Osterlind, S. J. (2008). The impact of middle-grades mathematics curricula and the classroom learning environment on student achievement. *Journal for Research in Mathematics Education*, *39*(3), 247-280.

Thompson, T. (2013). Autism research and services for young children: History, progress and challenges. *Journal of Applied Research in Intellectual Disabilities, 26*, 81-107.

Turnbull, H. R. (2005). Individuals with Disabilities Education Act reauthorization: Accountability and personal responsibility. *Remedial and Special Education, 26*(6), 320-326.

U.S. Department of Education, National Center for Education Statistics (2012). *Digest of Education Statistics, 2011* (NCES 2012-001), Chapter 2.

U.S. Department of Education, National Center for Education Statistics. (2013). *Digest of Education Statistics, 2012* (NCES 2014-015).

U.S. Department of Education, National Center for Education Statistics. (2014). *National Assessment of Educational Progress (NAEP), various years, 1990–2013: Mathematics and Reading Assessments.*

U.S. Department of Education, Office of Special Education and Rehabilitative Services, Office of Special Education Programs. (2006). *26th annual report to Congress on the implementation of the Individuals with Disabilities Education Act, 2003.*

Van Garderen, D. (2008). Middle school special education teachers' instructional practices for solving mathematical word problems: An exploratory study. *Teacher Education and Special Education, 31*(2), 132–144.

Vaughn, S., & Bos, C. S. (2012). *Strategies for teaching students with learning and behavior problems* (8th Ed.). Upper Saddle River, NJ: Pearson Education, Inc.

Verhoeff, B. (2013). Autism in flux: A history of the concept from Leo Kanner to DSM-5. *History of Psychiatry, 24*(4), 442-458.

Verschaffel, L., Greer, B., & De Corte, E. (2000). *Making sense of word problems*. The Netherlands: Swets & Zeitlinger Publishers.

Vilenius-Tuohimaa, P., Aunola, K., & Nurmi, J. (2008). The association between mathematical word problems and reading comprehension. *Educational Psychology*, *28*(4), 409-426.

Vince-Garland, K. (2012). *Coaching in an interactive virtual reality to increase fidelity of implementation of discrete trial teaching.* (Doctoral dissertation). Retrieved from UCF libraries catalog. (ucfl.031001415)

Walker, Z. (2012). *The effects of the combination of interview practice in a mixed- reality environment and coaching on the interview performance of young adults with intellectual disabilities.* (Doctoral dissertation). Retrieved from UCF libraries catalog. (ucfl.031001273)

Watson v. City of Cambridge, 32 N.E. 864 (Mass.1893).

Whalon, K. J., & Hart, J. E. (2010). Children with autism spectrum disorder and literacy instruction: An exploratory study of elementary inclusive settings. *Remedial and Special Education, 32*(3), 243-255.

Whitby, P. J. (2012). The effects of *Solve It!* on the mathematical word problem solving ability of adolescents with autism spectrum disorders. *Focus on Autism and Other Developmental Disorders, 28*(2), 78-88.

Whitby, P., & Mancil, G. (2009). Academic achievement profiles of children with high functioning autism and Asperger syndrome: A review of the literature. *Education and Training in Developmental Disabilities*, *44*(4), 551-560.

Whitby, P. J., Travers, J. C., & Harnik, J. (2009). Academic achievement and strategy instruction to support the learning of children with high-functioning autism. *Academic Achievement and Strategy Instruction, 19*(1), 3-9.

Williamson, P., Carnahan, C. R., & Jacobs, J. A. (2012). Reading comprehension profiles of high-functioning students on the autism spectrum: A grounded theory. *Exceptional Children, 78*(4), 449-469.

Wittrock, M. C. (1974). Learning as a generative process. *Educational Psychologist, 11*, 87-95.

Wittrock, M. C. (1991). Generative teaching of comprehension. *The Elementary School Journal, 92*(2), 169-184.

Wolff, S. (2004). The history of autism. *European Child & Adolescent Psychiatry, 13*(4), 201-208.

Woodward, J., Beckmann, S., Driscoll, M., Franke, M., Herzig, P., Jitendra, A.,… Ogbuehi, P. (2012). *Improving mathematical problem solving in grades 4 through 8: A practice guide* (NCEE 2012-4055). Washington, D.C.: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education. Retrieved from http:// ies.ed.gov/ncee/wwc/publications_reviews.aspx#pubsearch/.

Xin, Y., Jitendra, A. K., & Deatline-Buchman, A. (2005). Effects of mathematical word problem-solving instruction on middle school students with learning problems. *Journal of Special Education*, *39*(3), 181-192.

Yell, M. L., & Katsiyannis, A. (2001). Promises and challenges in education law: 25 years of legal developments. *Preventing School Failure, 45*(2), 82-88.

Yell, M. L., Katsiyannis, A., & Bradley, R. (2011). The Individuals with Disabilities Act: The evolution of special education law. In J.M. Kauffman & D.P. Hallahan (Eds.). *Handbook of Special Education* (pp. 61-76). New York: Routledge.

Yell, M. L., Rogers, D., & Rogers, E. (1998). The legal history of special education: What a long, strange trip it's been! *Remedial and Special Education, 19*(4), 219-28.

Zakas, T. L., Browder, D. M., Ahlgrim-Delzell, L., & Heafner, T. (2013). Teaching social studies content to students with autism using a graphic organizer intervention. *Research in Autism Spectrum Disorders*, *7*(9), 1075–1086.

Zhang, D., & Xin, Y. (2012). A follow-up meta-analysis for word-problem-solving interventions for students with mathematics difficulties. *Journal of Educational Research, 105*(5), 303–318.

Zollman, A. (2009). Mathematical graphic organizers. *Teaching Children Mathematics*, *16*(4), 222-229.

Zollman, A. (2011). Write is right: Using graphic organizers to improve student mathematical problem solving. *Investigations in Mathematics Learning, 4*(3), 50-60