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THE EFFECTS OF A MODIFIED LEARNING STRATEGY ON THE MULTIPLE
STEP MATHEMATICAL WORD PROBLEM SOLVING ABILITY OF MIDDLE
SCHOOL STUDENTS WITH HIGH-FUNCTIONING AUTISM OR ASPERGER'S
SYNDROME

by

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A dissertation submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy
in the Department of Child, Family, and Community Sciences
in the College of Education
at the University of Central Florida
Orlando, Florida

Summer Term
2009

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ABSTRACT

Children with HFA/AS are outperformed by their neuro-typical peers on mathematical problem solving skills even though they have average-to-above-average intelligence (Dickerson Mayes & Calhoun, 2003b); have average-to-above-average computation skills (Chiang & Lin, 2007); and, are educated in the general education setting (Twenty Eighth Annual Report to Congress, 2008). In order to graduate with a regular diploma, all students must take and pass three high school mathematics courses including algebra I. Students with HFA/AS present with a unique set of cognitive deficits that may prevent achievement in the mathematics curriculum, even though they present with average mathematical skills. The purpose of the study was to determine the effectiveness and efficiency of the use of a modified learning strategy to increase the mathematical word problem solving ability of children with high functioning autism or Asperger's syndrome; determine if the use of *Solve It!* increases the self-perceptions of mathematical ability, attitudes towards mathematics and attitudes towards solving mathematical word problems; and, determine if *Solve It!* cue cards or a *Solve It!* multimedia academic story works best as a prime to increase the percentage correct if the student does not maintain use of the strategy.

The subjects were recruited from a central Florida school district. Diagnosis of ASD was confirmed by a review of records and the completion of the Autism Diagnostic Inventory-Revised (Lord, Rutter, & Le Couteur, 2005). Woodcock Johnson Tests of Achievement (Woodcock, McGrew, & Mather, 2001) subtest scores for reading comprehension and mathematical computation were completed to identify the current

level of functioning. The Mathematical Problem Solving Assessment- Short Form (Montague, 1996) was administered to determine the need for word problem solving intervention. The subjects were then taught a mathematical word problem solving strategy called *Solve It!*, during non-content course time at their schools. Generalization data were collected in each subject's regular education mathematics classroom. Sessions were video-taped, work samples were scored, and then graphed using a multiple baseline format. Three weeks after the completion of the study, maintenance data were collected. If subjects did not maintain a high use of the strategy, they were entered into the second study to determine if a video prime or written prime served best to increase word problem solving.

The results of the study indicate a functional relationship between the use of the *Solve It!* strategy and the percentage correct on curriculum based mathematical word problems. The subjects obtained efficient use of strategy use in five training sessions and applied the strategy successfully for five acquisition sessions. Percentage correct on mathematical word problems ranged from 20% during baseline to 100% during training and acquisition trials. Error analysis indicated reading comprehension interference and probable executive functioning interference. Students who did not maintain strategy use quickly returned to intervention level using a prime. Both primes, cue cards and multimedia academic story, increased performance back to intervention levels for two students. However, one prime, the multimedia academic story and not the cue cards, increased performance back to intervention levels for one student.

Findings of this study show the utility of a modified learning strategy to increase mathematical word problem solving for students with high functioning autism and Asperger's syndrome. Results suggest that priming is a viable intervention if students with autism do not maintain or generalize strategy use as a means of procedural facilitation.

To Ann

For teaching me to believe in myself.

ACKNOWLEDGMENTS

This study was funded by a dissertation grant award received from the Organization for Autism Research (OAR). With the funding received, all supplies were purchased for the implementation of the study including curriculum and Touch IPODs. Upon completion of the study, each participating teacher was allowed to keep the curriculum and each participating student was allowed to keep the Touch IPOD. The generosity of the OAR, made for very happy participants.

To the students with autism and their families: Thank you for sharing your lives with me. The opportunity to spend one on one time with each participant allowed for me to gain a depth of understanding that I would not have otherwise experienced. It is because of students like you, that I do what I do. You have so much to offer, yet so much at risk.

To my family: Bob, Kori and Gracie. Over the course of the last three years, each of you has made sacrifices so that I could pursue my dream. Please believe that in my heart, I was not only pursuing my dream, but yours. Through this accomplishment, I hope to provide each of you with the support needed for you to pursue your dreams and for us as a family to pursue our dreams. Each of you is unique and talented. You bring so much joy to my life. Without you, I am nothing.

To my colleagues at UCF: The intense immersion into the world of academics has allowed us to form life-long relationships. Even with our differences, we all have a common thread that flows through our blood: the equity and justice in education for children with disabilities. This common thread binds us forever. It has been an honor to

work, play and study along side each of you. Kara Rosenblatt, Beth Christner, Chrissy Ogilvie, Heather Batchelder, and my colleagues in the mathematics education department: Thank you for your friendship and support over the course of our studies. It is hard to believe we are finished. Really, we are just beginning.

To my friend BiYing Hu: Thank you for our intellectual, yet sometimes heated, discussions on education, culture, and research. A good friend is someone who you can disagree with and still know you respect each other. Our differences and passion are what make us such good friends. You have seen me at my worst and at my best (I hope that you will keep the worst to yourself). I look forward to future collaborations.

To my mentors: Wilfred Wienke, G. Richmond Mancil, Cynthia Pearl, Mary Little, Maria Reyes, Marjorie Montague and Jane West. The experiences each of you has afforded me are tremendous. You have taught me, supported my research, and guided me in my professional development. When I leave UCF, I will continue your legacy through the work that I do. I promise to make you proud.

To Project Lead: Lisa Dieker and Wilfred Wienke. I cannot express the gratitude that I feel towards you and Project LEAD. Thank you for allowing me to study under your guidance and for providing me the opportunity to pursue a doctorate degree. Even on the hardest of days, I still get a smile on my face when I think that someone paid for me to do what I love. Thank you.

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CHAPTER 1 INTRODUCTION

Background and Need

People who have Autism Spectrum Disorders (ASD) are said to have social communication disorders (Church, Alisanski, & Amanullah, 2000; Myles & Simpson, 2002). Yet, many students with ASD also experience difficulties with academic achievement. Educators report difficulties in teaching students with ASD and identifying appropriate educational interventions for students with ASD. As more children are diagnosed with ASD and expected to meet the same academic standards as their neuro-typical peers, there is a demand for effective educational strategies.

There are an estimated 560,000 children between the ages of birth to 21 with an ASD (Center for Disease Control, 2007). Of 150 children, 1 will be diagnosed with an ASD by the age of 8 (Center for Disease Control, 2007). Roughly 50-70% of children with an ASD have an I.Q. greater than seventy (Bertrand et al., 2001; Chakrabarti & Frombonne, 2001). Children who have an ASD, with an I.Q. greater than 70, are often referred to as having high functioning autism (HFA).

According to the Twenty-eighth Annual Report to Congress on Children with Disabilities (2008), children with ASD, including those with HFA/AS, are increasingly served in the general education setting. In 1990-1991, only 4.8% of children with autism spent 80% or more of the day in the general education setting compared to 2003-2004 where 29.1% of children with autism spent 80% or more of the day in the general education setting (OSEP, 2004). The general education service placement of students

with ASD increased at a faster rate than all other disability categories combined (Sansoti & Powell Smith, 2008).

Autism Spectrum Disorders

ASDs are listed in the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV-TR) (American Psychiatric Association, 2000) under the broad category of Pervasive Developmental Delay (PDD). The PDD category consists of five disorders with similar diagnostic and behavioral characteristics. The disorders under PDD are autistic disorder, Asperger's Disorder (commonly referred to Asperger's Syndrome), Pervasive Developmental Delay-Not Otherwise Specified, Childhood Disintegrative Disorder and Rett's Disorder. Childhood Disintegrative Disorder and Rett's Disorder have a slightly different developmental trajectory than the other PDD disorders. Rett's disorder has been identified as a genetic disorder and can be identified with a blood test (Volkmar et al., 2004). Both Rett's Disorder and Childhood Disintegrative Disorder present with normal childhood development with severe regression after several years of normal development (American Psychiatric Association, 2000). The Center for Disease Control (2007) refers to Autistic Disorder, Asperger's Syndrome, and Pervasive Developmental Delay- Not Otherwise Specified as ASD, as do much of the autism community. To be diagnosed with one of the three ASDs, children must present with a qualitative impairment in social communication, social interaction, and restricted/repetitive interests. Qualitative Impairments occur before the age of two (American Psychiatric Association, 2000). Even though children are diagnosed based

upon social interaction, social communication, and restricted/repetitive interests, they may also present with a unique cognitive profile.

ASD Cognitive Profile

Executive functioning are thinking skills. Students with ASD have executive functioning deficits that include poor organizational skills, attention difficulties, motivational issues and work completion problems (Happe, 2001). Executive functioning deficits include: (a) Memory/Planning, including cognitive processes such as organization, working memory, and interference control; (b) Set Shifting/Mental Flexibility, including cognitive processes such as perseveration, attention, and self monitoring; and (c) Inhibition/Response Control, including cognitive processes such as impulse control (Happe). Students with executive functioning deficits have significant challenges in abstract concepts, inferences and applied problems (Donnelly, 2005). Executive functioning is one theory of ASD that accounts for the learning issues children with autism may present. Great variability in the executive functioning of children with autism has lead researchers to seek out other explanations. Memory, one component of executive functioning (Happe; Williams, Goldstein, & Minshew, 2006) has been presented as another theory to account for the cognitive deficits found in children with ASD.

Memory has been identified as one of the primary cognitive domains that is responsible for the clinical manifestations of ASD or is secondary to general cognitive deficits such as executive functioning (Williams, Goldstein & Minshew, 2006). The

pattern of memory for children with ASD can be conceptualized as a disorder of information processing that affects complex information processing abilities (Minshew & Goldstein, 1998). Children with ASD do not use organizational strategies or context to support memory (Frith, 1970a, 1970b; Fryffe & Prior, 1978) and have difficulty using semantic, syntactic and time events to facilitate retrieval of information (Tager-Flusberg, 1991). Furthermore, it appears that memory for low-level materials is intact and memory for complex levels of organization is impaired (Fein et al., 1996). Visual memory and visual working memory have been identified as strengths for individuals with ASD (Williams, Goldstein, & Minshew, 2006). However, visual memory, verbal memory, visual working memory and verbal working memory of individuals with autism are impacted by the complexity of the material (Williams, Goldstein, & Minshew).

Academic Achievement Profile

Children with high functioning ASD, i.e. high functioning autism and Asperger's syndrome, are most appropriately served in a general education setting. In order to assist children with HFA/AS, teachers need to understand the overall pattern of deficits expected for children with HFA/AS, and then examine the achievement profile of the individual student (Griswold, Barnhill, Smith Myles, Hagiwara & Simpson, 2002). Review of the literature suggests that children with HFA/AS have average mathematical abilities (Chiang & Lin, 2007; Dickerson Mayes & Calhoun, 2003a 2003b) and perform normally in early years (Dickerson Mayes & Calhoun, 2003a 2003b; Goldstein, Minshew & Siegel, 1994). Computational skills appear to be intact (Chiang & Lin,; Dickerson

Mayes & Calhoun, 2003a 2003b; Goldstein, Minshew & Siegel). However, complex problem solving within the mathematics domain impacts applied mathematical ability (Goldstein, Minshew & Siegel; Griswold, Barnhill, Smith Myles, Hagiwara & Simpson, 2002; Minshew Goldstein, Taylor, & Siegel, 1994). Organizational and attention skills may also impact multiple step problem solving (Dickerson Mayes & Calhoun, 2003a) and reading comprehension deficits may impact grade level word problems. Deficit areas such as problem solving may account for the significant difference between average- to above-average IQ and average mathematical ability findings (Chiang & Lin). Dickerson Mayes & Calhoun (2003a) report that 23% of students with HFA/AS in their sample met criteria for a mathematics learning disability compared to 11% of the general population (LDOnline, 2008). Given the characteristics of students with HFA/AS, it is easy to understand why a student may have difficulty in the mathematics classroom under the mandates of mathematical reform.

Mathematics Reform

The National Council of Teachers of Mathematics (NCTM) standards emphasize the development of mathematical thinking, which includes higher-level thinking, reasoning and problem-solving skills relating to the real world (NCTM, 2000). Higher-level thinking, reasoning and problem solving skills that relate to the real world are weaknesses for children with HFA/AS (Dickerson Mayes & Calhoun, 2003a, 2003b; Barnhill, Hagiwara, Smith Myles, & Simpson, 2000; Goldstein, Minshew, & Siegel, 1994; Griswold, Barnhill, Smith Myles, Hagiwara & Simpson, 2002; Minshew,

Goldstein, Taylor, & Siegel, 1994). The NCTM process standards align closely with the executive dysfunction that has been identified for children with autism. To become independent learners, students need to develop cognitive and meta-cognitive skills in the form of learning strategies (Bebko & Riccuiti, 2008; Pressley & Harris, 2006; Shumaker, Denton, & Deshler, 1984). Fortunately, learning strategies have been developed and validated for children with learning disabilities. Cognitive strategy instruction emerged in the 1950s in the field of psychology as information processing theory (Pressley & Harris, 2006).

Cognitive Strategies

Strategies are knowledge of procedures or how to do something. Pressley, Forrest-Pressley, Elliot-Faust, and Miller (1985) define a strategy as “cognitive operations over and above the processes that are natural consequences of carrying out a task, ranging from one such operation to a sequence of interdependent operations. (p. 102)” Strategies include cognition for learning such as memorization or comprehension and can be consciously learned activities (Pressley, Forrest-Pressley, Elliot-Faust, & Miller). Cognition for learning purposes is referred to as procedural knowledge or implicit memory (Rabinowitz, 2002). This is in contrast to declarative knowledge or explicit memory, which are facts. There is evidence to support that procedural knowledge leads to greater declarative knowledge and vice-versa, a strong declarative base leads to ease in procedural facilitation (Rabinowitz). Students with HFA/AS may have good declarative knowledge for facts and procedural knowledge for specific processes (rote)

but may experience deficits in conceptual knowledge (Solomon, Ozonoff, Cummings, & Carter, 2008).

Both procedural and declarative knowledge are stored in long-term memory and are only activated when needed (Pressley & Harris, 2006). Active thinking takes place in working memory. Working memory is the part of intelligence that permits active use and manipulation of information. Working memory is extremely limited, only so much information can be utilized at one time. Decreased working memory abilities have been associated with learning disorders and language disorders (Swanson & Saez, 2003) and with ASD including HFA/AS (Bennetto, Pennington, & Rogers, 1996; Ozonoff & Jensen, 1999). However, research on working memory of people with HFA/AS has produced mixed results (Ozonoff & Strayer, 2001). Ozonoff and Strayer suggest that working memory for people with HFA/AS may be intact and that a central executive dysfunction mediating executive processes may interfere with task performance. The central executive function is multidimensional and not all components are affected in ASD explaining the heterogeneity of the disorder. Meta-cognition is the process of self-monitoring the when and where to apply strategies (Pressley & Harris). Children with HFA/AS may not be good meta-cognitive thinkers as self-monitoring is part of the executive functions (Solomon, Ozonoff, Cummings, & Carter, 2008).

Meta-cognition is thinking about thinking, including the knowledge about the value of using strategies (Pressley & Harris, 2006). Meta-cognition includes knowing when and where to use a strategy. Knowing that a strategy will produce a desired result increases the likelihood of the strategy use. It has been suggested that children with ASD,

including HFA/AS are poor meta-cognitive strategy users (Solomon, Ozonoff, Cummings, & Carter, 2008). Good information processors activate long-term memory into working memory and use meta-cognition to self-monitor strategy use (Pressley & Harris).

Generally, children increase their use of strategies as they proceed through middle school, high school and college (Pressley & Hilden, 2006). Children do discover some strategies on their own (Pressley & Harris, 2006). Sometimes strategies are learned based upon the demand of new tasks. However, children and adults do not discover and use the most potent strategies as they confront academic tasks (Pressley & Harris). There is evidence that middle school children mix effective and ineffective strategies but will shift to effective strategies only with practice (Schlagmeuller & Schnieder, 2002). There is little evidence in any domain that children will certainly discover the most effective strategies, fortunately, strategies can be taught, acquired and generalized (Pressley & Harris). Therefore, strategies must be taught and students must be afforded practice opportunities across different settings and activities.

Swanson and Sachse-Lee (2001) studied the role of working memory, including both executive and phonological processes, on mathematical word problem solving for children with learning disabilities. The authors report that the results indicate that students with learning disabilities experience difficulty in solving word problems, general working memory, verbal working memory, phonological processing and specific components needed to solve word problems such as identifying information related to the question, goals, operations and algorithms in comparison to age matched peers.

Achievement matched peers were better able to identify the goal of the mathematical word problem even though they were of younger age than the students with learning disabilities. More importantly, the authors suggest that executive processes play a more important role than phonological processes in mediating working memory and solution accuracy (Swanson & Sachse-Lee). One of the core problems in mathematical word problem solving identified in this study for children with LD relates to central executive functioning deficits.

Following Swanson and Sashse-Lee (2001), Passolunghi and Pazzaglia (2005) studied the role of working memory and executive function in mathematical word problem solving. They authors suggest that working memory deficits are secondary to central executive function deficits for students who are poor mathematical word problem solvers. Central executive functioning includes working memory, inhibitory process and updating processes (holding information while retrieving needed information from long term memory). The authors suggest that difficulty in mathematical word problem solving is related to all three components of the central executive and not only working memory (Passolunghi & Pazzaglia).

Given that students with HFA/AS experience executive functioning deficits (Happe, Booth, Charlton, & Hughes, 2006), it seems logical that one of the core problems in mathematical word problem solving for this population would be executive functioning. Cognitive/meta-cognitive strategy instruction for mathematical word problem solving may facilitate the executive functions needed for information processing.

ASD and Cognitive Strategy Instruction

It has been suggested that people with ASD are not good strategy users (Benneto, Pennington, & Rogers, 1996). This may be an implication of the executive functioning deficits (Happe, Booth, Charlton, & Hughes, 2006) reported for children with ASD as the self-generation of strategies is one aspect of executive functioning (Bebko & Ricciuti, 2000). However, in studies that suggested poor strategy use by people with ASD (Benneto, Pennington, & Rogers), direct strategy use was not investigated, instead it was inferred from participant's recall or recognition performance. (Bebko & Ricciuti, 2000). Bebko and Ricciuti (2008) studied the use a rehearsal strategies in students with ASD to determine if the strategy use would be developed spontaneously, to determine if the use of the strategy for this population would increase performance, and to determine what conditions would elicit greater strategy use.

Bebko & Ricciuti (2008) suggest that children with HFA/AS do use strategies spontaneously, the use of strategies does increase the performance of children with HFA/AS, and by teaching external cognitive and meta-cognitive strategies, children with HFA/AS increase their performance of tasks significantly. The findings support the view of an executive functioning deficit hypothesis in autism that hampers information processing. The results of this study have clear implications for children with HFA/AS and the practitioners serving them. Children with HFA/AS benefit from strategy instruction and should be taught strategies to reduce the cognitive load. The “hows” of learning must be taught to children with HFA/AS in an explicit format and external support in the use of strategies may be needed. Cognitive/meta-cognitive strategy

instruction for children with HFA/AS must be tailored to meet the unique cognitive profile for children with autism (Bebko & Ricciuti, 2008; Songlee, 2006; Songlee et al., 2008).

Cognitive/meta-cognitive strategy instruction to increase academic performance has been validated for students with learning disabilities, but few have been tested for children with HFA/AS. To date, research on cognitive strategy instruction with children with HFA/AS has been conducted on a memory (Bebko & Ricciuti, 2008), test taking (Songlee, 2006; Songlee et al., 2008), social skills (Webb, Miller, Pierce, Strawser, & Jones, 2004), reading comprehension (O’Conner & Klein, 2004), and writing (Delano, 2007). Research studies on the use of cognitive/meta-cognitive strategy instruction in mathematics for children with HFA/AS have not been reported. The reason few academic interventions such as cognitive/meta-cognitive strategy instruction, have been researched may be because the behavioral, and social needs of children with autism seem to be the most pressing concern, however, with the increase in the number of children with high-functioning autism and the effectiveness of early diagnosis and intervention, the social and behavioral impairments maybe of less concern and academic goals are within reach (O’Connor & Klein, 2004; VanBergeijk, Klin & Volkmar, 2008). As more children with HFA/AS are served in the regular educational setting, there is a need for effective educational strategies to meet the unique cognitive profile and achievement profile of the HFA/AS population. Cognitive strategies must be tested with the HFA/AS population to determine the effectiveness and/or the need for adaptations to meet the need of the HFA/AS population. It has been suggested that *Solve It!* Problem Solving Routine for

mathematical word problem solving may be a good instructional fit for children with HFA/AS as the strategy provides support for the cognitive and meta-cognitive strategy use that children with HFA/AS may lack (Montague, 2003).

Solve It! Problem Solving Routine

Solve It! Problem Solving Routine is a strategy instruction curriculum package developed by Montague (1996) that may be an effective intervention in assisting children with HFA/AS to learn how to solve mathematical word problems. The curriculum consists of teaching students seven cognitive strategies and three meta-cognitive strategies. The seven cognitive strategies are: read, paraphrase, visualize; hypothesize; estimate; compute; and check. The three meta-cognitive strategies include self-management, self-questioning, and self-evaluation. The meta-cognitive strategies are: say, ask; and check. The strategies employed in the curriculum are thought to facilitate linguistic and numerical information processing, formations for visual representations in memory, comprehension of problem information and development planning for problem solution (Mesler, 2004). The instructional model includes four components: (a) assessing performance and appropriate identification of students for the instructional program; (b) explicit instruction in the acquisition and application of strategies for mathematical problem solving; (c) process modeling; and, (d) evaluating student outcomes, with an emphasis on strategy maintenance and generalization (Montague, 2000). The curriculum package includes scripted lessons and implementation checklists. *Solve It!* has been

effective for teaching children with learning disabilities a strategy to solve mathematical word problems (Montague, 1997).

Montague (2000) has suggested that *Solve It!* Problem Solving Routine may be a good instructional fit for children with HFA/AS, however, research studies have not yet been conducted with *Solve It!* and children with HFA/AS. Difficulty solving mathematical word problems for students with HFA/AS may be exacerbated due to the underlying cognitive deficits that contribute to the academic weakness for children with HFA/AS. Given that children with HFA/AS may not acquire problem-solving strategies on their own (Bebko & Ricuitti, 2008), *Solve It!* may be an effective intervention as it capitalizes on the student's strengths, rote/procedural knowledge and visual reasoning, while supporting learning weaknesses, conceptual/declarative knowledge and abstraction (Dickerson Mayes & Calhoun, 2003a 2003b; Goldstein, Minshew, & Siegel, 1994; Griswold, Barnhill, Smith Myles, Hagiwara & Simpson, 2002; Minshew, Goldstein, Taylor, & Siegel, 1994).

Rationale

Children with HFA/AS are outperformed by their neuro-typical peers on mathematical problem solving skills, even though they: have average-to-above-average intelligence (Dickerson Mayes & Calhoun, 2003b); have average-to-above-average computation skills (Chiang & Lin, 2007); and, are educated in the general education setting (USDOE, 2008). In order to graduate with a regular diploma, all students must take and pass three high school mathematics courses including algebra I. Algebra has said

to be the gateway to college (USDOE, 2008). Students with HFA/AS present with a unique set of cognitive deficits that may prevent achievement in the mathematics curriculum due to difficulties with information processing. Information processing includes components of working memory, executive functioning, procedural memory and declarative memory (Passolunghi & Pazzaglia, 2005). Students with HFA/AS present with good declarative and procedural memory, however, demonstrate deficits in conceptual knowledge (Solomon, Ozonoff, Cummings, & Carter, 2008) and information processing for complex materials (Goldstein, Minshew & Siegel, 1994; Griswold et.al, 2002; Minshew Goldstein, Taylor, & Siegel, 1994). It appears logical that the executive functioning deficits inherent to students with HFA/AS interfere with the ability to organize and plan steps to solve complex problems; monitor and inhibit responses for multiple step problem solving; and use mental flexibility that is needed to update and manipulate information in working memory for complex problem solving (Happe, Booth, Charlton, & Hughes, 2006). Cognitive strategy instruction provides structure and routine to complex cognitive tasks, therefore, cognitive strategy instruction may assist students with HFA/AS in compensating for the executive functioning deficits that interfere with complex problem solving, such as mathematical word problems. In order for learning strategies and meta-cognitive strategies to be effective for children with HFA/AS, they must compensate for the unique set of cognitive needs children with HFA/AS present (Bebko & Ricciuti, 2000; Songlee, 2006; Songlee et al., 2008).

Problem Statement

Cognitive strategy instruction and meta-cognitive strategies have shown to be effective with disability groups such as learning disabilities (Bebko & Ricciuti, 2008; Pressley & Harris, 2006; Shumaker, Denton, & Deshler, 1984; Swanson, 2001). Meta-cognitive strategies may assist the student with HFA/AS in circumventing the executive functioning deficits that prevent them from performing in accordance with their neuro-typical peers (Bebko & Ricciuti, 2008). However, little research has been conducted on the effects of learning strategies on the academic achievement of children with HFA/AS. This study investigates the effects of cognitive strategy instruction in mathematical word problem solving to increase the percentage correct on multiple-step mathematical word problems for children with HFA/AS and the effects of two priming methods that could developed and used in the classroom should students not maintain the learned skill.

Research Questions

1. What is the effect of the *Solve It!* Problem Solving Routine on the percentage correct of multiple step word mathematical problems for middle school students with HFA/AS?
2. What is the effect of the *Solve It!* Problem Solving Routine on reported self-perceptions in and attitudes towards mathematical word problem solving for children with HFA/AS?
3. Does the use of a multimedia academic story written for the *Solve It!* Problem Solving Routine or the use of written *Solve It!* cue cards work best as a prime

if the student does not maintain the use of the *Solve It!* Problem Solving Routine?

List of Terms, Acronyms, and Definitions

Autism Spectrum Disorders (ASD). ASD is a term that is used interchangeable with Pervasive Developmental Delay, the broad category listed in the DSM-IV-R. ASDs include autistic disorder, Asperger's Syndrome, Rett's disorder, childhood disintegrative disorder and pervasive developmental delay-not otherwise specified.

Autistic Disorder. Autistic disorder is characterized by a severe impairment in social interaction, communication, and repetitive behaviors (American Psychiatric Association, 2000). Children with autistic disorder demonstrate severe language/communication impairment prior to the age of two.

Asperger's Syndrome (AS). AS is a disorder of social interaction, social communication and restricted interests listed in the DSM-IV-R as a PDD or ASD. It is characterized by typical language development and average to above average IQ.

Cognitive Strategy Instruction. Is a broad term used to define the teaching of strategies that assist students in becoming self regulated learners.

Constructivist Approach. The constructivist approach is a psychology theory of learning, which states that people generate their own meaning and learning through experiences. Constructivist approach implies that students must develop meaning for themselves for learning to take place.

CRA. CRA is an intervention approach in teaching students to develop abstract conceptualizations by moving them from concrete understanding to representational understanding to abstract understanding.

Direct Instruction. Direct Instruction is an intensive instructional method based on the theory that learning can be greatly accelerated if instructional presentations are clear and systematic (Northwest Regional Education Laboratory, 1998).

Executive Function. Executive functioning is thinking skills. Executive functioning deficits that include: 1) Memory/Planning, including cognitive processes such as organization, working memory, and interference control; 2) Set Shifting/Mental Flexibility, including cognitive processes such as perseveration, attention, and self monitoring; and 3) Inhibition/Response Control, including cognitive process such as impulse control (Happe, Booth, Charlton, & Hughes, 2006).

Generalization. *“The occurrence of relevant behavior under different, non-training conditions (i.e., across subjects, settings, people, behaviors, and/or time) without the scheduling of the same events in those conditions as had been scheduled in the training conditions* (Stokes and Baer, 1977, p. 350)

High-functioning autism (HFA). HFA is a term to describe children with autistic disorder with an IQ of 80 or higher. Some studies set the IQ criteria at 70. Many times, people with Asperger’s Syndrome are also included in this classification.

Learning Disabilities. Learning disabilities is a broad term for is a neurological disorder, which results in learning difficulties in specific areas. People with learning disabilities have average to above average intelligence.

Meta-cognitive Strategy Instruction. Meta-cognition is the process of monitoring and controlling thought (Martinez, 2006).

Multimedia Academic Stories. A multimedia intervention based upon the theory of social stories but developed to target academic concepts in the content areas. The multimedia component includes visual, written and audio modes of input.

National Council for Teachers of Mathematics (NCTM). A national organization that serves mathematic teachers and administrators by providing resources and professional development. NCTM provides a framework for teaching mathematics with principles for school mathematics, content standards, and process standards.

Neuro-typical Peer. A neuro-typical peer is a person with normal neurological functioning. People with autism and autism specialists often refer to those without autism as neuro-typical.

No Child Left Behind (NCLB). NCLB is sweeping legislation enacted in 2001 to assure high quality education for all students. This includes highly qualified teachers for all students and mandates that all students achieve adequate yearly progress.

Priming. A prime is an antecedent event that prepares the student to perform the task or behavior by previewing the task before the demand. Priming can be used as a strategy to explicitly teach generalization of learned skills.

Social Stories. Social stories are a cognitive strategy to increase the social abilities of children with ASD. A social story is an individualized story that assists children with ASD in interpreting and understanding confusing or challenging social situations (Gray, 2000).

Solve It! Solve It! is a validated cognitive strategy intervention that targets mathematical word problem solving. The strategy consists of 7 cognitive processes and three meta-cognitive processes that good problem solvers use.

Theory of Mind. Theory of mind is the ability to infer the thoughts or beliefs of others (Barnhill, 2001).

Video Modeling. Video modeling is defined as modeling in which the model is not a live one, but one that is videotaped, in an effort to change or learn behaviors (Nikopoulos & Nikopoulou-Smyrni, 2008). An observer discriminates a model's behavior by viewing the video and subsequently performs that specific behavior in natural settings.

Working Memory. Working memory is the part of intelligence that permits active use and manipulation of information.

CHAPTER 2 LITERATURE REVIEW

The purpose of this chapter is to present the literature and research to support the conceptual framework of the study presented in Chapter 1. First, an overview of autism spectrum disorders will be provided with a description of the disorder and prevalence. Second, the impact of the No Child Left Behind act will be discussed including the impact of accountability and the highly qualified teacher on students with high-functioning autism (HFA). Third, mathematical reform will be discussed as it relates to students with disabilities including those with HFA. Fourth, the academic functioning of students with HFA/AS will be provided and includes the implications of the academic profile of students with HFA/AS as it relates to reading, writing and mathematics. Fifth, cognitive strategy instruction will be presented. Finally, issues and strategies for generalization of learned skills will be presented.

Autism Spectrum Disorder Prevalence

There are an estimated 560,000 children between the ages of birth to 21 with an ASD (Center for Disease Control, 2007). This number is expected to increase as roughly 1 out of 150 children born are expected to receive a diagnosis of ASD (Center for Disease Control, 2007). One reason for the increase in diagnosis is due to better assessment and broadening of the diagnostic criteria of ASDs (Rutter, 2005). Roughly 50-70% of children with an ASD have an I.Q. greater than 70 (Bertrand et al., 2001; Chakrabarti & Frombonne, 2001). As early intervention methods are identified, the number of children

with HFA/AS is expected to increase as the obvious maladaptive characteristics of autistic disorder are reduced (O'Connor & Klein, 2004). To be diagnosed with an ASD, children must demonstrate a qualitative impairment in social interactions, social communication and restricted or repetitive interests (American Psychiatric Association, 2000), frequently referred to as the triad of impairments (Wing & Gould, 1979).

Autism Spectrum Disorders: Varied Levels of the Triad of Impairments



Figure 1. Triad of Impairment (Wing & Gould, 1979)

Social Interaction

Social interaction refers to the ability to interact with peers. Students with HFA/AS have difficulty with social interaction, including initiating and maintaining conversation, adapting social skills to various situations and monitoring social cues (Myles & Simpson, 2002). The abnormal range of social interaction can manifest in

different ways for different students with HFA/AS (Barnhill, 2001). Although some students with HFA/AS may be able to identify social cues in isolation, they may not be able to do so in context or real world social activities that involve themselves (Konig & Magill-Evans, 2001). Some Students with HFA/AS may use simple social skills such as greetings, but unable to extend or reciprocate the extension of a greeting.

Social Communication

Social communication refers to nonverbal and verbal communication skills. Even though students with HFA/AS may have high vocabulary skills, researchers have shown that they have poor auditory comprehension and nonverbal skills (Barnhill, 2001; Konig & Magill-Evans, 2001). The inability to comprehend social communication and nonverbal social language places students with HFA/AS at a clear disadvantage in understanding emotional meaning compared to their neuro-typical peers (Barnhill). While people with HFA/AS are able to identify the meaning of facial, posture and gesture in isolation, they may not be able to do this in context (Konig & Magill-Evans). The verbal ability of students with HFA/AS gives the appearance that they are effective communicators and this can presents difficulties when expectations are set higher than student abilities (Farrugia & Hudson, 2006). Students with HFA/AS do not show anxiety symptoms the same way as their neuro-typical peers. They do not reveal stress through voice, posture or tone and, as a result, situations may escalate to a crisis before someone notices (Myles & Southwick, 1999).

Restricted or Repetitive Interests

Students with HFA/AS tend to have restricted interests which interfere with the ability to change topics or discuss topics outside of their area of interest (Barnhill, 2001). While the interest may be similar to their neuro-typical peers, the way they engage in the interest is different in that the child with HFA/AS will isolate him/herself in the activity. Many times individuals with HFA/AS will chose one topic of interest and develop an obsessive interest in that topic to the exclusion of all others, and will possess a degree of knowledge on the topic that is not consistent with neuro-typical peers (Myles & Simpson, 2002). According to Barnhill, persons with HFA/AS may engage in restricted interests to facilitate conversation, indicate intelligence, provide an enjoyable activity, to relax or to provide order and consistency. Students with HFA/AS demonstrate rigidity in routine, compulsion to finish tasks once they start, fear, based on a single experience and insistence on a set of rules (Barnhill). This rigidity makes it difficult for the student with HFA/AS to adapt to new settings and to change their behavior to meet the demands of the setting.

Differential Diagnosis

It is important for teachers to understand the diagnostic umbrella of Pervasive Developmental Delay (PDD) in relation to the ASDs so they have a basic understanding of the commonalities of the disorders should a student be placed in their classroom. ASDs are listed in the *Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR)* under a broad category of Pervasive Developmental Delay (PDD) (American

Psychiatric Association, 2000). The disorders listed in the PDD category are Autistic Disorder, Rett's Disorder, Childhood Disintegrative Disorder, Asperger's Disorder and Pervasive Developmental Delay-Not Otherwise Specified. Asperger's Disorder is more commonly referred to as Asperger's syndrome (AS). Autistic Disorder, Asperger's Syndrome, and Pervasive Developmental Delay-Not Otherwise Specified are the autism spectrum disorders, commonly referred to as ASD (Center for Disease Control, 2007). The PDDs and the ASDs have similar diagnostic and behavioral characteristics. A brief summary of the differential diagnosis of the PDDs, including the ASDs, follows.

Autistic disorder is characterized by a severe impairment in social interaction, communication, and repetitive behaviors (American Psychiatric Association, 2000). Children with autistic disorder demonstrate severe language/communication impairment prior to the age of two. Some children with autism have normal development and regress around the age of 18 months. AS is characterized by a severe impairment in social interaction, social communication and restricted interests (American Psychiatric Association). Children with AS develop language skills prior to the age of 2 and people with AS have at least average intelligence. Pervasive Developmental Delay-Not Otherwise Specified (PDD-NOS) is a sub-threshold category (American Psychiatric Association). Children who demonstrate some characteristics of the other PDDs, and do not meet criteria for any other PDD, may receive a diagnosis of PDD-NOS. Rett's disorder is characterized by a severe regression of development after a period of normal development and is generally seen in girls (American Psychiatric Association). Diagnosis of Rett's disorder is confirmed with a simple blood test as researchers have discovered a

genetic marker for the disorder (Volkmar et al., 2004). Childhood Disintegrative Disorder (CDD) is characterized by a severe regression in development up to the age of 10 years old (American Psychiatric Association, 2000). CDD is a rare yet devastating disorder, as families see a typically developing child severely regress with a loss of skills in the areas of social interaction and communication while developing abnormal repetitive behavior patterns. CDD and RD are rare disorders and children with these diagnoses usually present with greater severity of cognitive functioning over the development of the condition (American Psychiatric Association). Many times children with CDD and RD need services that are difficult to provide in a general education setting. More often, children with HFA, AS, and PDD-NOS are served in the general education setting (Twenty-eighth Annual Report to Congress on Children with Disabilities, 2008).

Studies comparing the diagnostic criteria for HFA and AS that controlled for IQ have documented no significant difference in the two disorders. Furthermore, the validity of AS as a distinct disorder according to the DSM-IV-TR is questionable as many research studies indicate that people with AS meet criteria for both AS and autism (Prior, 2003). Most studies set the criteria for HFA/AS at an IQ of 80 or higher. For the purpose of this study, subjects will meet criteria for HFA or AS as researchers have suggested comparability of the two disorders (Prior, 2003). Children with HFA/AS are likely to be served in the general education setting; therefore, it is imperative that teachers understand the cognitive profile of this population to gain an understand of the learning difficulties this group of children may encounter.

Cognitive Profile

Students with HFA/AS have executive functioning deficits that include poor organizational skills, attention difficulties, motivational issues and work completion problems (Happe, Booth, Charlton, & Hughes, 2006). Executive functioning deficits include: (a) memory/planning, including cognitive processes such as organization, working memory, and interference control; (b) set shifting/mental flexibility, including cognitive processes such as perseveration, attention, and self monitoring; and (c) inhibition/response control, including cognitive processes such as impulse control (Happe, Booth, Charlton, & Hughes). Students with executive functioning deficits have significant challenges in abstract concepts, inferences and applied problems (Donnelly, 2005). Executive functioning is one theory of autism that accounts for the learning issues students with HFA/AS may present. The great variability in executive functioning of children with autism, including HFA/AS has lead researchers to seek out other explanations. Memory, one component of executive functioning has been presented as another theory to account for the cognitive deficits found in children with HFA/AS (Happe, Booth, Charlton, & Hughes; Williams, Goldstein, & Minshew, 2006).

Memory has been identified as one of the primary cognitive domains that is responsible for the clinical manifestations of autism spectrum disorders or is secondary to a general cognitive deficit such as executive functioning (Williams, Goldstein & Minshew, 2006). The pattern of memory for children with HFA/AS can be conceptualized as a disorder of information processing that affects complex information processing abilities (Minshew & Goldstein, 1998). Children with HFA/AS do not use

organizational strategies or context to support memory (Frith, 1970a.1970b; Fryffe & Prior, 1978) and have difficulty using semantic, syntactic and time events to facilitate retrieval of information (Tager-Flusberg, 1991). Furthermore, it appears that memory for low-level materials is intact and memory for complex levels of organization is impaired (Fein et.al.,1996). Visual memory and visual working memory have been identified as strengths for individuals with ASD (Williams, Goldstein, & Minshew, 2006). However, visual memory, verbal memory, visual working memory and verbal working memory of individuals with autism are impacted by the complexity of the material (Williams, Goldstein, & Minshew). To become independent learners, students need to develop cognitive and meta-cognitive skills in the form of cognitive strategy instruction (Bebko & Ricuitti, 2008; Pressley, 2006; Shumaker, Denton, & Deshler, 1984).

Academic Profile

Griswold et. al. (2002) suggest knowing that a child has HFA/AS has little value to the teacher due to the heterogeneous nature of autism spectrum disorders. Teachers need to understand the overall pattern of deficits expected for students with HFA/AS, and then examine the achievement profile of the individual student. Relatively little research has been conducted on the academic achievement of students with HFA/AS.

The academic profile in reading suggests that basic reading and decoding are intact for students with HFA/AS (Dickerson Mayes & Calhoun, 2003a 2003b; Barnhill, Hagiwara, Smith-Myles, & Simpson, 2000; Goldstein, Minshew, & Siegel, 1994; Griswold et.al., 2002; Minshew, Goldstein, Taylor, & Siegel, 1994). Reading ability is

commensurate with IQ up to around age eight (Dickerson Mayes & Calhoun, 2003b). During the early years, students with HFA/AS may perform at or above their peers on reading tasks. After age eight, reading instruction focuses more on comprehension including abstract concepts such as main ideas, inferences and causes/effect and material becomes less explicit which may explain the decrease in reading ability when compared to neuro-typical peers (Dickerson Mayes & Calhoun, 2003b). Comprehension deficits are an area identified as part of the academic profile in HFA/AS (Barnhill, Hagiwara, Smith-Myles, & Simpson, 2000; Dickerson Mayes & Calhoun, 2003a 2003b; Goldstein, Minshew & Siegel, 1994; Griswold et. al., 2002; Minshew Goldstein, Taylor, & Siegel, 1994). Reading comprehension maybe further impacted by the theory of mind and attention deficits (Dickerson Mayes & Calhoun, 2003a).

Both written expression and graphomotor deficits are identified as weaknesses for students with HFA/AS (Barnhill, Hagiwara, Smith-Myles, & Simpson, 2000; Dickerson Mayes & Calhoun, 2003a 2003b; Griswold et al., 2002). Graphomotor deficits may be caused by motor coordination difficulties. Written expression may be impacted by organization and attention deficits (Barnhill, Hagiwara, Smith-Myles, & Simpson; Dickerson Mayes & Calhoun, 2003a; 2003b; Griswold et al.).

Review of the literature suggests that students with HFA/AS have average mathematical abilities (Dickerson Mayes & Calhoun, 2003a; 2003b) and perform similarly to neuro-typical peers in early years (Dickerson Mayes & Calhoun, 2003a; 2003b; Goldstein, Minshew & Siegel, 1994). Computational skills appear to be intact, however, complex problem solving within the mathematics domain impacts applied

mathematical ability (Goldstein, Minshew, & Siegel; Griswold, Barnhill, Smith-Myles, Hagiwara & Simpson, 2002; Minshew, Goldstein, Taylor, & Siegel, 1994).

Organizational and attention skills may also impact multiple step, problem solving (Dickerson Mayes & Calhoun, 2003a) and reading comprehension deficits may impact grade level word problems. Deficit areas such as problem solving, may account for the significant difference between average-to-above-average IQ and average mathematical ability findings in students with HFA/AS (Chiang & Lin, 2007). Dickerson Mayes & Calhoun (2003a) report that 23% of students with HFA/AS in their sample met criteria for a mathematics learning disability. The National Council of Teachers of Mathematics (NCTM) standards emphasize the development of mathematical thinking, which includes higher-level thinking, reasoning and problem solving skills relating to the real world (NCTM, 2000). Higher-level thinking, reasoning and problem solving skills that relate to the real world are weaknesses for students with HFA/AS (Barnhill, Hagiwara, Smith-Myles, & Simpson, 2000; Dickerson Mayes & Calhoun, 2003a 2003b; Goldstein, Minshew & Siegel, 1994; Griswold et al.; Minshew, Goldstein, Taylor, & Siegel). Charts presented in Appendix A provide a review of the research-based studies on academic achievement of students with HFA/AS, the research design of the studies on the academic achievement of students with HFA/AS, and the overall findings from the study.

Mathematical Ability and HFA/AS

The mathematical ability of children with HFA/AS has gained little attention in the research literature. To further support the academic achievement profile of students

with HFA/AS in mathematics, a review of the literature (Chiang & Lin, 2007) is presented.

Chiang and Lin (2007) conducted a review of the literature of the mathematical abilities of students with HFA/AS in order to determine if students with HFA/AS have mathematical deficits, if students with HFA/AS have a weakness in mathematics, and if students with HFA/AS have giftedness in mathematics. In order to conduct the synthesis of the literature, the authors searched the *Education Resources Information Center* and *PsychInfo* databases using terms such as Asperger's Disorder/Syndrome, High-functioning autism, mathematics and academic achievement between the years 1986 to 2006. Studies providing characteristics of students with high-functioning autism and mathematical ability were included in this study.

In regards to mathematical deficits and students with HFA/AS Chiang and Lin (2007) identified eight studies that used standardized achievement tests to investigate mathematical ability. The results of the studies indicated that students with HFA/AS have average overall mathematical abilities when compared to their neuro-typical peers. In regards to students with HFA/AS and mathematical weaknesses, the authors compared the arithmetic subtest score to the overall subtests score to identify weaknesses. The studies suggested a significant difference between the arithmetic subtest score and the average subtest scores on standardized mathematical achievement tests, however, the effect size was small. Therefore, it was concluded that students with HFA/AS do have a weakness in mathematics, but it is modest. In regards to giftedness in mathematics, the literature review indicates that students with HFA/AS have average-to-superior

mathematical abilities, suggesting that some students with HFA/AS may have mathematical giftedness.

Chiang & Lin (2007) report an overall weakness in mathematics for students with HFA/AS. This study analyzed overall mathematic ability and not the individual subtests that contribute to the mathematic weakness. A hierarchical linear regression of the mathematical subtest scores may have shown which subtest areas contribute to the overall weakness. Research studies suggest students with HFA/AS have average to above average computational skills and difficulty with applied problems (Goldstein, Minshew, & Siegel, 1994; Griswold, Barnhill, Smith-Smith-Myles, Hagiwara & Simpson, 2002; Minshew, Goldstein, Taylor, & Siegel, 1994). Comparison of the applied problems subtest to overall full scale IQ may have shown further discrepancy. Achievement tests such as the Woodcock Johnson Tests of achievement provide visual support for students, especially during the earlier achievement levels. As the levels increase, the applied problems become more consistent with word problems and include less visual support. The visual support of the standardized test may have contributed to the success of the students with HFA/AS. Goldstein, Minshew, & Siegel suggested that students with HFA/AS academic profile changes with student's age. Student's achievement levels tend to decrease as the student enters middle school where the content becomes more applied, conceptual and abstract. Analysis of the data by grade level (elementary, middle, and high school) may have revealed significant differences in mathematical achievement across the grade span.

Students with HFA/AS may display significant difficulty with mathematical word problems due to the academic achievement deficits and executive functioning deficits. Mathematical word problems require reading comprehension, mental flexibility, organization, attention, and working memory (Desoete, Roeyers, & De Clerq, 2003). Although students with HFA/AS may have the rote/procedural knowledge to solve word problems without context, solving word problems requires the simultaneous use of cognitive processes (Jitendra, Griffin, Deatline-Buchman, & Sczeniak, 2007). As students move from elementary to middle school, the achievement gap increases in mathematics for students with ASD (US DOE, 2008) as the standards in mathematics becomes more applied and abstract. The reason for the increase in the achievement gap in mathematics between neuro-typical students and students with disabilities, including those with HFA/AS, during middle school, may be due to increased need for executive processes that children with HFA/AS may lack as material becomes more applied, abstract, and complex.

When students with autism do not receive educational services to meet their unique learning needs, they are at risk for becoming low achievers (Kinney & Fisher, 2001). Students with HFA/AS are expected to perform and be assessed alongside their neuro-typical peers according to the accountability standards under the No Child Left Behind Act (NCLB).

No Child Left Behind Act

No Child Left Behind (NCLB) is the re-authorization of the Elementary and Secondary Education Act and has been identified by some as the most significant piece of education legislation enacted by the federal government since Brown versus the Board of Education (Yell, Katsiyannas & Shiner, 2006). The purpose of NCLB is to ensure that students in public schools achieve grade-level learning standards in safe schools while being taught by highly qualified teachers (Yell, Katsiyannas & Shiner, 2005). NCLB does this by mandating accountability, scientifically-based instruction, increased parental involvement and school choice, and highly qualified teachers for all students, including students with disabilities (NCLB, 2001)

Increased accountability for the achievement of all students and assuring adequate yearly progress (AYP) is mandated by the NCLB act (Yell, Katsiyannas & Shiner, 2006). In order for a school to meet AYP, at least 95% of enrolled students must participate in testing, all students must score at the proficient level, and all students and subgroups must meet set targets for graduation and attendance (NCLB, 2001). The increased accountability of the NCLB act has made it imperative that students have access to the general curriculum in order to make positive contributions to AYP (West & Whitby, 2008).

The NCLB act (2001) recognizes the importance of having well-trained teachers in classrooms and requires teachers hired in public schools be highly qualified in the subject areas they are teaching by 2005-2006 (Yell, Drasgow & Lowery, 2005). To be highly qualified under the NCLB act (2001), teachers must have a bachelor's degree,

have full state certification in the area they teach, and demonstrate subject matter competency in the subject matter they teach. These requirements apply to those teaching students with exceptional needs. The highly qualified mandate poses a difficult situation for special educators, as many special education teachers are not certified in the content areas they teach.

One result of the implementation of the NCLB act (2001) is students with mild disabilities who were previously served in resource rooms or varying exceptionality classrooms are mostly being served in less restrictive environments in order to meet the accountability standards and highly qualified teacher standard (West & Whitby, 2008). By moving students from specialized classrooms into co-taught teaching environments, students have greater access to the general curriculum increasing the likelihood of passing standardized testing (Yell, Katsiyannas & Shiner, 2006) and are taught by a highly qualified teacher in the regular education environment (Yell, Drasgow & Lowery, 2005). According to the Twenty-eighth Annual Report to Congress on Children with Disabilities (2008), children with autism spectrum disorders, including those with HFA/AS, are increasingly served in the general education setting. In 1990-1991, only 4.8% of children with autism spent 80% or more of the day in the general education setting compared to 2003-2004 where 29.1% of children with autism spent 80% or more of the day in the general education setting (Office of Special Education Programs, 2004). The general education service placement of students with autism has increased at a faster rate than all other disability categories combined (Sansoti & Powell Smith, 2008). Academic achievement becomes increasingly important as the number of students with

autism served in the regular education setting increases (US DOE, 2004). Concerns for the academic achievement in the mathematics classroom for children with disabilities, including HFA/AS, have increased under the mandates of mathematics reform (Woodward & Montague, 2002).

Mathematics Reform

The National Council for Teachers of Mathematics (NCTM) made the following statement in the executive summary on the Principles and Standards for School Mathematics:

In this changing world, those who understand and can do mathematics will have significantly enhanced opportunities and options for shaping their future. Mathematical competence opens doors to productive futures. A lack of mathematical competence keeps those doors closed. The National Council for Teachers of Mathematics challenges the notion that mathematics is for only the select few. On the contrary, everyone needs to understand mathematics. All students should have the opportunity and the support necessary to learn significant mathematics with depth and understanding. There is no conflict between equity and excellence. (NCTM, 2000, p. 1)

As a result of the changing world, a decline in the mathematical abilities of students in the United States when compared with other nations, and a shift in the theoretical paradigm to constructivist and cognitive approaches, mathematics reform was born (Woodward & Montague, 2002). To ensure high quality instruction, the NCTM developed six principles for school mathematics, five process standards for teaching mathematics and curriculum standards in Pre K-12 mathematics to guide the sequential learning of mathematics (NCTM, 2000).

The six principles for school mathematics are equity: high expectations for all students; curriculum: a coherent focus on important mathematics that is sequenced across grade levels; teaching: understanding what students know, what they need to learn as well as challenging and supporting students to learn mathematics well; learning: students have a deep understanding of what they have learned and build upon previous knowledge; assessment: guides teaching and provides information to both the student and teacher; and technology: an essential component in teaching mathematics as it influences what and how mathematics are taught and enhances student's learning.

The NCTM content standards describe strands of content that students should learn across the grade levels. The content Standards are: Number and Operations; Algebra; Geometry; Measurement; and Data Analysis and Probability. Each content standard is explicitly described in each grade level to provide developmentally appropriate sequential learning.

The NCTM provides five process standards to guide ways in which students can acquire and apply the content standards. The five process standards are: problem solving, reasoning and proof process, communication, connections and representation (Gagnon & Maccini, 2001). The process standards allow students to develop a rich understanding of mathematical thinking and the ability to apply mathematic concepts in complex situations. The research base for how to teach problem solving continues to be in a stage of development. However, van Garderen (2008) suggested that explicit instruction, critical thinking, exposure to different types of word problems, and opportunities to practice what they have learned in real world situations are important recommendations

that need to be incorporated into problem solving instruction. NCTM (2000) is clear in its recommendation that teachers need to focus time and energy on problem solving. van Garderen examined the problem solving instructional practices of middle school special education mathematics teachers. The results of the study suggest that special education middle school mathematics teachers are focusing more attention on concrete instructional approaches versus critical thinking, give more practice problems than real world problem solving activities, use below grade level text and curriculum materials, and only spend one hour per week teaching problem solving (van Garderen). NCTM (2000) stresses the importance of teaching problem solving in all areas of mathematics. The lack of instruction in problem solving is of great concern to students whose disability, such as HFA/AS, greatly impacts their ability to problem solve across all domains (Goldstein, Minschew, & Siegal, 1994). The NCTM standards and processes are based upon a cognitive and constructivist approach to learning (Woodward & Montague, 2002). Mathematics reform has brought about much discussion and concern for children with disabilities.

Reform Mathematics and Students with Disabilities

Traditionally, students with disabilities have been taught mathematics via a direct instruction approach. Special education history has placed an emphasis on rote learning, mastery of math facts and basic operations while focusing less on problem solving (Swanson, Hoskyn, & Lee, 1999). While direct instruction has been effective for factual information, it does little to develop higher order thinking skills (Palincsar, 1998). While

some special educators believe that the constructivist approach will lead to greater failure for students with disabilities, others believe that they are compatible (Woodard & Montague, 2002). Given the call to provide students with disabilities access to the general education curriculum, special educators need to reconsider teaching approaches and adapt the approaches to align with the mathematics reform agenda (Woodward & Montague).

Curriculum reform in mathematics is based upon thinking skills and relies on the ability to understand and represent problems; draw on mathematical knowledge and know where, when, how and why to apply that knowledge; and explain the concepts of the problem and why procedures are used (NCTM, 2000). Traditional mathematics instruction focuses on rote acquisition of declarative and procedural knowledge and does not focus on conceptual knowledge (NCTM). Padron, Waxman and Riveria (2003) suggested that the traditional notion of educating students in basic skills before exposing them to more challenging academic material leads to a limited mastery of cognitive skills. A basic skills mastery approach can result in the inability to solve problems and develop higher order thinking.

Hudson, Miller and Butler (2006) suggest educators develop strategies to adapt and merge traditional teaching strategies for diverse learners with the cognitive/constructivist approach encouraged by mathematics reform. Mathematics reform supports constructing knowledge via interacting with mathematical materials, representing ideas and process in different ways, and sharing ideas with other students as well as making connections in between classroom and real world problem solving, and development of deep conceptual knowledge. However, explicit instruction may be

needed after students have struggled with the problems on their own and are unable to construct an appropriate knowledge base. To merge explicit teaching with mathematics reform, the authors suggest using a structured planning format that focuses on high, average and low mathematical achievers. There are commonalities in the needs of these three groups that teachers can plan around. The commonalities are the need for high interest, authentic learning tasks, and an appropriate level of challenge and mastery before progressing to the new content area. The authors further suggest two evidence-based practices for mathematics, Anchored Instruction and the Concrete-Representational-Abstract Approach (CRA), as they align well with the constructivist approach of mathematics reform. Anchored Instruction consists of using authentic problem situations in the form of a video designed to catch the students' interests while engaging them in mathematical problem solving tasks. Explicit instruction on the skills necessary to complete the task can be done prior to the anchored instruction. The CRA approach presents students with visual representation of the problem, which assists students in making the connections between the visual representation and concepts. Explicit instruction can enhance the CRA approach with advanced organizers to review the skills necessary to support learning and via teacher demonstrations and opportunities to represent the problem in multiple ways so that all children develop at least one way to solve the problem.

Mathematical curriculum reform stresses the exact abilities that students with HFA/AS struggle with while traditional mathematics focuses on the strength of students with HFA/AS. The strength in rote acquisition and procedural knowledge gives the

illusion of high mathematical ability, yet when students with HFA/AS are presented with activities that require the use of problem solving skills, they struggle (Barnhill, Hagiwara, Smith-Smith-Myles, & Simpson, 2000; Dickerson Mayes & Calhoun, 2003a 2003b; Goldstein, Minshew, & Siegel, 1994; Griswold et.al., 2002; Minshew, Goldstein, Taylor, & Siegel, 1994). The need to use executive functioning skills to be successful in mathematics occurs during middle school when mathematics becomes more applied and abstract (Goldstein, Minshew, & Siegel, 1994). Successful mathematical word problem solving is a complex process that involves reading, writing, and computational skills as well as complex executive functions (Passolunghi & Pazzaglia, 2005; Swanson & Sachse-Lee, 2001).

Mathematical Word Problem Solving

Swanson and Sachse-Lee (2001) studied the role of working memory, including both executive and phonological processes, on mathematical word problem solving for students with learning disabilities. The participants were 73 elementary school students including students with learning disabilities ($n = 24$), chronological age matched controls, and achievement age matched controls. Inclusion criteria for the students with learning disabilities included an $IQ > 85$, reading or mathematics comprehension scores at or below the 25th percentile ranking, no history of brain injury and identification of a learning disabilities by a multidisciplinary team. The subjects completed mathematical word problem processing tasks that include recall of text on mathematical word problems and solving of mathematical word problems. Phonological processing, verbal working

memory, auditory digit sequencing, and visual-spatial working memory were also assessed during the study. The researchers used several MANOVAs, an ANCOVA, hierarchical regression and correlation analysis to evaluate phonological processes and working memory processes on mathematical word problem solving for students with learning disabilities in comparison to age matched and achievement matched controls. The study indicated that students with learning disabilities experience difficulty in solving word problems, general working memory, verbal working memory, phonological processing and specific components needed to solve word problems such as identifying information related to the question, goals, operations and algorithms in comparison to age matched peers. Achievement matched peers were better able to identify the goal of the mathematical word problem even though they were of younger age than the students with learning disabilities. More importantly, the study revealed that executive processes play a more important role than phonological processes in mediating working memory and solution accuracy (Swanson & Sachse-Lee, 2001). In general, the findings support models of higher order processing and suggesting working memory activates knowledge from long-term memory and regulates and controls the cognitive system. One of the core problems identified in this study for children with LD and mathematical problem solving relates to central executive functioning deficits. Cognitive/meta-cognitive strategy instruction for mathematical word problem solving should facilitate the executive functions needed for information processing (reference).

In a study completed by Passolunghi and Pazzaglia (2005), the authors assessed the central executive system of updating and inhibitory processes on the mathematical

word problem solving performance of high and low achieving mathematics students. The central executive system of working memory consists of inhibitory processes and updating processes (Passolunghi & Pazzaglia). The inhibitory process allows people to suppress irrelevant information. Poor mathematical word problem solvers demonstrate poor memory for critical information and better memory for irrelevant information (Passolunghi, Cornoldi, & De Liberto, 1999). Updating processes refers to holding information in working memory, while new items arrive and dropping items that are no longer needed (Passolunghi & Pazzaglia). Updating is a complex process that requires different levels of activation to items being manipulated in working memory and continuously updating larger amounts of active information. In mathematical word problem solving, a mental model is formed and is continuously update with each step of the problem for problem solution. Memory updating ability has been linked to poor mathematical word problem solving ability (Passolunghi & Pazzaglia).

Passolunghi & Pazzaglia (2005) assessed the updating ability of students with poor mathematical word problem solving ability and good mathematical word problem solving ability, The participants were 78 fourth grade students, 43 good mathematical word problem solvers and 35 poor mathematical word problem solvers. The participants were matched on verbal IQ, age, gender, and grade. Children included in the poor mathematical word problem solvers were identify by a score of < 30th percentile and the teacher noted difficulty with mathematical word problems. The students completed an updating test, unexpected memory tasks, and a reading comprehension test. Data were analyzed using a repeated measures analysis of variance, an ANOVA, and *t* tests.

Results of the analysis suggest that poor mathematical word problem solvers are able to retrieve information into working memory; however, poor mathematical word problem solvers have difficulty with intrusion errors and updating tasks as they work towards problem solution. Results of this study suggest that the central executive system has a major role in solving mathematical word problems. Mathematical word problem solving is a higher order thinking skill. Teachers need interventions and strategies to teach students higher level thinking skills.

Swanson (2001) conducted a meta-analysis of the research outcomes of higher-ordered processing interventions for adolescents with learning disabilities. The purpose of the meta-analysis was to identify what instructional components could best predict positive outcomes for higher order processing skills for adolescences with learning disabilities. Databases were searched from 1963 to 1997. Searches included terms such as learning disabilities, reading disabilities, slow learners, educationally handicapped, dyslexia paired with a variety of words indicating treatment. Studies were included in the analysis if the dependent measure was a higher order cognitive process conducted with children 11 years of age or older, there was a control group, the participants had average intelligence ($IQ > 84$), and the treatment group received an intervention that was over and above what would be provided in a regular school day and the study was in English. Fifty-eight studies were included in the analysis. Results of the study indicated that magnitude of the effect size was greater if studies used a cut off criteria of > 84 IQ and $> 25^{\text{th}}$ percentile on reading recognition. As a single intervention, extended practice was the only intervention that produced a significant amount of variance in effect size. When a

factor analysis was conducted, only one factor, advanced organizers, new content/skill and extended practice, contributed to the variance in effect size. Therefore, Swanson found that interventions in higher order processing skills that include advanced organizers, new content/skill and extended practice conducted with adolescences with learning disabilities who have reading recognition scores > 25th percentile and an IQ score > 84 produced the greatest effect size. The higher order processes included attributions, mathematics, meta-cognition, problem solving, text understanding, word knowledge and speed of processing. The findings of this study suggest an explicit instructional approach to teaching higher order processing such as mathematical word problem solving. Cognitive strategy instruction uses an explicit teaching format in which learners are told why they are learning the strategy, given the steps to practice the strategy, receive guided instruction and modeling of the strategy, and have ample practice opportunities (Rosenshine,1997).

Cognitive Strategy Instruction

Pressley and Harris (2006) provide an overview of strategy instruction from research and to basic classroom implications. Strategy Instruction emerged in the 1950's, under the auspicious title of information processing theory (Pressley & Harris). Pressley, Forrest-Pressley, Elliot-Faust, and Miller (1985) define a strategy as “cognitive operations over and above the processes that are natural consequences of carrying out a task, ranging from one such operation to a sequence of interdependent operations (page 2).” Strategies include cognition for learning purposes such as memorization or

comprehension and can be consciously learned activities (Pressley et al.) Strategies are knowledge of procedures or how to do something. This is referred to as procedural knowledge or implicit memory. This is in contrast to declarative knowledge or explicit memory, which are facts. There is evidence to support that procedural knowledge leads to greater declarative knowledge and vice-versa, a strong declarative base leads to ease in procedural facilitation (Rabinowitz, 2002).

Both procedural and declarative knowledge are stored in long-term memory and are only activated when needed (Pressley & Harris, 2006). Active thinking takes place in working memory. Working memory is the part of intelligence that permits active use and manipulation of information. Working memory is extremely limited, only so much information can be utilized at one time. Smaller working memory capacity has been associated with learning disorders and language disorders (Swanson & Saez, 2003). Working memory in people with HFA/AS has been assessed with mixed results. Some studies assessing the working memory of people with HFA/AS have suggested impairments (Bennetto, Pennington & Rogers, 1999; Ozonoff & Jenson, 1999) while others suggest an intact working memory with central executive deficits (Ozonoff & Strayer, 2001). In order for people to problem solve, information must become activated in working memory. Meta-cognition is the process of self-monitoring the when and where to apply strategies (Pressley & Harris, 2006).

Meta-cognitive Strategy Instruction

Teachers need instructional strategies that they can readily use with students who have disabilities in the regular education setting. Fortunately, many strategies have been developed for students with learning disabilities. Among these, meta-cognitive strategies have shown to be effective for students with and without disabilities. Meta-cognition is the process of monitoring and controlling thought (Martinez, 2006). Good problem solvers use these processes unconsciously, poor problem solvers do not. Effective problem solving instruction depends on understanding the development of these processes, the strategies that good problem solvers use to access and apply these processes and the ways in which these important processes can be taught to students who either do not know about them, or do not seem to use them as they solve mathematical problems (Sowder, 1988). By teaching students to think consciously about how to learn, teachers are able to increase student abilities. Children with autism have difficulty with self-monitoring. Students with HFA/AS may benefit from meta-cognitive learning strategies; however, limited research has been conducted in the area of academics and children with HFA/AS.

Kroesbergen and Van Luit (2003) conducted a meta-analysis of mathematical interventions for students receiving services in special education. The results provide further support of teaching students meta-cognitive strategies. The mathematics interventions were divided into three categories: preparatory mathematics, automaticity of basic math facts and problem solving strategies. The research questions were: Which category is studied most and which category produces the highest effect size? Were there

any trends in outcomes? And, Which variables explained the greatest variance in effect size? To answer the research questions, a database search was conducted between the years 1985 and 2000 using the terms mathematics, arithmetic, addition, subtraction, multiplication, division, interventions, instructions, disabilities, mental retardation, etc. Criteria for inclusion in the meta-analysis required an elementary school mathematics classroom setting, addressed an intervention involving mathematics instruction, the study was conducted with children who had mathematical difficulties, a between subjects or within subjects control group was reported, and an effect size reported. The results of the study indicate interventions that address basic mathematical facts has been studied the most, however, there was not a significant difference in the effect sizes for the three categories. Interventions for older children and children with learning disabilities had greater effect sizes. While most studies used direct instruction, self-instruction strategies produced the greatest effect size. The authors concluded that self-instruction should be used for problem solving and direct instruction should be used for working with basic mathematical facts. While computer-assisted instruction served to motivate students, the computer did serve to remediate the difficulties that students encountered. It was also found that students with exceptional needs did not benefit from peer tutoring in development of skill. Lastly, the findings suggested children with exceptional needs must be monitored closely under the mandates of mathematical reform as some of the new strategies may not work as well as traditional strategies for special learners. The results of this study suggest that self-instruction, a meta-cognitive strategy, is an effective intervention for teaching middle school students to problem solve.

There are seven meta-cognitive skills that should be considered when teaching mathematical word problems (Sternberg (1985). The meta-cognitive skills include: (a) recognizing the problem, (b) defining the problem, (c) problem representation, (d) developing a plan, (e) resource allocation, (f) self- monitoring of problem solving, and (g) evaluating problem solving. Meta-cognitive strategy instruction for teaching mathematical word problems should include skill development in the seven areas (Sternberg).

Generally, students increase their use of strategies as they proceed through middle school, high school and college (Pressley & Hilden, 2006). Students do discover some strategies on their own (Pressley, 1990). Some strategies may be learned based upon the demand of new tasks. However, children and adults do not discover and use the most potent strategies as they confront academic tasks (Pressley & Harris, 2006). There is evidence that middle school students mix effective and ineffective strategies but will shift to effective strategies only with practice (Schlagmeuller & Schnieder, 2002). There is little evidence that students will discover the most effective strategies. Fortunately, strategies can be taught, acquired and generalized (Pressley & Harris). Therefore, strategies must be taught. Strategy instruction for teaching mathematical word problems should be a blending of cognitive and meta-cognitive strategies to facilitate problem solving ability. Good problem solvers use both cognitive and meta-cognitive strategies to solve word problems (Montague, 2003).

Strategy Instruction for Mathematical Word Problem Solving

Cognitive strategy instruction for mathematical word problem solving emerged in the 1950s with Polya's four steps for problem solving. In the 1980s, Montague, in series of studies (Montague, 1984, 1992; Montague & Bos, 1986; Montague, Applegate, & Marquard, 1993), further developed cognitive strategy instruction for mathematical word problem solving. Others were soon to follow.

In 1986, Montague and Bos investigated the use of an eight step cognitive strategy on the mathematical verbal problem solving ability of high school students with learning difficulties in mathematics. The eight steps were read, state the problem, paraphrase, visualize, hypothesize, estimate, calculate and self-check. Instructional techniques in this study included modeling, corrective feedback, verbal rehearsal, self-questioning, and direct instruction. The subjects were six high school students with mathematical performance difficulties. Confirmation of mathematical ability was confirmed through formal and informal assessment. The study included baseline, treatment, maintenance and generalization phases. Treatment consisted of both training and acquisition. Results of the study indicated a functional relationship between the use of the cognitive strategy and percentage correct on the verbal performance of mathematical word problems. Maintenance and generalization data varied. A retraining session increased the percentage correct in maintenance back to intervention phase levels.

In 1992, Montague conducted a second study investigating the multiple step mathematical word problem-solving ability of student with learning disabilities. The purpose of the study was to determine if cognitive strategy instruction, meta-cognitive

strategy instruction or both contributes to the gains in mathematical word problem solving. A single subject multiple baseline design was used to determine the functional relationship between mathematical word problem solving and the use of the *Solve It!* Problem Solving Routine. The study included a baseline, two treatment, maintenance, generalization, and retraining phases. In the first treatment phase participants received either cognitive or meta-cognitive strategy instruction. In the second treatment phase, the participants received the treatment they did not receive in treatment phase one so that during this phase they were using both the cognitive and meta-cognitive processes.

Results of the study indicate that during treatment phase one, students using only the meta-cognitive strategies achieved slightly higher than those using the cognitive strategies. Results of both the meta-cognitive and cognitive strategy participants in treatment phase one showed variable gains. The meta-cognitive group produced a higher mean for number of correct responses than the cognitive group (meta-cognitive group: baseline mean = 3.2, Treatment phase one mean = 5.8. Cognitive group: Baseline mean = 3.2, Treatment phase one mean = 3.8.). During treatment phase two, in which all participants were trained in both cognitive and meta-cognitive processes, all six participants made further increases in number of correct responses (Treatment phase mean for participants starting with meta-cognitive strategies = 5.9; Treatment phase mean for participants starting with cognitive strategies = 5.6). Results generalized and to a second setting. Maintenance data were slightly lower than intervention phase two, but returned to intervention levels after one practice session. These results suggest that strategy use should be infused with in the mathematics curriculum or that priming

sessions for procedural facilitation are an effective strategy should students not maintain strategy use over time. Overall, outcomes of this study suggest that both cognitive and meta-cognitive processes contribute to effective mathematical word problem solving, however, the meta-cognitive process may be more important than the cognitive processes.

Montague, Applegate and Marquard (1993) conducted a group study in which 72 middle school students with LD were given the *Solve It!* intervention. In this study, students were taught the *Solve It!* Problem Solving Routine in small groups of 8-12 students. The instruction took place across three instructional periods and ranged from 5-7 days. Results were analyzed using a pre/post test quasi-experimental design. Following intervention, the participants performed at the same level as average-achieving students on math problem solving tests and maintained performance over a four-month period. Students were able to generalize the problem solving routine to more complex problems. Overall, the results of this study further validate the use of the *Solve It!* Problem Solving Routine as an effective intervention to teach children with learning disabilities to solve mathematical word problems (Montague, Applegate, & Marquard).

Maccini and Hughes (2000) studied the effects of the STAR strategy on the mathematical word problem solving ability of middle school student with learning disabilities. In this study, the authors infused a graduated teaching sequence for problem representation (concrete-semi-concrete-abstract). Students were taught to: S-search the word problem; T-translate words into an equation in picture form; A-answer the problem; R-review the solution. The single subject multiple baseline design across subjects

included baseline, three treatment, and maintenance phases. Data were collected on percentage correct (accurate solution) and accurate representation for addition, subtraction, multiplication and division. The treatment phases varied by representation during the translate phase. During the first treatment phase, students were taught to use manipulatives to concretely represent the word problem. In the second phase, the students were taught to draw the algebra blocks to represent the word problem. In the third phase they used the manipulatives or drawing to write an equation to represent the word problem.

Results of the study indicate a functional relationship between strategy use/accurate solution and the use of the STAR strategy with graduated representational instruction. All participants increased their strategy use and increase their solution accuracy on addition, subtraction, multiplication, and division. Maintenance data suggests that while solution accuracy was maintained, solution representation maintenance varied especially for addition and subtraction. The authors explain that this may be due to an increase in number of steps needed for problem representation. Students performed better on near maintenance checks versus far maintenance checks. This may indicate the need for refresher lessons or a prime that can serve as procedural facilitation.

Daniel (2003) studied the use of the *Solve It!* Problem Solving Routine to further validate its use with children to increase the ability to solve multiple step mathematical word problems and to determine if the use of the curriculum increased students self perceptions of mathematics ability and attitudes towards mathematical word problem solving. The participants in the study were middle school students with learning

disabilities and age match, average achieving, neuro-typical peers. Data analysis was conducted using a univariate analysis of variance to determine difference among the groups on word problems and the Mathematical Problem Solving Short Form. Results from the study suggest a significant improvement in math problem solving for middle school students with learning disabilities compared with a control group, and improvement in their knowledge and awareness of strategies to the level of average achieving students following *Solve It!* instruction.

Mesler (2004) studied the effects of a modified *Solve It!* Problem Solving Routine on the mathematical word problem solving ability of students with spina bifida. Given the unique characteristics of students with spina bifida, Mesler removed the cognitive step of estimating and use a graduated teaching approach with one and two-step word problems. In this study, a single subject multiple baseline across participants design was employed. Furthermore, Mesler eliminated the estimation process, provided manual support for diagram development, and used only one-step problems initially. All students improved to criterion, and two students generalized the strategy to two-step problems.

Results of this study suggested a functional relationship between the increased ability to solve mathematical word problems and the use of the *Solve It!* Problem Solving Routine for students with spina bifida. The findings suggest that minor adaptations may be made to the curriculum based upon the unique characteristics of the target population (Mesler, 2004).

Xin, Jitendra, Deatline-Buchman (2005) studied the effects of general cognitive strategy instruction and schema based strategy instruction on the mathematical word

problem solving ability of middle school students with learning disabilities. The participants were 22 students with mathematical word problem solving difficulties as reported by their teachers who achieved less than 70% on a mathematical word problem solving assessment. The students were randomly assigned to two treatment groups. Students in both treatment groups received instruction three to four times per week for three to four weeks. The sessions were approximately one hour in length. The general cognitive strategy instruction group received the general textbook model of problem solving, read, plan, solve, and look back. The students in the schema-based instruction learned how to use schema in the form of basic organizers to illustrate the word problem. Throughout the study, the participants in both groups were tested four times on their ability to solve mathematical word problems. Data were analyzed using a repeated-measures ANOVA. The authors found that students who received schema based instruction performed significantly better than students who received basic problem solving instruction. Results of this study suggest that good cognitive based strategy instruction for students with learning disabilities in middle school should include schema-based instruction.

Chung and Tam (2005) tested the efficacy of three instructional methods on the mathematical word problem solving ability of middle school students with intellectual disabilities (IQ range of 55-70). The methods included traditional teaching, worked example instruction and cognitive strategy instruction. The procedures for the cognitive strategy instruction were modified from *Solve It!*. The cognitive steps included read, select, draw, write, and check. The meta-cognitive steps were identical to Montague's

Solve It! Problem Solving Routine. The authors utilized a cross subject experimental design to determine the efficacy of the instruction on mathematical word problem solving ability on immediate and delayed work samples. The authors used curriculum based, two step addition and subtraction word problems to measure word problem solving ability.

Results of the study indicated that there was a significant difference between the performance each instructional group. Students with intellectual disabilities who were taught with worked examples or cognitive strategy instruction outperformed the students who were taught with traditional teaching methods. The results of this study indicated that the *Solve It!* Problem Solving Routine can be modified to meet the needs of the target population and that cognitive strategy instruction for teaching students with intellectual disabilities is an effective method.

van Garderen (2007) studied the effects of cognitive strategy instruction and diagrams as a means to increase the mathematical word problem solving ability of middle school students with learning disabilities. The participants were three eighth grade students with learning disabilities. A single subject multiple probe design was used to determine the effects of the cognitive strategy instruction and the use of diagrams on the multiple step mathematical word problem solving of middle school students with learning disabilities. The author used a modified *Solve it!* Problem Solving Routine. The steps of the strategy included: read, visualize, plan, compute, and check. The meta-cognitive steps of say, ask, and check, were infused in each step. The scripted lessons from the *Solve It!* Problem Solving Routine were used during instruction. During the visualization step, students were guided on how to use diagrams to create schematic representations.

Results of the study suggest that students were able to learn to use diagrams as a form of schematic representation, that using a diagram alone increased the percentage correct for two of the three participants, and that diagrams imbedded in cognitive strategy instruction increased both the one and two-step mathematical word problem solving ability for middle school students with learning disabilities. This article demonstrates the importance of the schematic visual representation needed for students to develop a proper plan and hence, accurate solution. The results further supports the use of *Solve It!* Problem Solving Routine and suggests slight modifications to enhance the learning of student with learning disabilities may be indicated.

Finally, Montague and Dietz (2009) evaluated the literature on cognitive strategy instruction and mathematical problem solving to determine if cognitive strategy instruction for mathematical word problem solving could be deemed evidenced based. Using criteria suggested by Horner, et al. (2005) and Gersten, et al. (2005), the author evaluated seven articles that meet criteria for inclusion in the study. Five single subject and two group experimental designs were identified. Analysis of the findings according to the standards set forth by Horner, et al. and Gersten, et al. suggest that cognitive strategy instruction for mathematical word problem solving cannot be identified as an evidenced based strategy. Montague suggested that more empirical evidence is needed to further validate the use of cognitive strategy instruction and mathematical problem solving. Implications of this finding are that more empirical studies need to be conducted on mathematical problem across different settings and varied participants to increase the evidence base. Very limited research on cognitive strategy instruction in any domain has

been conducted with students who have ASD, including HFA/AS, though studies that have been conducted with this population have produced positive results.

Cognitive Strategy Instruction with Children with ASD

Very little research has been conducted on strategy instruction for students with autism. This may be because the behavioral and social needs of children with autism seem to be the most pressing concern. However, with the increase in the number of children with high-functioning autism, the social and behavioral impairments are of less concern and academic goals are within reach (O'Connor & Klein, 2004). Cognitive strategy instruction used to increase the social skills of children has demonstrated positive outcomes (Webb, Miller, Pierce, Strawser, & Jones, 2004). Only four studies have assessed the effectiveness of learning strategy instruction on the academic performance of students with HFA/AS (Bebko & Riccuiti, 2008; Delano, 2007; O'Connor & Klein, 2004; Songlee, et al., 2008).

Bebko and Riccuiti (2008) studied the use of rehearsal strategies with students with autism spectrum disorders to determine if the strategy use would be developed spontaneously, to determine if the use of the strategy for this population would increase performance, and to determine what conditions would elicit greater strategy use.

Rehearsal is a basic memory strategy that has been that has been studied extensively in the neuro-typical population. Neuro-typical children develop this strategy as early as 6 years of age and use it effectively (Bebko, 1984). Executive functioning impairments have been directly related to the lack of strategy use resulting in the performance deficits

(Bebko & Ricciuti). The researchers found that children with high-functioning autism did use the rehearsal strategy spontaneously (64% were identified as spontaneous strategy users). The development of the spontaneous use of the strategy came at a later age than neuro-typical peers. Children in the study with autism performed spontaneous rehearsal strategy use similar to children without autism one to two years younger; indicating an apparent delay of spontaneous rehearsal strategy use of one to two years. Children with moderate autism did not demonstrate spontaneous rehearsal strategy use. The authors suggest that executive functioning for children with high-functioning autism may not be universally compromised instead executive functioning may be weak for children with high-functioning autism.

Bebko & Ricciuti (2008) also tested the conditions of the environment that would elicit greater strategy use. The activities supported during the use of the rehearsal strategy in memory tasks involved monitoring the use of the strategy, evaluating the effectiveness of the strategy, and determining how long to use the strategy. By providing external support in meta-cognition, students with moderate and high-functioning autism increased their performance significantly. It may be that the use of external support in meta-cognition during memory tasks reduces the executive load and facilitates strategy use and ease of recall. Reducing the mental effort during task performance may free up executive resources that are then available for storage of information (Bebko & Ricciuti).

Overall, Bebko & Ricciuti (2008) suggested: that children with high-functioning autism may use strategies spontaneously; the use of strategies does increase performance on tasks for children with high-functioning autism; and by teaching external cognitive

and meta-cognitive strategies, children with high-functioning autism increase their performance of tasks significantly. The findings support the view of an executive functioning deficit hypothesis in autism that hampers information processing. The results of this study have clear implications for children with autism and the practitioners serving them. Children with autism benefit from strategy instruction and should be taught strategies to reduce the cognitive load (reference). The “hows” of learning must be taught to children with autism in an explicit format and external support in the use of strategies may be needed. Cognitive/meta-cognitive strategy instruction for children with autism must be tailored to meet the unique cognitive profile for children with autism (Bebko & Ricciuti; Songlee et al., 2008).

O'Connor and Klein (2004) explored the use of procedural facilitation to increase the reading comprehension of students with HFA. The participants were 20 adolescents diagnosed with HFA, PDD-NOS, or AS according to the DSM-IV. The purpose of the study was to determine if answering pre-reading questions; completing cloze sentences; and resolving anaphora by identifying antecedents, versus simply reading, would produce a significant difference in reading comprehension. A repeated analysis of variance concluded that the conditions differed significantly. The effects of anaphoric cuing, searching for pronouns in prior text, were significant and produced a medium effect size. Anaphoric cuing appeared to assist the student in developing self-monitoring. This study has educational implications. First, teachers need to instruct students with HFA/AS to look for antecedents of pronouns as they read. Teachers could also highlight pronouns as a cue for students to go back in the text and identify the character in question. Second, as

this article was the first of its kind, it suggests that students with HFA/AS may benefit from strategy instruction.

Songlee et al. (2008), studied the effects of a test-taking strategy with students with HFA/AS. The purpose of the study was to determine if a test-taking strategy would increase the performance of students with HFA/AS on controlled practice tests and on general classroom tests. Four subjects participated in this single-subject, multiple probe, across subjects study. The subjects were male adolescents age ranging from 12.1 to 17.8, with IQ's that ranged from 110 to 140 The intervention was the PIRATES strategy which consists of: Prepare to succeed; Inspect the instructions; Read, remember and reduce; Answer or abandon; Turn back; Estimate; and Survey. All training and testing sessions took place in the school setting. Results of the research study indicate that all subjects increased their performance on the controlled test, generalized the strategy to general classroom tests, and three out of four subjects maintained strategy use two weeks after instruction. This study suggests that strategy instruction may be a valuable intervention for students with HFA/AS.

Delano (2007) studied the effects of self-regulated strategy development delivered via a video model on the written language performance of adolescents with AS. Three adolescent male subjects participated in the study. Each participant had a diagnosis of AS and was confirmed by the researcher using the Asperger's Syndrome Diagnostic Scale. The participants' ages ranged from 13.6 to 17.4 years. All sessions took place in a school conference room, outside of the general education classroom. A multiple baseline design across participant response was used to determine the effects of the intervention on the

number of words written and functional essay elements used. During baseline, the number of words written ranged from 11 to 121 and contained few functional essay elements. During the intervention phase on written words, each subject increased the number of words written, as well as the duration that they were engaged in the writing task. When the intervention on increasing the number of functional essay elements was introduced, the number of words increased and the number of functional essay elements increased. Again, the time engaged in the writing task also increased. Maintenance results were mixed. Two of the participants maintained the number of words written at one week and three months. The third participant decreased in number of words written at the three-month maintenance check. The number of functional essay elements used was not maintained for two of the participants and decreased over time for the third participant. Duration of writing time was maintained for all but one participant. Overall, the results of this study have a positive impact on the use of strategy instruction for students with HFA/AS. Further research is needed to determine how long the intervention would need to be implemented so that maintenance effects are demonstrated. This study combined the use of the instructional strategy with the video model. It is impossible to determine if the instructional strategy or the video model produced the results. The author suggests that future studies separate the instructional strategy from the video model, and evaluate the result separately to determine which intervention produces the results.

While there has been little research in the area of cognitive strategy instruction, the research that has been conducted on cognitive strategy instruction suggests that it may be an effective intervention for use with students with HFA/AS as well as students with

learning disabilities. Other strategies have emerged in the field of autism as effective interventions for conceptual based learning. While interventions for children with ASDs have primarily been developed for teaching social concepts, social stories and video modeling may lend themselves to teaching cognitive and meta-cognitive strategies. *Solve It!* Problem Solving Routine is a cognitive strategy that lends itself well to be developed into a social story format.

Social Stories

Social stories are a cognitive/behavioral intervention to increase the social abilities of children with ASD. A social story is an individualized story that assists children with ASD in interpreting and understanding confusing or challenging social situations (Gray, 2000). A social story is written to provide the student with autism an understanding of what people do, think or feel in a certain situation. The social story enhances children's understanding and gives them the appropriate behavioral response to perform. Research suggests that social stories are an effective strategy to use to increase the social communication skills, attention skills and organizational skills of children with HFA/AS (Sansosti, Powell-Smith & Kincaid, 2004).

Sansosti, Powell-Smith and Kincaid (2004) conducted a synthesis of the literature on social stories interventions for children with autism spectrum disorders that provided further support for their use with this target population. Review of the *PsychINFO* and *ERIC* database yielded 10 studies on social story interventions. Of the 10 studies, 2 were not included in the synthesis because the study did not contain methods and outcome data

to confirm experimental control. Of the eight remaining studies, two used an AB design and were classified as pre-experimental, as there was no control. Two studies used an ABAB design, one used a variation of an ABAB/Reversal design, and three used a multiple base-line design. One article discussed treatment integrity, one study discussed social validity, and none of the articles programmed for generalization. All of the studies showed an efficacy of the social story intervention. All of the interventions targeted a social skill as the dependent variable and the social story as the independent variable.

Preliminary results of the synthesis of the literature suggest social stories may be considered a promising practice, not an evidenced-based practice, as empirical studies are limited. Due to the lack of control, limited information on treatment fidelity and social validity, it may be premature to suggest that social stories meet criteria as an evidenced-based practice. More research on the use of social stories as an intervention needs to be conducted, and should employ rigorous control, examine treatment fidelity, program for generalization, and compare treatment effects of neuro-typical peers.

Video Modeling and Social Stories

For students who need visual training and reinforcement, such as students with autism spectrum disorder (ASD), video modeling can be a useful tool. According to Spencer (2002), video modeling can be employed in three ways. First, modeling can be done by someone who resembles the student; second, the video could be of the student performing the task himself; and last, using one of the methods along with discrimination training. Video modeling can be used to decrease anxiety, teach adaptive behaviors, and

help the student learn conversational and interpersonal skills. Since individuals diagnosed with ASD tend to lack the ability to interact and successfully carry on conversations with others, modeling in all of its forms may be a helpful tool in the teacher's arsenal.

Hagiwara and Smith-Smith-Myles (1999) conducted a study on the use of a social story delivered via a multimedia format. The study was a single-subject research design across settings. The participants were three white, male elementary school students who had been clinically diagnosed with autism and met the following criteria: mild-to-moderate social skills or behavior deficits; basic listening and written language skills; and adequate fine motor skills to manipulate a computer mouse. The Autism Behavior Checklist, and the Behavior Assessment System for Children was administered to further validate the autism characteristics and the social skills deficits. The dependent variable for each subject was identified via a functional analysis. The dependent variable for participant I and II was percent correct on a hand washing task analysis, and the dependent variable for participant III was average duration of on-task behavior. The independent variable was the use of an individualized multimedia social story.

After baseline was collected, the participants were taught how to access the multimedia social story via the computer. Each participant was taught how to move the mouse, use the cursor and click on the play button to start the movie. Once mastery of computer use was established, each participant was introduced to his individualized multimedia social story. The multimedia social story was viewed immediately prior to the task demand. After stability was achieved in setting I, the multimedia social story was introduced in setting II. Once stability in setting II was met, the multimedia social story

was introduced in setting III. Inter-observer agreement was calculated on 33% of the observations of multimedia social story use. Reliability co-efficient were 100% for participant I and II and 89% for participant III.

Data analysis indicated that all of the participants showed some skill level improvements. The multimedia social story was effective for some of the participants in some of the settings, and some generalization of skill was noted. No consistent effect of the intervention has found. The authors noted that many interventions for children with autism have not been universally effective due to the heterogeneity of the disorder. The authors further suggest that more research in this area is need as this study is the first of its kind in special education.

Scattone (2008) conducted a single-subject research study, using a multiple baseline across behaviors design, to determine if the combination of video modeling and social stories would increase the conversation skills of an adolescent with AS. The dependent variable was conversation skills including eye contact, smiling, and initiation of conversation. The independent variable was the use of a video social story on conversation skills. The participant watched the video one time a day at home and prior to the task demand. The conversational skill data were collected at school. Results indicated the effectiveness of the video social story in increasing two of the three conversational skills.

Combining the theory behind social stories and visual modeling to target the meta-cognitive strategies needed in academic functioning may be a viable intervention to use to increase mathematical word problem solving ability. However, with any good

intervention, generalization of the strategy use to other settings and behavior must be demonstrated.

Generalization

According to the seminal research on generalization by Stokes and Baer (1977), generalization is defined as,

The occurrence of relevant behavior under different, non-training conditions (i.e., across subjects, settings, people, behaviors, and/or time) without the scheduling of the same events in those conditions as had been scheduled in the training conditions. (page 350)

Generalization occurs when no extra training is needed in the generalization setting, or occurs when some training in the generalization setting is necessary, but is clearly less than the intervention. Generalization cannot be claimed when training is necessary for similar effects across all conditions. In 1977, Stokes and Baer reported that most studies used a “train and hope” strategy for generalization. Few studies used a “train to generalize model,” however, the studies that did train to generalize produced positive results, suggesting, that training to generalize is warranted. Generalization should not be expected unless programming is developed to facilitate its occurrence (Stokes & Baer).

In order to establish if generalization has occurred, observations in the natural setting must be made prior to and after instruction has occurred and documentation, as to the change in behavior in the natural setting should be collected (Koegal et al., 1998; Koegal, Koegal, Frea, Green-Hopkins, 2003; Rogers, 2000). Children with autism have difficulty generalizing skills from one setting to the next; therefore, explicit teaching of

generalization is needed (Koegal et al). Fortunately, strategies for generalization of learned skills have been developed for children with autism. Priming is a strategy that can be used in a natural setting to facilitate generalization.

Priming

A prime is an antecedent event that prepares the student to perform the task or behavior by previewing the task before the demand. Priming can be used as a strategy to explicitly teach generalization of learned skills. Previous research suggests that priming is an effective strategy to use as an intervention for children with autism. While past research in the use of priming and student with autism has focused mainly on the social and play behavior of students with autism (Zanolli, Daggett, & Adams, 1996), recent research suggests that priming may be an effective intervention to increase academic engagement (Koegel, Koegel, Frea, & Green-Hopkins, 2003).

Koegal, Koegel, Frea and Green-Hopkins (2003) studied the effects of priming, previewing classroom assignments prior to the presentation of the task in the classroom setting, on the academic engagement of students with HFA/AS. The participants of this study were two male students diagnosed with autism, ages 5.6 and 15.0 years at the beginning of the study. A single-subject repeated reversals design was used to evaluate the effectiveness of the intervention on increasing academic engagement and decreasing disruptive behavior. All priming sessions were conducted outside of the general education setting and all data were collected in the general education setting. For student one, age 5.6, priming sessions were conducted in the evening by the parents. For student

two, age 15, the speech language pathologist conducted the priming sessions at the school. Results of the study indicate that priming produced an increase in academic engagement and reduced disruptive behaviors. Effect size was calculated for each of the dependent measures and revealed large effects for all dependent measures. For student one, effect size for academic responding was -1.95 and for appropriate classroom behaviors -2.5. For student two, effect size for academic responding was -2.44 and for appropriate classroom behaviors -3.3. The results of this study have practical implications. The improvement of classroom on-task engagement in the inclusive setting may occur without the need for academic revisions by utilizing priming.

Solve It! Problem Solving Routine Instruction

Solve It! was first investigated over 20 years ago (Montague, 1984; Montague & Bos, 1986). The strategy has a sound theoretical base in Polya's (year) seminal work on mathematical problem solving (Polya, 1954). *Solve It!* is a strategy instruction curriculum package developed by Montague (1996) that may be an effective intervention in assisting children with HFA/AS to learn how to solve mathematical word problems. The curriculum consists of teaching students seven cognitive strategies and three meta-cognitive strategies. The seven cognitive strategies are: read, paraphrase, visualize; hypothesize; estimate; compute; and check. The three meta-cognitive strategies include self-management, self-questioning, and self-evaluation. The meta-cognitive strategies are: say, ask; and check. The strategies employed in the curriculum are thought to facilitate linguistic and numerical information processing, formations for visual

representations in memory, comprehension of problem information and development planning for problem solution (Mesler, 2004). The instructional model includes four components: (a) assessing performance and appropriate identification of students for the instructional program; (b) explicit instruction in the acquisition and application of strategies for mathematical problem solving; (c) process modeling; and, (d) evaluating student outcomes, with an emphasis on strategy maintenance and generalization (Montague, 2000). The curriculum package includes scripted lessons and implementation checklists. *Solve It!* has been effective for teaching children with learning disabilities a strategy to solve mathematical word problems (Montague, 1997). *Solve It!* may be an effective strategy for teaching children with HFA/AS to solve mathematical word problems as it provides the support for executive functioning. The curriculum includes strategy cue cards that can be used as a prime for procedural facilitation if the student does not maintain the strategy. The strategy is easily converted into a video model and social story format that could be used as a prime for procedural facilitation should cue cards not work for students with HFA/AS due to their unique cognitive and academic characteristics.

Summary

The number of children diagnosed with HFA/AS is increasing (Center for Disease Control and Prevention, 2007) and these children are typically served in the general education settings (US DOE, 2008). In order to be diagnosed with an ASD, children with HFA/AS must present with deficits in the area of social interaction, social

communication, and restricted interests/repetitive behaviors (APA, 2000). Although, HFA/AS is primarily thought of as a social disorder, children with HFA/AS present with a unique cognitive profile (Solomon, Ozonoff, Cummings, & Carter, 2008), academic profile (Whitby & Mancil, in press), executive functioning deficits (Happe, 2001) that may prevent them from achieving in the regular education setting. Mathematical word problem solving presents unique difficulties for children, including those with HFA/AS, as it requires reading comprehension, writing, and mathematical ability as well executive functions for problem solving (Passolunghi & Pazzaglia, 2005). Fortunately, effective strategies for higher level thinking skills have been developed for children with learning disabilities in the form of cognitive strategy instruction. Cognitive strategy instruction must fit the unique cognitive profile of students with HFA/AS in order for the intervention to be effective (Songlee et.al., 2008). *Solve It!* (Montague, 2000) is a cognitive strategy instruction curriculum package that has been validated for children with learning disabilities. The cognitive and meta-cognitive steps of the *Solve It!* Problem Solving Routine may provide support for the executive functioning deficits that children with HFA/AS may exhibit and help them to better solve mathematical word problems.

The purpose of this study is to determine if the use of the *Solve It!* Problem Solving Routine will increase the mathematical word problem solving ability of middle school students with HFA/AS and to determine if the gains maintain over time as well as generalize to a secondary setting. Given that maintenance and generalization of acquired skills is problematic for children with HFA/AS, systems for procedural facilitation need to be developed to extend teaching of skills into the novel settings. If the skill does not

maintain or generalize, procedural facilitation, as suggested by O’Conner and Klein (2004) is warranted. A secondary study will be implemented if the skill does not maintain. Procedural facilitation for this study will be evaluated by using *Solve It!* curriculum cues cards presented in written format or a multimedia academic story presented in an auditory and visual format delivered as a prime.

CHAPTER 3 METHODOLOGY

Introduction

The purpose of this study was to answer the following research questions: (1) What is the effect of the *Solve It!* Problem Solving Routine on the percentage correct in multiple-step mathematical word problem solving for middle school students with HFA/AS? (2) What is the effect of *Solve It!* on the reported self-perceptions of the ability to solve word problems and the attitudes towards mathematical word problems for children with HFA/AS? And (3) Does the use of a multimedia academic story written for the *Solve It!* Problem Solving Routine or the use of written *Solve It!* cue cards work best as a prime if the student does not maintain the use of the *Solve It!* Problem Solving Routine?? The dependent variable was percentage correct on mathematical word problem solving for the primary and secondary study and pre- and post-measures on the *Solve It! Mathematical Problem Solving Assessment Short Form (MPSA-SF)* for the primary study research question 2. The independent variables were the *Solve It!* Problem Solving Routine and multimedia enhanced *Solve It!*, i.e. the multimedia academic story.

The *Solve It!* Problem Solving Routine appears to be a good instructional fit for children with HFA/AS (Montague, 1997) as it uses the students' strengths as visual thinkers and in rote memorization (Dickerson Mayes & Calhoun, 2003a 2003b; Goldstein, Minshew, & Siegel, 1994; Minshew, Goldstein, Taylor, & Siegel, 1994) while providing support of the executive-function deficits such as attention, sequencing and organization (Happe, 2001). To address the research questions two studies using a single

subject research design were employed. This section describes the pilot studies, participants, setting, materials, pre/post intervention measures, study design and experimental procedures for the primary and secondary study, data analysis, and strategies to ensure treatment integrity, reliability and social validity.

Pilot Studies

Two pilot studies were conducted. The first was intended to determine the appropriateness of the strategy with the target population and the second was intended to determine if the *Solve It!* Problem Solving Routine could be delivered via a multimedia academic story and produce results similar to prior research.

Pilot Study One

The purpose of the first pilot study was to determine if the use of the *Solve It!* Problem Solving Routine would increase the percentage correct on math achievement level word problems for a student with HFA/AS. The subject was a middle school student with Asperger's syndrome. The diagnosis of HFA/AS was substantiated via medical and school records. The *Woodcock Johnson Test of Achievement* was administered to determine the level of achievement in reading comprehension and computational skills. Subtest results indicated that the participant was able to comprehend reading material above the third grade level and had grade level computational skills. Parents requested to be part of the study because the student skipped all word problems on mathematical homework and tests. *Solve It!* pre-tests indicated that the student could perform one- and

two-step word problems with 100% accuracy, but performed three-step word problems with 0% accuracy. Due to the student's high academic ability, as demonstrated on the Woodcock Johnson Test of Achievement, only three-step word problems from the *Solve It!* Problem Solving Routine and three-step Florida Comprehensive Achievement Test (FCAT) questions were used for this pilot study. FCAT questions were chosen to increase the social validity of the intervention, as the student will need to obtain high FCAT scores to participate in advanced placement mathematic courses. During baseline, the participant achieved 0% for three consecutive trials. During intervention phase training condition, the participant achieved 100% for three consecutive trials. During intervention phase acquisition condition, the participant scored 100% for three consecutive trials. The maintenance condition was conducted one week after the training was completed. The participant achieved 66% correct on the mathematical word problems during maintenance. One week later, the participant completed the mathematical word problems, immediately after reading the *Solve It!* cue cards, one time a week for two consecutive weeks. During the post-maintenance phase, the participant achieved 33% and 66% correct. See Appendix B for graphical representation of the results. Results of the study were similar to prior research (Daniel, 2003; Mesler, 2004; Montague, 1992; Montague, Applegate, & Marquard, 1993). However, in the present study, a decrease in percentage correct, using the *Solve It!* cue cards were exhibited in the post-maintenance phase. This was likely a result of the length of the intervention, as it was a shortened version of Montague's *Solve It!* Problem Solving Routine. However, it may suggest that the cue cards did not serve as an effective prime for the mathematical word problem solving.

Results of the first pilot study suggest that students with HFA/AS may benefit from *Solve It!* cognitive strategy instruction in mathematical problem solving, may need procedural facilitation to continue using the strategy after initial learning as the student did not maintain use of the strategy, and that cue cards from the curriculum package may not be enough support to facilitate the use of the strategy. During the study, the student repeatedly asked if he could skip a step. A rule was established for use of the strategy during training. The rule was: Students must use all seven steps of the strategy whenever they are solving a word problem. Providing the rule may build upon the concrete cognitive process and adherence to routine that students with HFA/AS present with (Barnhill, 2001) and therefore, increase generalization. A multimedia academic story was tested along with the *Solve It!* cue cards during the secondary study to determine if the *Solve It!* cue cards or the multimedia academic story serve as the best prime to assist students with increasing the percentage correct on mathematical word problems or maintaining the skill they have gained. The multimedia academic story was added because the written cue cards did not serve as an effective prime in the first pilot study. The multimedia academic story provided multiple input of the strategy and utilized the visual strengths of students with HFA/AS.

Pilot Study Two

The purpose of the second pilot study was to determine if the multimedia academic story delivered the same content as the *Solve It!* Problem Solving Routine, as determined by an increase in the percentage correct on grade-level mathematical word problems for

middle school students with learning disabilities. For the second pilot study, children with learning disabilities were chosen as the participants because all prior research was conducted with this population, therefore, comparison of delivery modality effectiveness could only be conducted with the learning disability population. To determine the effectiveness of the multimedia academic story as a modality to deliver the *Solve It!* Problem Solving Routine as a means to increase the percentage correct on multiple step mathematical word problems for middle school students with learning disabilities, an ABAB design was employed. The multimedia academic story of *Solve It!* increased the percentage correct on mathematical word problems when used with middle school students with learning disabilities. Results of the multimedia academic story, a combination of video modeling and social stories, were similar to Scattone (2008) and Hagiwara and Smith-Myles (1999), in that the subjects made an overall increase in the target behavior. However, the change from the baseline phase II to intervention phase II was not as effective as the change from baseline phase I to intervention phase I, therefore, the results need to be used with caution (Scruggs, Mastropieri, Cooke & Escobar, 1986). The multimedia academic story is not meant to replace the *Solve It!* Problem Solving Routine in the classroom. It is a tool that teachers could use to enhance the curriculum or increase students' access to the curriculum. Teachers can use the multimedia academic story during center time, independent work time or homework time to increase practice trials on problem solving. The multimedia academic story teaches the problem solving strategy via multiple learning pathways, i.e., visual, auditory or reading, and may increase

access to the curriculum for children with language-based learning difficulties such as children with HFA/AS. See Appendix C for the graphical representation of this study.

The results of this study suggest that the multimedia academic story was an effective modality to deliver the *Solve It!* Problem Solving Routine. It should be noted that the participants received three days of training on using the *Solve It!* Problem Solving Routine prior to viewing and using the multimedia academic story. As a result of the second pilot study, the multimedia academic story written for the *Solve It!* Problem Solving Routine, was used as a prime in the secondary study.

Participants

Participants were recruited through a large school district in Central Florida. Four adolescent middle school students with HFA/AS were chosen for the study. Prior to participating in the study, Institutional Review Board (IRB) approval was obtained from the University of Central Florida (See Appendix D). Upon IRB approval, school district approval was obtained (See Appendix E). Parents and teachers of the participants signed consent forms for their children to participate in the study (See Appendix F). The participants signed assent forms (See Appendix G). Participants had a diagnosis of HFA/AS obtained independently from a physician, licensed psychologist, psychiatrist or an autism diagnostic center. In addition, to confirm the student's autism spectrum diagnosis, the Autism Diagnostic Interview-Revised (ADI-R) was administered by a clinically trained researcher. Additional inclusion criteria for participants includes attendance at a public middle school, mathematics instruction delivered in a regular

education setting, a documented I.Q. of 80 or greater to substantiate high functioning autism, scores at least the 25th percentile ranking on reading comprehension per the Woodcock Johnson Tests of Achievement as the mathematical word problems are written at a third grade level, and average grade level computational ability measured via item response theory (Montague, 2000) as the study addressed problem solving not computational ability and the word problems are curriculum based measures. Participant's age ranged from 12-14, and grade level 7-8. See Table 1 for participant information.

Table 1
Participant Characteristics

Name	IQ	DX	Age	Read Comp	Calc	MPSA- Baseline Mean	ADI-R Lang/ Comm Cut off=8	ADI-R Social/Play Cut off=10	ADI-R General Behavior Cut of=3
NN	90	AD	14.3	77 SS	80 SS	35%	24	30	12
CC	107	AS	13.7	93 SS	121 SS	60%	22	23	12
NM	94	AD	13.8	93 SS	104 SS	50%	27	22	12

Nick

Nick is a 14.3 year-old eighth grade student. Nick spends all instructional time in the regular education setting. He receives an extra period of intensive mathematics due to low performance on statewide, standardized assessments. Nick was diagnosed with autistic disorder at the age of 15 months. He received intensive early intervention services

from the age of two until school age. Upon entering school, he continued to receive intensive in home therapies.

Nick has a restricted interest in nonproprietary computer software. He prefers only to use non-proprietary software (software that allows people to freely access the programming codes) so that he can build his own software and build upon others software. He spends most of his free time exploring nonproprietary software and building software in this system. If given a choice, all social conversation will surround computers and software. Nick is not interested in gaming and does not play computer games typical for his age, as most games his peers play are proprietary software such as Nintendo Games, Xbox, or Wi.

Nick struggles socially at school. He frequently comments that the students at his school do not understand him and at times feels bullied. He openly discusses that he would like a girlfriend, but does not understand how to develop a relationship. When observed during lunch, he was sitting alone. The teacher reports that he usually spends lunch by himself.

In academics, Nick is a B student and receives accommodations in the regular education setting. His accommodations are extra time, quiet setting for testing, reduced number of problems, and he can have mathematical problems read to him. Nick is aware of his accommodations, but does not self-advocate for use of the accommodations. Nick performs poorly on tests and has not passed the statewide grade level assessment.

Nick is very aware that he has an autism spectrum disorder. In private he asks questions and discusses the implications of having “Asperger’s syndrome”. Nick refers to

his ASD as AS even though he was diagnosed with AD. His parents also state that he has AS though they report he was diagnosed early as having AD. In public, he does not want any of his peers to know that he has an ASD, receives accommodations, or receives support services from exceptional education staff. Over the course of the study, he requested that the change agent not be seen in his classroom, as he was afraid that his peers would figure out that he was different. Nick would meet the change agent in the resource room where the teaching took place. Even though he did not want to be seen with the change agent or have any of his peers know that he was participating in the study, he was very eager to participate in the study as he was very aware that he had not passed the statewide test in mathematics and needed to pass the test to obtain a regular diploma.

Chris

Chris is a 13.7 year-old seventh grade student. Chris spends all instructional time in the regular education setting. He attends a learning strategies class daily that addresses social skills. Chris was diagnosed with Asperger's syndrome at the age of 10 years. Prior to the Asperger's diagnosis, he was diagnosed with a behavior disorder and served in a classroom for children with severe behavior disorders. He received intensive early intervention services in speech language from the age of two until school age. Chris had a severe regression in language and motor development around the age of 18 months.

Chris has a restricted interest in non-age appropriate games and items. He carries a stuffed animal pencil with him everywhere he goes. He reports that he enjoys Legos

and plays with his little sisters on the weekends. He has difficulty engaging others in social conversation and has limited eye contact. His social engagement is limited to answering questions and simple social greetings. Chris has difficulty with change and thrives on routine and structure. His teacher reported that he had a significant meltdown during class as the teacher had changed the seating assignments without warning.

Chris loves school. He is active in clubs and extra-curricular activities, but his teachers report that he is not fully accepted socially by his peers. He has very little awareness of his differences. It has been reported that he will follow his peers if he likes them and wants to be their friend. At times this scares his peers. During lunch, he attends a library group and loves to spend time with the librarian.

In academics, Chris is an A student and receives accommodations in the regular education setting. His accommodations are extra time and quiet setting for testing. Chris is aware of his accommodations, but does not self-advocate for use of the accommodations. Chris performs average on tests even though he has very high computational abilities.

Chris is unaware that he has an autism spectrum disorder. His parents have just started discussing his differences with him. In his social skills class, autism spectrum disorders and the subsequent characteristics are discussed openly as one goal of the course is to increase this group of students understanding of their disorder. Chris was very eager to participate in the study as he loves mathematics and enjoys the one on one adult attention.

Nate

Nate is a 13.8 year-old seventh grade student. Nick spends 80% or greater of the day in the regular education setting. He attends one hour a day in a learning strategies class for children with autism spectrum disorders. Nate was diagnosed with autistic disorder at the age of 18 months. He received intensive early intervention services from the age of 18 months until school age. Upon entering school, he continued to receive intensive in home therapies.

Nate has a restricted interest in Star Wars, computer games, and will become obsessive with certain people. His mother reports that he regressed significantly around the age of 4 after a neighborhood child moved away. More recently, his mother reports, he will befriend one person to the inclusion of others until the person tires of his attention. He spends most of his free time playing with Star Wars Legos. Nate reports that he will only eat certain foods and gets angry when pressed to eat other foods. He packs the same lunch every day, a peanut butter and jelly sandwich. Nate is very interested in having friends, but has difficulty maintaining meaningful friendships due to social interaction difficulties.

Nate fits in with the other children at school. He sits with other students at lunch and on the bus. He is very worried about his friends finding out that he has “Asperger’s Syndrome.” Nate and his mother both state that he has AS even though he was diagnosed with AD. In private he talks openly about what it is like to have an autism spectrum disorder. At one point, he shared with the change agent that he remembers what it is like to not be able to communicate and talk.

In academics, Nate is a B student and receives accommodations in the regular education setting. His accommodations are extra time and quiet setting for testing. Nate is aware of his accommodations, but does not self-advocate for use of the accommodations. Nate's performance on statewide tests and in classroom assignments has decreased since starting middle school. This is a great concern to his mother as she has worked very hard to overcome the struggles related to autism.

Nate is very aware that he has an autism spectrum disorder. In private he asks questions and discusses the implications of having "Asperger's syndrome." In public, he does not want any of his peers to know that he has an autism spectrum disorder, receives accommodations, or receives support services from exceptional education staff. When he walks to his learning strategies classroom he lags behind his peers so that his friends do not see him walk into the classroom for children with autism. Even though he did not want to be seen with the change agent or have any of his peers know that he was participating in the study, he was very eager to participate as he was very aware after reviewing the assent that he would be able to keep the IPOD at the end of the study.

Setting

The study took place in two public middle schools in a central Florida school district. See Table 2 for school demographics. Both schools provide a continuum of services for children with autism spectrum disorders. An exceptional educator provides support services for students with HFA/AS in the general education setting. Teacher, researcher, school administration, and parents agreed upon the time of day in which the

instruction was delivered. The participants were not removed from the content area courses, which would result in decreased exposure to the general education curriculum. Generalization procedures took place in the general education mathematics classroom. All conditions occurred in the school setting. The conditions of the study include pre-assessment, primary study: baseline, intervention training and acquisition phases, and maintenance; Secondary study: alternating treatments; and generalization throughout the course of the study.

Table 2
School Demographics

School	# Students	Grade Levels	% White	%Black	% Hispanic	% Other	% Low SES	% ESE
1	1022	6-8	52.8	25.6	12.5	9	32.8	14.6
2	1294	6-8	71.9	8.0	11.2	8.9	17.7	8.3

Source: Seminole County Public Schools. Retrieved at <http://doeweb-prd.doe.state.fl.us> on January 15, 2009.

Change Agent

The change agent in this study was the principal investigator. The principal investigator was a doctoral candidate in exceptional student education, and held a general educator’s teaching certificate with certification in exceptional student education. Prior teaching experience included four years teaching children with autism spectrum disorders in both self-contained classrooms and in the general education setting. Experience also included serving as an autism consultant to 34 schools in a large Central Florida school district. The principal investigator had attended numerous autism workshops and conferences, had presented professional development on autism for school districts,

presented at state and national conferences, and had been published in the area of autism. The principal investigator developed and was managing an assessment and remediation clinic for children with learning difficulties which included children with autism spectrum disorders at the time of the study.

Materials

During each phase, materials from *Solve It!* were used. These items included scripted lessons, pre/post-assessment, strategy cue cards, and strategy posters. See Appendix H for example materials. Curriculum based measures of one, two, and three-step word problems developed by Montague designed specifically for middle school students were utilized to assess progress along with released grade level Florida Comprehension Assessment Test (FCAT) exam questions. Each mathematics probe contained five mathematics word problems (See Appendix I). Four problems, 1 one-step, 2 two-step and 1 three-step word problem, were taken directly from Montague's curriculum based assessment. One medium grade level FCAT question was used as the fifth mathematical word problem to ensure that students were receiving instruction on solving high stakes test items (Jitendra, Griffin, Deatline-Buchman, & Sczesniak, 2007) and to facilitate generalization to the regular education classroom (Stokes & Baer, 1971). All generalization probes consist of one medium FCAT test item. During the secondary study, alternating primes were utilized. The primes consisted of a multimedia academic story created for the *Solve It!* Problem Solving Routine delivered via a touch IPOD and *Solve It!* cue cards taken directly from the *Solve It!* Problem Solving Routine.

The multimedia academic story is a video created using Camtasia software and Microsoft PowerPoint that is delivered via a Touch IPOD. The multimedia academic story consists of an academic story telling the student how and why to perform each step of the strategy and a video model of a student performing the step of the strategy. The multimedia academic story consists of seven short academic stories and video models as the *Solve It!* Problem Solving Routine has seven steps.

The academic story was designed to teach the *Solve It!* Problem Solving Routine. The academic story was designed according to Gray's (1998, 2002) and Gray and Garand's (1993) recommendations for social stories. The only difference between the social story and the academic story is that the academic story addresses the why and how of a learning concept instead of a social concept. The video model was developed with a handheld camera and consists of an age-related peer, modeling each step of the strategy. Students can read the academic story, listen to the academic story and watch a video model demonstrate the step of the strategy. Both the academic story and the video model were imbedded in a Microsoft PowerPoint and then videotaped using *Camtasia* software. See Appendix J for pictorial views of each slide in the multimedia academic story.

Pre/post-intervention Measures

Pre-Intervention assessment procedures took place in the school environment but outside of the classroom. Once eligibility was determined, each participant was administered the Mathematical Problem Solving Assessment Short Form (Montague, 2003) to determine pre-assessment measures of self reported attitudes and perceptions of

mathematical word problem solving ability. The assessment was conducted with each student at the completion of the study to determine if an increase in positive attitudes and self-perceptions of mathematical word problem solving ability was demonstrated after learning the *Solve It!* Problem Solving Routine.

Dependent Measures

Solve It! Mathematical Problem Solving Assessment Short Form (MPSA-SF) (Montague, 2003). The MPSA-SF is an informal diagnostic tool to identify strengths and weaknesses in mathematical problem solving. The MPSA-SF utilizes a student profile form to summarize and visually display the individual's strengths and weaknesses. The Likert-type scale shows change in the participant's attitude toward solving word problems and in the participants self reported use of strategies. This assessment will be administered as a pre-test and a post-test.

Curriculum Based Measures. Montague's CBM of math problem solving were calibrated using Item Response Theory methods to achieve equivalence with respect to difficulty level across measures. The internal consistency of the measures ranged from .70 to .80.

FCAT Mathematical Word Problems. The FCAT is intended to measure student knowledge of the Florida Sunshine State Standards (FL DOE, 2007). Questions were obtained from released FCAT tests. Released tests are available online. FCAT reliability indices at grades 4, 5, 8, and 10 are above 0.90 (FLDOE, 2001). Each question is rated for level of difficulty (easy, medium, difficult) and the answer is provided.

Primary Study

Primary Study: Design

A concurrent multiple baseline design across participants was utilized to evaluate the effectiveness of the modified learning strategy, *Solve It!*, intervention on increasing percentage correct on mathematical word problems and increasing the self-reported attitudes and perceptions of ability to solve mathematical word problems, as the study fit with the characteristics of the design (Kazdin, 1982). While the principal investigator implemented the intervention at the school outside the mathematics classroom, the general education teacher assessed the ability to solve mathematical word problems in the general education classroom to determine if skills generalized to the classroom. In a concurrent multiple baseline design, the independent variable is systematically and sequentially introduced to one subject at a time (Tawney & Gast, 1984). If changes in the dependent variables occurred following the introduction of the intervention, the change was able to be attributed to the intervention. The design began with baseline observation of the same behavior for all participants.

The baseline information collected over a period of time provided information on what the behavior would look like if no intervention occurred. At any time in the study when the intervention was applied to one participant and not the other participants, a comparison was able to be made between treatment and non-treatment effects (Kazdin, 1982; Tawney & Gast, 1984).

Two conditions were implemented in the intervention phase. Condition I consisted of a strategy training (Lessons 1-5). Condition II consisted of strategy acquisition (Lessons 6-10). The procedures in *Solve It! A Practical Approach to Solving Word Problems* (Montague, 2003) were utilized for the intervention phase conditions 1 and 2. The *Solve It!* Problem Solving Routine consists of 10 days of scripted lessons. An example of the scripted lesson is provided in Appendix K.

Primary Study: Experimental Procedures

Baseline and Intervention Phases

Baseline Phase. All participants entered baseline at the same time. Baseline data were collected on participant 1 until stability was reached. All other participants remained in baseline. Baseline data were collected until the participant reaches stability or for at least three out of four consecutive days (Kazdin, 1982; Tawney & Gast, 1984). Stability was defined as a “contratherapeutic or zero acceleration trend” (Tawney & Gast, 1984, p. 201) Once the participant reached a stable baseline, intervention began. Participant 2 remained in baseline until Participant 1 reached stability in intervention phase condition I. Participant 3 remained in baseline until Participant 2 reached stability in intervention phase condition I. Once stability was reached, baseline probes were implemented to avoid frustration of being held in baseline. Montague (1992) reports that students demonstrated frustration over the longevity of baseline.

Intervention Phase Training Condition. Training sessions followed the scripted lessons in the *Solve It!* Problem Solving Routine (See Appendix K). Training sessions

began with an overview of the strategy instruction. First, the investigator guided a discussion with the student about mathematical problem solving and why it is important to be a good problem solver. Then, the strategy was presented to the student describing the cognitive processes and modeling the meta-cognitive processes. During the first session, students were given a folder that contained a graph of their baseline data and strategy cue cards provided as part of the standard curriculum. Each student reviewed the baseline data with the instructor to support the need to increase mathematical word problem solving. The processes were presented on a wall chart. Students practiced verbalizing the processes and strategies by reading through the charts. The students were introduced to the acronym “RPV-HECC” (read-paraphrase-visualize-hypothesis-estimate-compute-check), as a strategy to memorize each step in the strategy. The students were required to memorize the strategy during the intervention training condition. The investigator demonstrated how to use the strategy to solve typical mathematical word problems. During the second problem, the student was asked to guide the instructor on each step. Together the instructor and the student solved three more mathematical word problems. Every training session after the first session ended with a mastery check of memorization of the strategy and a mathematical word problem probe consisting of five word problems. When 100% mastery of memorization of the strategy was achieved, at least five training sessions were completed, and the student achieved stability (defined as no deceleration trend for three out of four consecutive sessions) the acquisition phase began.

Intervention Phase Acquisition Condition. During the acquisition phase, each

session began by the participant completing the mathematical word problems. As the instructor handed out the worksheets, the students were given one verbal prompt to use the strategy but were not given access to the cue cards or the wall chart. After completion of the word problems, the instructor and the student corrected the student's work using the wall chart and cue cards. For each problem, the instructor modeled each step of the cognitive and meta-cognitive process. The student graphed the percentage correct after each session. Maintenance began when the student achieved stability for at least three out of four consecutive sessions and completes the five acquisition lessons. Stability was defined as no deceleration data points for three out of four consecutive data points.

Maintenance Phase. A maintenance phase was used in this study. The purpose of the maintenance phase was to determine if the increase in mathematical word problem solving is maintained over time. Maintenance was scheduled to begin three weeks after the completion of the study. However, it was conducted 4.5 weeks after the completion of the study due to scheduling conflicts at the schools. During maintenance phase, mathematical word problem probes were conducted daily for three days. If participants regressed or achieved below 100% during the maintenance phase, they met criteria of the secondary study.

Secondary Study

Secondary Study: Design

The secondary study was an alternating treatment design. The purpose of the second study was to determine which prime, *Solve It!* cue cards or the *Solve It!* multimedia academic story, functioned best to increase the percentage correct on mathematical word problems if the participant does not maintain the use of the strategy. In an alternating treatment design, two or more interventions are implemented in the same phase to change a specific behavior (Kazdin, 1982). The underlying rationale for this design is the difference in participant response under the different conditions (Kazdin). When performance differs sharply depending upon the different interventions, a functional relationship can be drawn (Kazdin). When comparing two or more treatments, one must consider multiple treatment interference. When comparing two or more treatments, it is always possible that the effect may be partially due to the sequence of the interventions or the effects of one treatment may result in a carryover of the other treatment (Kazdin, 1982).

To limit treatment interference, students were randomly placed in the starting treatment condition. The alternating treatments were *Solve It!* cue cards and the *Solve It!* multimedia academic story. Students met criteria for the secondary study if they did not maintain use of the strategy or receive 100% correct on maintenance probes. All three participants met criteria for the secondary study.

Secondary Study: Experimental Procedures

Baseline

During the secondary study, an alternating treatment design was used to determine if a prime, the *Solve It!* cue cards or the multimedia academic story, reviewed by the student immediately prior to completing the mathematical word problems will increase the percentage correct to intervention phase performance or higher. See Appendix J for a pictorial view of the multimedia academic story. Maintenance data from the primary study was used for baseline data. Stability was defined as a “contratherapeutic or zero acceleration trend” (Tawney & Gast, 1984, p.201). Prior to entering intervention each participant was introduced to the Touch IPOD. Once mastery of IPOD use was established, each participant was introduced to the multimedia academic story. Prior to using the multimedia academic story, each participant was taught how to access the multimedia academic story and demonstrated 100% proficiency on retrieving the story and clicking on the video to watch the multimedia academic story. Students were asked comprehension questions regarding the academic story and demonstrated 100% comprehension of the content of the story. Once students were competent on the touch IPOD use and achieved 100% comprehension on the academic story check, they began the intervention phase.

Intervention Condition Alternating Treatments

Alternating treatments usually occur within the same day (Kazdin, 1982), however, due to the length of the treatment (45 minutes) and the demands of the natural setting, alternating treatments occurred every other day. Each participant was randomly assigned to a treatment group to begin the alternating treatment condition to prevent preference bias. Alternating treatment continued for six consecutive days or until stability was reached in treatment for three data points.

During the alternating treatments condition, participants were given five word problems to complete after reviewing the *Solve It!* cue cards or viewing the *Solve It!* multimedia academic story. The word problems were identical to the word problems in the primary study. The word problems consisted of Montague's curriculum based measures and one grade level FCAT problem. For this condition, the students received two prompts: Read the cue cards or view the story and complete the word problems. Students did not have access to the word problems until they had completed reading the cue cards or viewing the academic story.

Generalization

Generalization probes were conducted throughout the study in the students' mathematics classrooms. Generalization probes began during the baseline phase. One probe was conducted each week during all phases of the study. All students in the regular education classroom completed one FCAT word problem as part of the mathematics lesson. A mean percentage correct was calculated for the classmates for peer comparison.

Data Collection

Data collection consisted of percentage correct on grade level curriculum based measures and FCAT mathematics word problems. See Appendix I for examples of mathematics problems. Each subject completed five word problems each session. Upon completion of the session, a copy was made of each student's work. The change agent graded the mathematical word problems upon completion. An inter-rater graded 33% of the students' work to determine reliability of the data collected. Data were graphed after each session.

Generalization data were also collected each week on the participants and a percentage correct for the participant's peers in the mathematics classroom. The percentage of the class completing the problem correctly on the grade level FCAT mathematics word problem was collected for each participant's general education class.

Pre- and post-test data on students' attitudes towards mathematical word problems, self report of strategies used, and self perception of performance on mathematical word problems was collected via the *Solve It! Mathematical Problem Solving Assessment Short Form (MPSA-SF)* (Montague, 2003). Increase in the overall score from pre- to post-measures indicates an increase in the student's attitudes towards mathematical word problems and self-perceptions as a mathematical word problem solver.

Data Analysis

The dependent measure was graphed and analyzed visually following procedures outlined by Kennedy (2005) to determine the effects of the intervention on the dependent variables. All phases were conducted until visual inspection of the graphed data revealed at least three out of four consecutive, stable data points. The principal investigator used the Microsoft Excel software program to graph the data. Line graphs were constructed for percentage correct on mathematical word problems during all phases. A line graph was constructed for the changes in attitudes towards solving mathematics word problems and self-perceptions as a mathematical word problem solver according to the procedures in the *Solve It!* Problem Solving Routine (Montague, 2003).

To determine the influence of the intervention on the dependent measure, visual analysis of line graphs was employed (Kazdin, 1982; Kennedy, 2005). If changes in the dependent variable occur following the introduction of the independent variable, that change can be attributed to the independent variable. Visual analysis includes trends of the data in terms of slope, magnitude, and variability (Kazdin; Kennedy, 2005). The immediacy of the effect (how quickly the change occurs) (Kennedy) and overlap of the data between phases (strength of the change) were analyzed to determine the effectiveness of the independent variable (Kennedy; Scruggs, Mastropieri, Cook & Escobar, 1986).

Visual analysis is also employed in evaluating an alternate treatment design. In an alternating treatment design, conditions are balanced and a consistent number of treatments are employed for each intervention (Kazdin, 1982). Data are plotted according

to intervention so the differences can be seen. If changes in the dependent measure occur following the introduction of the independent variable, that change can be attributed to the independent variable. Visual analysis includes trends of the data in terms of slope, magnitude, and variability (Kazdin; Kennedy, 2005). The immediacy of the effect (Kennedy) and overlap of the data between interventions (strength of the change) were analyzed to determine the effectiveness of the independent variable (Kennedy; Scruggs, Mastropieri, Cook & Escobar, 1986).

To support the results of the visual data analysis, percentage of non-overlapping data (PND) for percentage correct mathematical word problems was computed by dividing the number of data points in the intervention phase that did not overlap, with data points in the baseline phase by the total number of data points in the intervention phase. Non-overlapping data of 90% or higher indicated a highly effective outcome, 70-90% indicated a fair outcome, 50-70% a questionable outcome, and below 50% an unreliable treatment effect (Scruggs, Mastropieri, Cooke & Escobar, 1986).

Validity

Content validity was established two ways. First, content validity was established by using the *Solve It!* Problem Solving Routine. Scripted lessons taken directly from *Solve It! A Practical Approach to Teaching Mathematical Problem Solving Skills* by Marjorie Montague (2003). See Appendix K for scripted lessons. Montague's intervention is written at the third-grade reading comprehension level and focuses on one, two, and three-step word problem solving. *Solve It!* is a validated meta-cognitive

strategy for middle school students with learning disabilities. Second, content validity was established by using mathematical word problems previously validated for internal consistency and reliability. Questions are curriculum based measures developed by the curriculum developer and released FCAT questions. Released tests are available online. Each question is rated for level of difficulty (easy, medium, difficult) and the answer is provided.

Social validity was accomplished three ways. First, a pre- and post-comparison of the *Solve It! Mathematical Problem Solving Assessment Short Form (MPSA-SF)* was conducted to determine the differences in strategy use and self perceptions of word problem solvers as determined by the student. Second, the exceptional education support teachers were surveyed with the *Intervention Rating Profile-15 (IRP-15)* (Martens, Witt, Elliot, & Darveaux, 1985). The IRP-15 is a 15-item Likert scale that evaluates the acceptability of an intervention by teachers. Reliability of the instrument is .98 (Martens et al., 1985). Scores on the IRP-15 can range from 15 to 90. Higher scores indicate a greater acceptance level. See Appendix L for an example of the IRP-15.

Third, a neuro-typical peer comparison validation strategy was employed. During generalization probes throughout the course of the study, neuro-typical peers were asked to complete word problems. Mean percentage correct on word problems for the class was graphed alongside the participants in the study. Visual analysis was conducted to determine if the participants were performing at a similar achievement level as their neuro-typical peers.

Inter-rater Reliability

Inter-rater agreement is the extent to which two or more raters agree that a behavior occurred (Kazdin, 1982). Inter-rater agreement provides a measure of reliability. Kazdin recommends inter-rater agreement for three reasons: (a) to minimize researcher bias, (b) to control for inconsistency, and (c) to determine if the dependent variable is well defined. Inter-rater reliability was established by having a doctorate level special educator independently grade 33% of the work samples across all phases of the study. Comparison of the agreements and disagreements was made between special educator and principal investigator. Inter-rater reliability was calculated by the formula: $\text{agreements}/(\text{agreements} + \text{disagreements}) \times 100$. The inter-rater scored one of every third sample throughout the study.

Treatment Integrity

Treatment integrity was accomplished several ways. First, scripted lessons from the *Solve It!* Problem Solving Routine was used to teach the intervention. Second, the teacher used a treatment integrity checklist while teaching the lessons. Last, a research assistant collected treatment integrity data via the treatment integrity checklist for 33% of the intervention sessions. Each session was videotaped. A trained research assistant viewed 33% of the treatment sessions and conducted treatment integrity. There is one treatment integrity checklist for each lesson. The treatment integrity checklist was created by Montague, the author of *Solve It!*, and adapted for the unique characteristics of this study. See Appendix M for the treatment integrity checklist example.

CHAPTER 4 RESULTS

Introduction

The purpose of the primary study was to examine the effects of a modified learning strategy on the multiple step mathematical word problem solving ability of middle school students with HFA or AS and to determine if learning *Solve It!* increased students reported self-perceptions of ability to solve word problems and attitude towards mathematical word problem solving. The study was conducted across 6 phases: (a) pre/post intervention/ assessment phase, (b) baseline, (c) intervention condition 1: training, (d) intervention condition 2: acquisition, e) maintenance, (f) generalization. The purpose of the secondary study was to determine which prime, cue cards or a multimedia academic story, works best to increase percentage correct on mathematical word problems if a student does not maintain strategy use. The secondary study consisted of 2 phases: (a) baseline, and (b) alternating treatments. Inter-observer agreement was conducted to assess the reliability of behavioral observations and the findings. Finally, treatment integrity and social validity data were collected.

Pre/Post Assessment Results

As described in Chapter 3, the Mathematical Problem Solving Assessment Short Form (MPSA-SF) was used according to procedures outlined by Montague (1997). The purpose of administering the MPSA-SF was to determine the need for the intervention and determine the pre/post-intervention reports of self as a mathematical problem solver

and attitude toward word problems. The changes in the MPSA-SF determine if an increase in the perception of self as a problem solver and positive attitudes toward solving mathematical word problems occurred as a result of learning the *Solve It!* Problem Solving Routine. Data on the MPSA-SF is collected via a five-point Likert Scale ranging from the category of very poor to very good. Individual results are graphically represented in Figure 2.

The results of the pre/post intervention administration of the MPSA-SF reveal that the perceptions of self as a mathematical problem solver and attitudes towards mathematics, attitude towards word problems did not increase as all three participants rated themselves as very good (the highest rating) prior to intervention. All but one rated themselves at the same level post-intervention.

Pre-Intervention ratings on perceptions of self as a mathematical problem solver (PMP) ranged from 3-5 with a mean rating of 4.3. Post intervention ratings of self as a mathematical problem solver (PMP) ranged from 3-5 with a mean of 4.3 Pre-interventions ratings of attitude toward mathematics (ATTM) were all rated at 5. Post-intervention ratings of ATTM ranged from 3-5 with a mean of 4.3 Nick rated himself lower post intervention on ATTM.

Pre-intervention ratings of attitude toward solving mathematical word problems ranged from 2-5 with a mean of 4. Post-intervention of ATT ranged from 4-5 with a mean of 4.6. Pre-intervention ratings of knowledge of mathematical problem solving (KMPS-1) ranged from 1-2 with a mean of 1.6. Post intervention ratings of the KMPS-1 were all rated at 5.

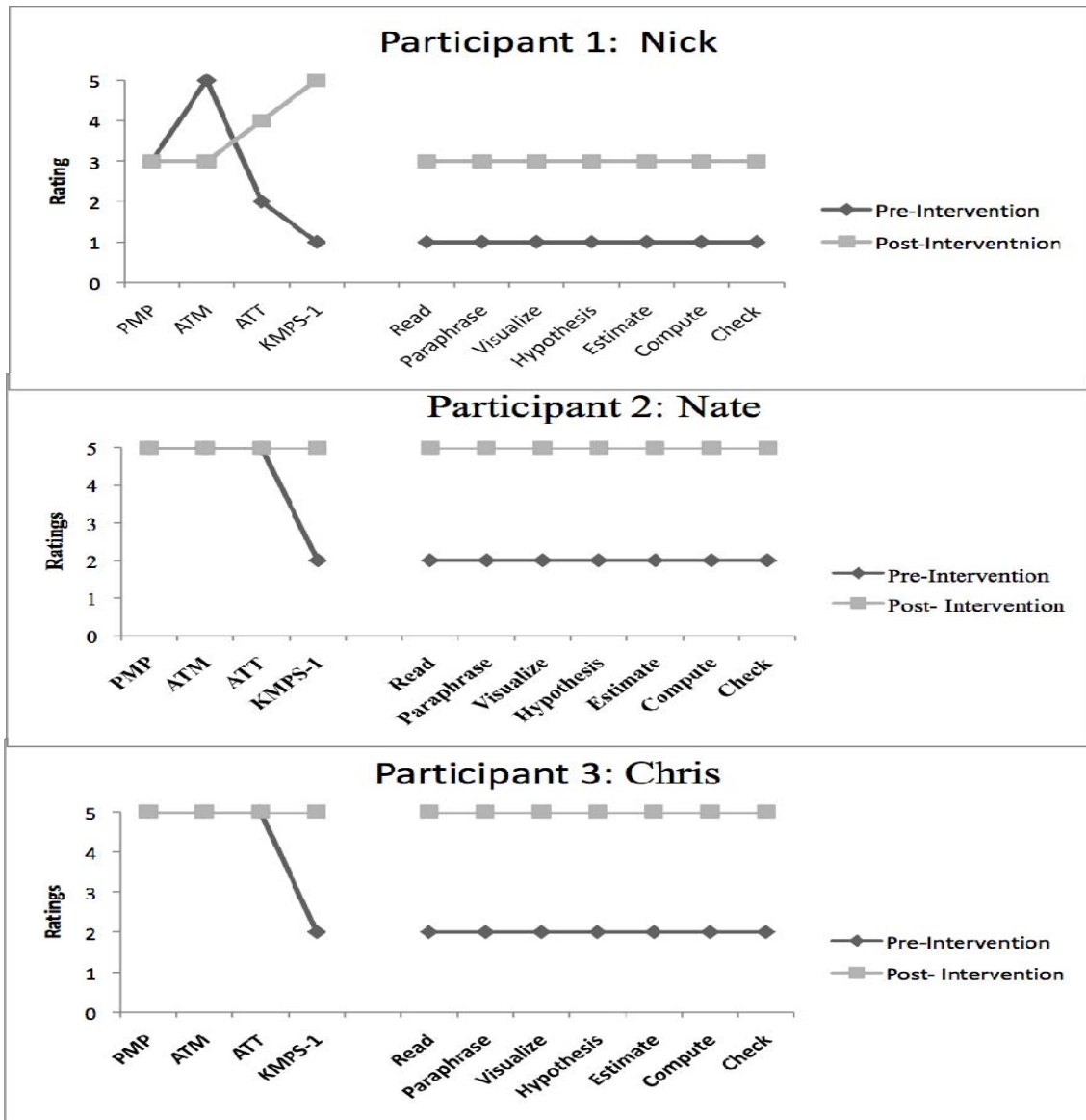


Figure 2. Graphical Representation of MPSA-SF

PMP=Perception of Math Performance; ATM=Attitude Towards Math; ATT= Attitude Toward Mathematical Problem Solving; KMPS=Knowledge of Mathematical Word Problem Solving

Further assessment of strategies for mathematical word problem solving indicated that all participants increased their knowledge of strategies in mathematical word problem solving. Overall, it appears that students did not increase their attitudes and perception of self as a mathematical problem solver. However, for Nick, it appears that *Solve It!* may have increased his awareness of his difficulties in mathematical word problem solving as he rated himself lower in his attitude toward mathematics post intervention.

Primary Study

To determine the effectiveness of *Solve It!* as an intervention to increase mathematical word problem solving ability for middle school students with HFA/AS, a single subject, multiple baseline across subjects design was employed. The primary study results consist of baseline phase, intervention training condition phase, intervention acquisition condition phase and maintenance phase. To assess the effectiveness of the intervention on the dependent measure, visual analysis included the change from phase to phase and the variability in the data within phases. To assess the overall effectiveness, percentage of non-overlapping data (PND) for correct mathematical word problems was computed by dividing the number of data points in the intervention phase that did not overlap with data points in the baseline phase by the total number of data points in the intervention phase. Non-overlapping data of 90% or higher indicated a highly effective outcome, 70-90% indicated a fair outcome, 50-70% a questionable outcome, and below 50% an unreliable treatment effect (Scruggs, Mastropieri, Cooke & Escobar, 1986).

Results are presented in Table 3. Figure 3 displays the results of the primary study graphically.

Table 3
Primary Study Results

	Nick	Nate	Chris
Baseline	Mean=35%, (Range=20-40%) Stable Slight Acceleration	Mean=50% (Range=40-60%) Stable Slight Acceleration	Mean=60% (Range=60-60%) Stable No Acceleration
Intervention Phase	Mean=84%	Mean=88%	Mean=96%
Training Condition	(Range= 80-100%) Stable Deceleration Trend	(Range=80-100%) Variability Stable Trend	(Range=80-100%) Stable Acceleration Trend
Intervention Phase	Mean=68%	Mean=92%	Mean=96%
Acquisition Condition	(Range=60-80%) Slight Variability Acceleration Trend	(Range=80-100%) Stable Deceleration Trend	(Range=80-100%) Stable Acceleration Trend
PND Baseline-	Mean=100%	Mean=100%	Mean=100%
Intervention Phase	Highly Effective	Highly Effective	Highly Effective
Condition 1 & 2			
Maintenance	Mean=60% Deceleration Trend	Mean=80% Deceleration Trend	Mean=60% Deceleration Trend

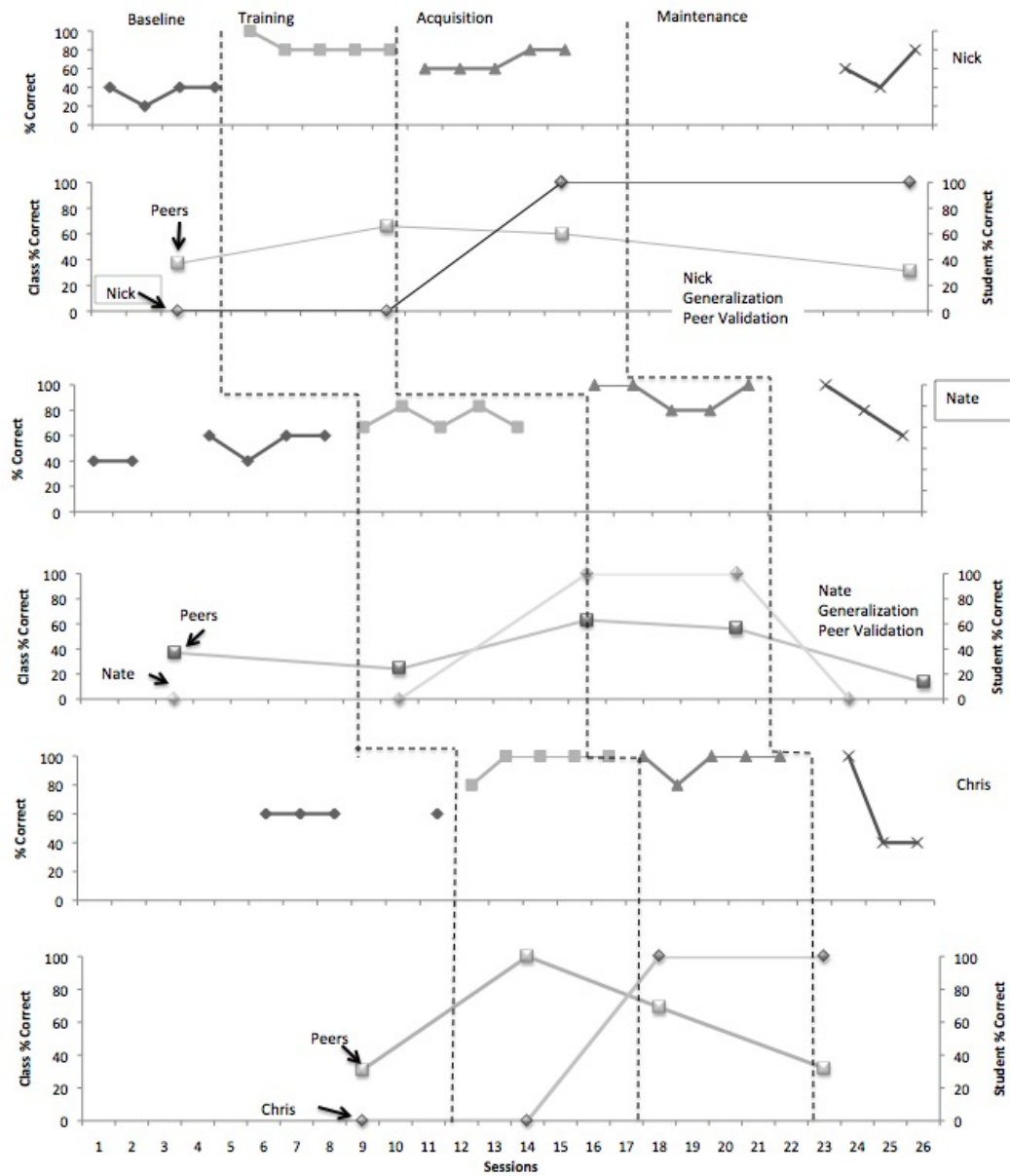


Figure 3 Primary Study Results

The Impact of the *Solve It!* Problem Solving Routine on the Mathematical Word Problem Solving Ability of Middle School Students with HFA/AS.

Participant 1 (Nick)

Nick's Baseline. During baseline Nick achieved a mean percentage correct of 35% (range = 20%-40%). The data were stable with a slight acceleration trend. Nick met criteria to enter intervention phase training condition after four days. Baseline criteria were met with no acceleration trend for 3 out of 4 consecutive data points. Nick was entered into intervention phase training condition while all others were held in baseline.

Nick's Intervention Condition Training Phase. During the intervention phase training condition, Nick immediately increased his percentage correct to 100% correct. He stabilized after five days in training with a mean percentage correct of 84% (range = 80%-100%). The *Solve It!* Problem Solving Routine requires a minimum of five days of training. Nick met criteria to enter the intervention condition acquisition phase upon completion of the five days of training and stable data for three out of four consecutive days. Data in the intervention condition-training phase had a slight deceleration trend. Upon stabilization of data and 100% memorization of the *Solve It!* Problem Solving Routine steps, Nick entered intervention condition acquisition phase and participant two entered intervention condition training phase.

Nick's Intervention Condition Acquisition Phase. During the intervention phase acquisition condition, Nick achieved a mean percentage correct of 84% (range = 60%-80%) with a slight acceleration and variability. Nick meet criteria for completion of the intervention condition acquisition phase by the curriculum by completing the five acquisition sessions as required by the *Solve It!* Problem Solving Routine and reaching

stability for three out of four consecutive data points. Once stability was reached in intervention condition acquisition phase, participant was allowed to enter as long as the participant had reached stability in intervention condition training phase.

Nick's Maintenance Phase. Maintenance was scheduled to occur three weeks after intervention condition acquisition phase. Due to scheduling conflicts in the district, maintenance did not occur until 4.5 weeks after intervention condition acquisition phase. School wide mandatory testing was scheduled and the administration was not allowed to permit visitors on campus for the week. During maintenance, Nick was given the prompt to complete the word problems and no other support was given. Nick achieved a mean of 60% during maintenance with a range of 40%-80% with variability and an acceleration trend. The highest data point was consistent with the acquisition phase, while the lowest data point was similar to baseline phase.

Participant 2 (Nate)

Nate's Baseline. Nate stabilized in baseline after 6 days of data collection. On day three, Nate hurt his finger in physical education class and missed the session as he went to the doctor. During baseline, Nate achieved a mean percentage correct of 50% (range = 40%-60%). The data were stable with a slight acceleration trend. Nate met criteria to enter intervention phase training condition after seven days. Baseline criteria were met with no acceleration trend for three out of four consecutive data points. Nate was entered into intervention phase training condition on day seven as participant one was stable in the intervention phase training condition. Participant 3 was held in baseline.

Nate's Intervention Condition Training Phase. During the intervention phase training condition, Nate immediately increased his percentage correct to 80% correct. He stabilized after 5 days in training with a mean percentage correct of 88% (range = 80%-100%). The *Solve It!* Problem Solving Routine requires a minimum of five days of training. Nate met criteria to enter the intervention condition acquisition phase upon completion of the five days of training and stable data for three out of four consecutive days. Data in the intervention condition-training phase had a stable trend. Upon stabilization of data and 100% memorization of the *Solve It!* Problem Solving Routine steps, Nate entered intervention condition acquisition phase as participant one had reached stability in the intervention condition acquisition phase. Nate reached stability on day five of the intervention condition-training phase, therefore, participant three was able to begin intervention.

Nate's Intervention Condition Acquisition Phase. During the intervention phase acquisition condition, Nate achieved a mean percentage correct of 96% (range = 80%-100%) with a slight acceleration, yet stable trend. Nate met criteria for completion of the intervention condition acquisition phase by completing the five acquisition sessions as required by the *Solve It!* Problem Solving Routine and reaching stability for three out of four consecutive data points. Once stability was reached in intervention condition acquisition phase, participant three was allowed to enter as long as the participant had reached stability in intervention condition training phase and had completed the required training sessions.

Nate's Maintenance Phase. Maintenance was scheduled to occur three weeks after intervention condition acquisition phase. Due to scheduling conflicts in the district and the delay of participant 1 in starting the maintenance phase, maintenance did not occur until 4.5 weeks after intervention condition acquisition phase. During maintenance, Nate was given the prompt to complete the word problems and no other support was given. Nate achieved a mean of 80% during maintenance with a range of 60%-100% with a deceleration trend. The highest data point was consistent with the acquisition phase, while the lowest data point was similar to baseline phase.

Participant 3 (Chris)

Chris's Baseline. Chris entered late into the baseline phase due to family circumstances. Data collection for the other two participants had begun and the study could not be delayed. During baseline, Chris achieved a mean percentage correct of 60% (range = 60%). The data were stable with no deceleration or acceleration trend. Chris met criteria to enter intervention phase training condition after three days. Baseline criteria were met with no acceleration trend for three out of four consecutive data points. Baseline probes were employed once stability was met. Chris was entered into intervention phase training condition when participant two stabilized in intervention phase training condition.

Chris's Intervention Condition Training Phase. During the intervention phase training condition, Chris immediately increased his percentage correct to 80% correct. He stabilized after 5 days in training with a mean percentage correct of 96% (range = 80%-

100%). The *Solve It!* Problem Solving Routine required a minimum of five days of training. Chris met criteria to enter the intervention condition acquisition phase upon completion of the five days of training and stable data for three out of four consecutive days. Data in the intervention condition-training phase had a slight acceleration trend. Upon stabilization of data and 100% memorization of the *Solve It!* Problem Solving Routine steps, Chris entered intervention condition acquisition phase.

Chris's Intervention Condition Acquisition Phase. During the intervention phase acquisition condition, Chris achieved a mean percentage correct of 96% (range = 80%-100%) with a slight acceleration and little variability. Chris met criteria for completion of the intervention condition acquisition phase of the curriculum by completing the five acquisition sessions as required by the *Solve It!* Problem Solving Routine and reaching stability for three of four consecutive data points.

Chris's Maintenance Phase. Maintenance was scheduled to occur three weeks after the intervention condition acquisition phase. Due to the delay of staggering in the maintenance phase for the first two participants, Chris's maintenance phase had to be delayed as well to have consistency across subjects. During maintenance, Chris was given the prompt to complete the word problems and no other support was given. Chris achieved a mean of 60% during maintenance with a range of 40%-100% with variability and a deceleration trend. The highest data point was consistent with the acquisition phase, while the lowest data point was similar to baseline phase.

Overall, a functional relationship between the increase in percentage correct on mathematical word problems and the *Solve It!* Problem Solving Routine for students with

HFA/AS was demonstrated. PND for each participant was at 100%, which indicates an effective intervention (Scruggs, Mastropieri, Cooke & Escobar, 1986). The immediacy of the effect for each participant indicates the strength of the intervention. Within phase analysis indicates a high level of change with low variability. Overall, trend in the data indicate a positive affect of the intervention. Results of the maintenance phase suggest that 4.5 weeks after the completion of the intervention phase, students with HFA/AS did not maintain use of the strategy at the intervention level. Overall, maintenance levels were higher than baseline levels, however, there were overlapping data points between baseline and maintenance.

Secondary Study

The purpose of the secondary study was to determine which prime, cue cards or the multimedia academic story, works best to increase the percentage correct if the participant does not maintain use of the strategy at the intervention level. During the secondary study, an alternating treatment design was used to determine if a prime, the *Solve It!* cue cards or the multimedia academic story, reviewed by the student immediately prior to completing the mathematical word problems increases the percentage correct to intervention phase performance or higher. In an alternating treatment design, a baseline phase is not required. However, for this study maintenance data from the primary study was used as baseline data. Each participant was randomly placed in the treatment group in which they would begin the alternate treatments. Results of the secondary study are presented in Table 4 and displayed in Figure 4.

Table 4
Secondary Study Results

	Nick	Chris	Nate
Baseline	Mean=60%	Mean=80%	Mean=60%
	(Range=40-60%)	(Range= 40-100%)	(Range= 60-100%)
	Acceleration trend	Deceleration Trend	Deceleration Trend
Cue Cards	Mean=93%	Mean=100%	Mean=40%
	(Range=80-100%)	(Range=40%)	(Range=100%)
	Acceleration Trend	Stable Trend	Stable Trend
Academic Story	Mean=93%	Mean=100%	Mean=93%
	(Range=80-100%)	(Range=80-100%)	(Range=100%)
	Acceleration Trend	Stable Trend	Acceleration Trend

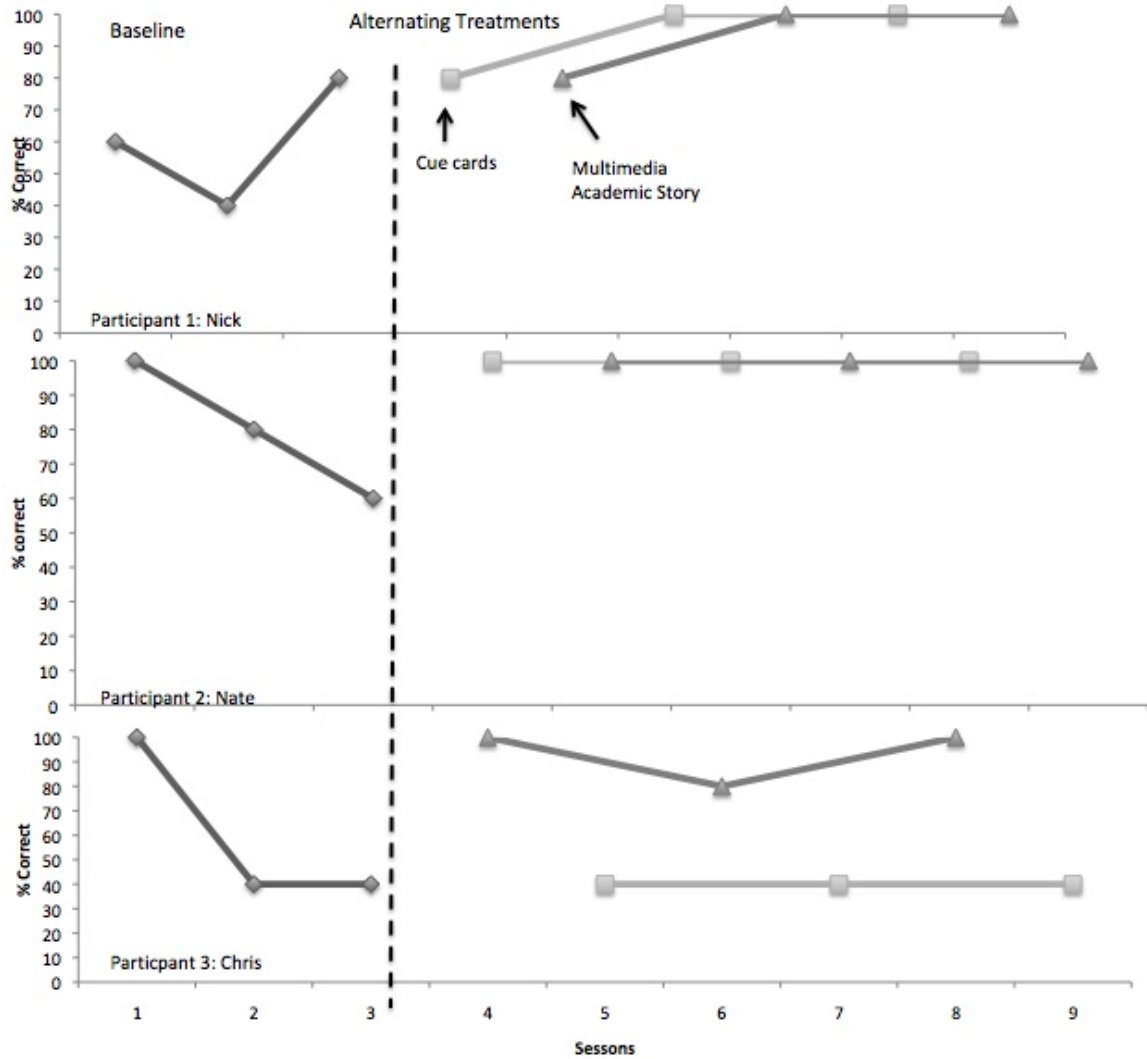


Figure 4 The Impact of *Solve It!* Cue Cards or *Solve It!*

Multimedia Academic Story on the Mathematical Ability of Students with HFA/AS

Participant 1 (Nick)

Nick's Baseline. During baseline, Nick was given the prompt to complete the word problems and no other support was given. Nick achieved a mean of 60% during

maintenance with a range of 40%-80% with variability and an acceleration trend.

Nick's Alternating Treatment. Nick was randomly selected to begin the alternating treatment with the cue cards as the prime. Immediately prior to solving the mathematical word problems, Nick was instructed to read the cue cards. Upon completion of reading the cards, Nick was handed the mathematical word problems and was prompted to complete the word problems. Using the cue cards, Nick's first data point in the alternating treatment was at 80% and all subsequent data points in the cue card treatment were at 100%. The mean percentage correct for the cue card treatment was 93% with a range of 80-100%. Using the multimedia academic story, Nick's first data point in the alternating treatment was at 80% and all subsequent data points in the cue card treatment were at 100%. The mean percentage correct for the multimedia academic story treatment was 93% with a range of 80-100%. Use of either prime was an effective intervention for Nick as the percentage correct increased higher than the intervention phase for both conditions.

Participant 2 (Nate)

Nate's Baseline. During baseline, Nate was given the prompt to complete the word problems and no other support was given. Nate achieved a mean of 80% during maintenance with a range of 60%-100% with a deceleration trend.

Nate's Alternating Treatment. Nate was randomly selected to begin the alternating treatment with the cue cards as the prime. Immediately prior to solving the mathematical word problems, Nate was instructed to read the cue cards. Upon completion of reading

the cards, Nate was handed the mathematical word problems and was prompted to complete the word problems. Using the cue cards, Nate's first data point in the alternating treatment was at 100% and all subsequent data points in the cue card treatment were at 100%. The mean percentage correct for the cue card treatment was 100% with a range of 100%. Using the multimedia academic story, Nate's first data point in the alternating treatment was at 100% and all subsequent data points in the cue card treatment were at 100%. The mean percentage correct for the multimedia academic story treatment was 100%. Use of either prime, was an effective intervention for Nate as the percentage correct increased higher the intervention phase in both conditions.

Participant 3 (Chris)

Chris's Baseline. During baseline, Chris was given the prompt to complete the word problems and no other support was given. Chris achieved a mean of 60% during maintenance with a range of 40%-100% with variability and a deceleration trend.

Chris's Alternating Treatment. Chris was randomly selected to begin the alternating treatment with the multimedia academic story as the prime. Immediately prior to solving the mathematical word problems, Chris was instructed to view the multimedia academic story on the Touch IPOD. After viewing the story, Chris was handed the mathematical word problems and was prompted to complete the word problems. Using the multimedia academic story, Chris's first data point in the alternating treatment was at 100%. The mean percentage correct for the multimedia academic story treatment was 93% with a range of 80-100%. Using the cue cards, Chris's first data point in the alternating

treatment was at 40% and all subsequent data points in the cue card treatment were at 40%. The mean percentage correct for the multimedia academic story treatment was 40%. Use of the multimedia academic story, was an effective intervention of Chris as the percentage correct increased back to results in the intervention phase. The use of cue cards as a prime was not an effective intervention for Chris as the percentage correct during this treatment decreased lower than the results in the baseline phase in the primary study.

Overall, priming was an effective intervention for all three participants. However, the type of prime resulted in large differences in percentage correct on mathematical word problems for one participant. These findings are consistent with the literature as prior research suggests that priming is an effective intervention to increase academics for children with autism (Koegel, Koegel, Frea, & Green-Hopkins, 2003). However, this is the first study that has addressed using a multimedia academic story as a prime in the area of cognitive strategy instruction. The varied results of the effectiveness of the types of prime is also consistent with the literature in that it supports the heterogeneous nature of HFA/AS and individualization of each student's needs when developing academic supports (Griswold, Barnhill, Smith-Smith-Myles, Hagiwara & Simpson, 2002).

Social Validity

Social validity was accomplished three ways. First, a pre- and post-comparison of the *Solve It! Mathematical Problem Solving Assessment Short Form (MPSA-SF)* was conducted to determine the differences in strategy use and self perceptions of word

problem solvers as determined by the student. Second, the exceptional education support teachers were surveyed with the *Intervention Rating Profile-15 (IRP-15)* (Martens, Witt, Elliot, & Darveaux, 1985). Third, generalization data were collected in the general education setting during all phases and neuro-typical peer comparison data were collected along side the generalization data in the general education setting.

Results of the MPSA-SF indicate that all three participants increased their knowledge of mathematical word problem strategies. Pre-Interventions ratings ranged from 1-2 with a mean rating of 1.6. Post-intervention ratings ranged from 3-5 with a mean rating of 4.3. All three students rated themselves the highest on perception of self as a mathematical problem solver and the highest on attitudes toward mathematics and mathematical word problems during the pre-intervention phase. The inflated scores during the pre-intervention phase made increases between the pre and post intervention difficult.

The IRP-15 (Martens, Witt, Elliot, & Darveaux, 1985) was administered to the special education support teachers who assisted with the study at the end of the study. While the special educators were not the change agent in this study, they did assist with maintenance data collection. Results of the study were shared with the special educators before completing the IRP-15 and the special educators were given a copy of the curriculum and were asked to review the curriculum prior to the interview. Scores on the IRP-15 range from 15-90. High scores on the IRP-15 indicate a high preference for the intervention. The IRP-15 was conducted with two special educators, one at each school site. After reviewing the curriculum and the results of the study, both educators indicated

a high preference for using the curriculum with students who have HFA/AS. The first teacher, who supported Chris in his general education setting, scored 59 of 60 on the IRP-15. The second teacher, who supported Nick and Nate in the general education setting, scored 55 of 60. Both teachers scored lower on question number ten which asks the teacher if they have used this type of intervention in the past. Both teachers had limited experience with cognitive strategy instruction and no experience with the multimedia academic story.

Generalization Data and Peer Validation Data

Generalization data and peer validation data were collected in the general education setting as a means of social validity. Generalization data were collected in the regular education mathematics classroom. One time per week the teacher administered a medium level, two-step novel mathematical word problem as bell work. The only prompt the students received was to complete the word problem. Only one word problem was administered as the teacher could not take time away from the general curriculum to administer a five-question word probe. Dichotomous data on the participant (correct or incorrect) was collected. The mean percentage correct was calculated for the rest of the class. All three participants did not demonstrate generalization until at least the intervention phase training condition. Individual generalization data follows.

Nick's Generalization and Peer Validation Data

During baseline, Nick did not answer the question correctly compared to 40% of his class that answered the question correctly. During the intervention condition-training phase, Nick did not answer the question correctly compared to 66% of his peers who answered the question correctly. During the intervention condition acquisition phase, Nick answered the question correctly compared to 60% of his peers. During the maintenance phase, Nick answered the question correctly compared to 31% of his peers who answered the question correctly (See Figure 5).

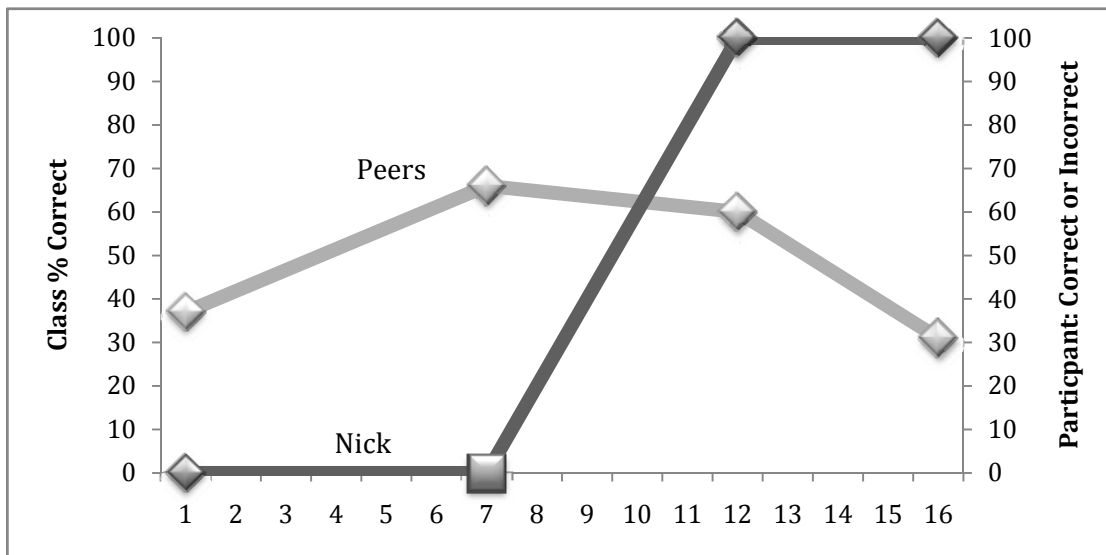


Figure 5 Nick's Generalization and Peer Validation Data

Nick's Correct or Incorrect on One Word Problem versus the Percent of the Class that Answered the Question Correctly

Nate's Generalization and Peer Validation Data

During baseline, Nate did not answer the question correctly compared to 37% of his class that answered the question correctly. During a second week of baseline, Nate did not answer the question correctly compared to 24% of his class that answered the question correctly. During the intervention condition-training phase, Nate did answer the question correctly compared to 63% of his peers whom answered the question correctly. During the intervention condition acquisition phase, Nate answered the question correctly compared to 56% of his peers. During the maintenance phase, Nate did not answer the question correctly compared to 17% of his peers who answered the question correctly (See Figure 6).

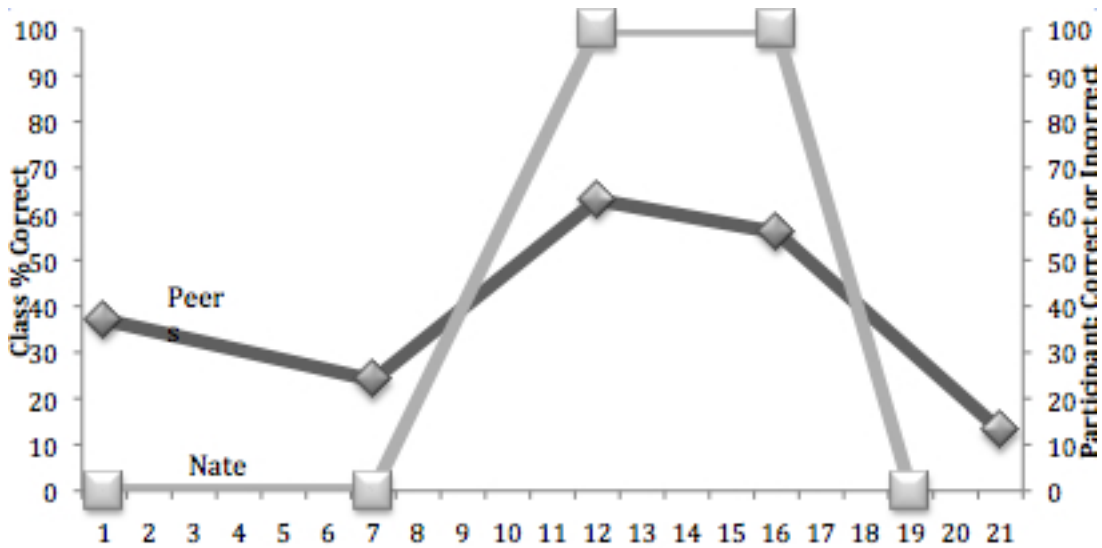


Figure 6 Nate's Generalization and Peer Validation Data

Nate's Correct or Incorrect on One Word Problem versus the Percent of the Class that Answered the Question Correctly

Chris's Generalization and Peer Validation Data

During baseline, Chris did not answer the question correctly compared to 31% of his class that answered the question correctly. During intervention phase training condition, Chris did not answer the question correctly compared to 100% of his class that answered the question correctly. During the, intervention phase- acquisition condition, Chris did answer the question correctly compared to 69% of his peers who answered the question correctly. During the maintenance phase, Chris answered the question correctly compared to 32% of his peers (See Figure 7).

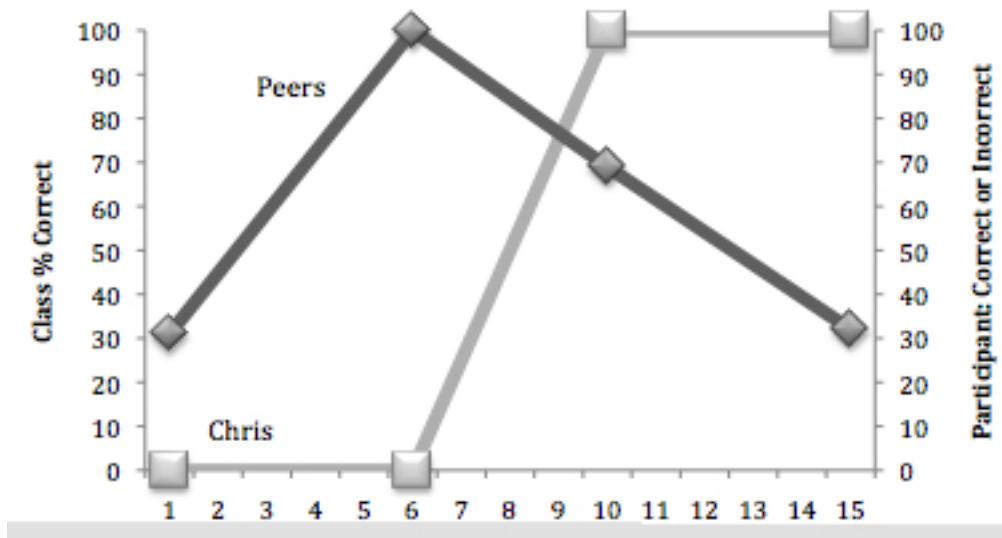


Figure 7 Chris's Generalization and Peer Validation Data

Chris's Correct or Incorrect on One Word Problem versus the Percent of the Class that Answered the Question Correctly

Overall, the use of the strategy did generalize to the regular education setting. During baseline the participants were not able to use the strategy as they had not learned the strategy and did not answer the question correctly. By the intervention condition training phase, all three participants had used the strategy as evidenced by the acronym being written on the paper and steps of the strategy implemented, however, only one participant answered the problem correctly. By the intervention condition acquisition phase all three participants used the strategy as evidenced by their papers and all three of the participants answered the problem correctly. Two of the three participants answered the generalization question correctly in the maintenance phase. The student who did not answer the question correctly did not use the strategy as evidenced by the work sample.

Inter-Rater Reliability

Inter-rater reliability was established by having a doctorate level special educator independently grade 33% of the work samples across all phases of the study. Comparison of the agreements and disagreements were made between special educator and principal investigator. Inter-rater reliability was calculated by the formula: $\frac{\text{agreements}}{\text{agreements} + \text{disagreements}} \times 100$. Inter-rater reliability was at 98% agreement. On one problem, the student had labeled the answer incorrectly. The inter-rater had marked the problem wrong while the change agent had marked the problem correct. After review of the problem and the student work sample, the problem was marked as correct.

Treatment Integrity

To determine treatment integrity, all sessions were videotaped and a research assistant collected treatment integrity data via the treatment integrity checklist for 33% of the intervention sessions. Treatment session videos were randomly selected from all phases of the study over the course of the study. A doctorate level special educator viewed the videotapes independent of the change agent and assessed the implementation of the lessons via the treatment integrity checklist. According to the inter-observer for treatment integrity, treatment was carried out with 100% fidelity. While this appears high, it should be noted that the change agent used a scripted lesson while teaching, followed the treatment checklist during each teaching session, and teaching sessions were delivered in a one on one setting, limiting teaching distractions.

CHAPTER 5 DISCUSSION

Introduction

The purpose of this chapter is to expound on the results of the primary and secondary studies. The chapter begins with a summary of the findings organized around each of the research questions. Next, the unique finding for each participant as it relates to the characteristics of autism is presented. In addition, this chapter addresses the contribution of the current findings to theory. Then, the limitations of the study are presented. Finally, the chapter concludes with the implications for future research and practice. See Appendix N for student work samples.

Summary of Findings

In research question 1, (*What is the effect of the Solve It! curriculum on the percentage correct of multiple step word mathematical problems for middle school students with HFA/AS*) a functional relationship between *Solve It!* and the percentage correct on mathematical word problems for middle school students with HFA/AS was demonstrated in the primary study. The immediacy and strength of change was demonstrated for all three participants. The findings in the current study are consistent with past research conducted with students with learning disabilities (Montague, 1992; Montague & Bos, 1986; Montague, Applegate, & Marquard, 1993) and spina bifida (Mesler, 2004). During the maintenance phase, all participants achieved higher percentage correct than the baseline phase, yet lower than the intervention phase. The

results of the maintenance condition in the primary study indicated some maintenance of strategy use as all three participants wrote the strategy on the paper and demonstrated use of the strategy by underlining the important parts in the question, drawing a visualization, writing an estimate, and computing the answer. The cognitive processing steps of reading and checking, can only be demonstrated on the work samples by the student checking off that the task was performed. On two of the three participant's work samples, checking did not appear to be utilized indicating that the students may have skipped this step and did not catch mistakes or moved to quickly through the steps. Findings in the maintenance condition were consistent with research on *Solve It!* for children with spina bifida (Mesler, 2004) and similar to research on *Solve It!* for children with learning disabilities (Montague, 1992; Montague & Bos, 1986; Montague, Applegate, & Marquard, 1993). In the current study, mean percentage correct in maintenance was slightly lower than past studies utilizing *Solve It!* with children who had learning disabilities.

On the second research question addressed in the primary study, (*What is the effect of the Solve It! Problem Solving Routine on reported self-perceptions in and attitudes towards mathematical word problem solving for children with HFA/AS?*), the participants had very little or no increase in self-perceptions and attitudes toward mathematical word problem solving and mathematics in general. This is inconsistent with prior research indicating that the use of *Solve It!* did increase self-perceptions and attitudes toward mathematical word problem solving for children with learning disabilities (Montague & Bos, 1986; Montague, 1992; Daniel, 2003). This may have been due to ceiling effect at the pre-intervention phase of the study. Many times people with autism have a lack of

self-awareness (Smith-Myles & Simpson, 2002), which may have accounted for the high rating at the pre-intervention phase. However, feedback on mathematical ability and mathematics grades may have also contributed to the perception of self as very good in mathematics and mathematical word problem solving as participant 2 was receiving a grade of B and participant 3 was receiving a grade of A in their current mathematics course. However, participants 2 and 3 had not yet started Algebra which is much more abstract. Observation of work samples from the regular education setting indicated that both participants' (2 and 3) mathematics class focused on more on basic concepts and procedural learning. One regular education teacher stated that students had not begun looking at problem solving and word problems in her classroom and did not think her students would be able to apply the concepts to the word problems on the generalization probes. This may explain why the students perceived themselves as "very good" at the pre-intervention phase of the study even though they met criteria for the study on the baseline measures. Nick was taking algebra along with a mandatory remedial math class as he scored poorly on the statewide assessment in mathematics. The remedial mathematics class was 100% inquiry based learning. Nick was acutely aware of his difficulties in this class. He openly discussed that he was not learning because of how the class was taught.

All participants were surprised when they saw their scores during baseline (students were not shown the baseline data until immediately prior to entering the intervention phase). Each participant was intensely interested in his score during the intervention and graphed his data daily. Graphing the data appeared to be a motivator for all participants

as indicated by comments such as “ I want to keep my record of 100% going,” and “Wow! Look at the change when I used the strategy.” Graphing the data during intervention phase acquisition condition became stressful for Nick as his scores decreased below intervention phase training condition. Nick became anxious about his performance and appeared frustrated when his score was less than 80%. Nick would make comments such as “ I have to get this right. Math is so important for college.” Even though Nick met criteria to move to the Intervention phase acquisition condition, the modeling of the strategy use and the strategy cues in the environment provided procedural support. Nick may have needed more time with the procedural supports in place to acquire the strategy. Prior research has suggested that procedural facilitation strategies may be needed for some children with ASD instead of traditional cognitive strategy instruction as children with ASD may need more and longer support to implement the strategy effectively (O’Connor & Klein, 2004). Nick became acutely aware of his difficulty in mathematical word problems over the course of the study. He would frequently make comments such as “ I just do not know what to do. If someone could tell me what to do, I could easily do it.” This comment was in reference to setting up the problem solving and in determining what the question was asking the student to solve. Nick rated himself lower on the attitude toward mathematical word problem solving at the post-intervention phase of the study.

Results for the third research question (*Does the use of a multimedia academic story written for the Solve It! program or the use of written Solve It! cue cards increase the percentage correct if the student does not maintain the learned skill?*) were mixed.

For Nick and Nate, both the *Solve It!* cue cards and the *Solve It!* multimedia academic story were effective primes and served as procedural facilitation as both increased their performance on mathematical word problems in the alternating treatments phase when compared to baseline. Both primes were not effective for Chris. Only the multimedia academic story served as a prime to facilitate the use of the procedure. During the alternating treatments, Chris appeared to be very distracted by a class assignment. One of his classes was having a play, and he had auditioned for a part. During the alternating treatment phase, he was waiting to hear if he had been assigned the part he wanted. He persevered on this topic for most conversation and did not want to miss any of this class for the study. Each day he carried his script with him and informed the change agent of how many days were left until he would hear if he got the part. He was worried that the part would be announced early and he would miss hearing it. This external distraction may have had an impact on his performance but only when Chris was using the cue cards as a prime. When using the multimedia academic story delivered via a Touch IPOD with headphones, he was able to remain focused on the task as evidenced by the percentage correct and work samples. The varied results strengthen past research that suggests that supports for children must be individualized due to the heterogeneous nature of the disorder (Griswold et al., 2002). The results of the secondary study extend the findings of O'Connor and Klein (2004) on the effectiveness of procedural facilitation in reading comprehension to the area of mathematical word problem solving. Procedural facilitation is different than cognitive strategy instruction in that the process prompts the executive processes and student internalization of the process may not be expected.

Meta-cognition has been identified as an area of concern with people with autism (Solomon, Ozonoff, Cummings, & Carter, 2008) and is a difficult area to assess. For this study, all three participants quickly memorized the cognitive process and the procedures for each. All three participants had more difficulty self-monitoring themselves with the meta-cognitive process of say, ask, and check for each cognitive process. They were able to recite and define the cognitive strategies as required by the curriculum but had difficulty remembering to say, ask and check within each step even though it was presented on the cue cards and posters.

The following section discusses the unique findings for student implementation of each step of the strategy as they relate to cognition, meta-cognition, executive function and the characteristics of HFA/AS. The cognitive steps in the Solve It strategy are read, paraphrase, visualize, hypothesize, estimate, compute and check (Montague, 2003). Within each cognitive step, they student are taught to use the meta-cognitive steps of say, ask, check (Montague).

Solve It! Strategy Steps

Read

The first step in the strategy is to read the problem. The participants were taught to read the problem, ask themselves if they understand the problem and if not go back and re-read until they understand the problem. Even though all three participants in the study had reading comprehension skills above the readability level of the word problems, some

language interference was evident. For example, at one point during baseline, Nick was completing a word problem that began with “Three boys went to the movies, they bought tickets”. While solving the problem he stated, “I do not know how many of the boys bought tickets.” This was also written on his paper as an explanation for not completing the problem. Another example of language interference for Nick occurred during the intervention condition-training phase. Nick stopped during the second problem and stated, “ I know how to solve this problem but why would anyone pay \$46.99 for a dog pen?” The word problem was about purchasing supplies to build a pen for a dog. The supplies listed in the problem were related to building a pen. After questioning Nick, the change agent realized that Nick thought the pen was a writing pen that had a dog on it. He was unable to pick up the context clues to determine the appropriate meaning for the word. Nate did not know the meaning of a dog pen and also asked the change agent what it meant. During another word problem, Nate laughed hysterically at a question that read, “Mr. Black bought 9 gallons of brown paint...” Nate thought it hilarious that the proper noun, Mr. Black, and the adjective, brown, refer to color. He could not get past the hilarity of the sentence to perform the work until the researcher changed the proper noun to a different name. His interpretation of the language and the subsequent emotional liability that followed interfered with his ability to perform the word problem. This is also an example of the mental inflexibility and set shifting difficulties that children with HFA/AS may demonstrate (Happé, Booth, Charlton, & Hughes, 2006).

Paraphrase

The second step in the strategy is to paraphrase. During baseline, there was no evidence, written or verbal, that the students paraphrased the problem to increase their understanding. During intervention phase training condition, the students were able to state that paraphrasing was putting the question into their own words or saying the important parts of the question. They were taught to underline the important parts of the question. All three participants consistently underlined the important parts of the question during intervention phase training and acquisition condition, maintenance phase, and 98% of the time during generalization. Nate did not use the strategy on the last generalization data point collected as evidenced by his work sample. None of the three participants was able to put the question in his own words even with modeling and practice. All three participants simply re-read the underlined parts of the question. This is not surprising, given the mental inflexibility (Happé, Booth, Charlton, & Hughes, 2006) and the communication deficits (Farrigua & Hudson, 2006) reported with persons with HFA/AS. Many times the high verbal ability of students with HFA/AS give the illusion that they are effective communicators when indeed they are not (Farrigua & Hudson). Even though the internalization of paraphrasing as evidenced by saying the question in their own words was not evident, the external support of underlining the important parts of the question appeared to provide enough support to solve the problem correctly. Nate began crossing out the unimportant parts of the question. Nick began writing in the noun (Three boys) in place of the pronoun (They) once he was taught how to identify what the pronoun meant.

Visualize

The next step in the strategy involves creating a visualization of the problem to assist in problem solution development and problem solving. Initially, all three participants drew pictorial representations of the word problem. After roughly two days of modeling how to use a schematic representation versus a pictorial representation, the students started using tables, graphs, and visual organizers. Schematic representation leads to greater problem solving ability and assists the student in moving to an abstract representational level (Fuchs et al., 2004; Jitendra, DiPipi, & Perron-Jones, 2002; Xin, 2008). None of the three participants spontaneously used an abstract representation. On the third training day, however, the participants were introduced to creating an equation as a visual representation. Nate and Chris quickly adapted their visualizations into an abstract representation of an equation as evidenced by their work samples. For both Nate and Chris, the equation became the most frequent visualization used for problem solving. Both participants continued to use tables and simple pictorials when the problem was easier to solve using this type of representation. Nick was able to develop a pictorial representation of the problem. He struggled with the representation and abstract levels of visualization. Nick frequently would use the type of visual representation that was last used by the change agent during modeling. He would attempt to create a table or a visual organizer but was unable to make connections between the parts of the problem in order to solve. This is consistent with prior research on cognition of children with ASDs regarding difficulty with abstract concepts (Donnelly, 2005) and with organization of information (Happe, Booth, Charlton, & Hughes, 2006). This also may be a component

of poor visual working memory with students who have an ASD (Frith, 1970a, 1970b; Fryffe & Prior, 1978; Minshew & Goldstein, 1998; Williams, Goldstein, & Minshew, 2006). It may be that Nick had difficulty holding multiple pieces of information in his working memory while pulling connections from his long-term memory. Findings that memory for low-level materials is intact and memory for complex levels of organization is impaired with person who have HFA/AS (Fein, Dunn, Allen, Aram, Hall, Morris, & Wilson, 1996), may provide an explanation for why Nick performed well on one-step problems, okay on two-step problems and struggled with three step problems.

Hypothesize

The next step in the strategy was to hypothesize or develop a plan to solve the problems. The students were to use the problem and visualization to determine how many steps the problem required and what operations were needed to solve the problem. Chris demonstrated no difficulty in this area. He very quickly would determine how many steps and write the operations symbols on his paper to help organize his work. Once Nate was able to create a schematic representation of the problem, he, too, could quickly figure out how many steps he needed to solve the problem. Nate relied on key words and many times key words can be misleading in multiple step higher-level word problem solving (Xin, Jitendra, & Deatline-Buchman, 2005). Nate would frequently write down the opposite operation (division instead of multiplication) and not catch his mistake until he was estimating. During estimating, he would learn that something was not working right and would change the operation. This was evidenced on his work samples. Nick had

difficulty determining if a word problem was more than two steps. He verbalized and wrote on his paper, “Maybe I would....” indicating that he was unsure of himself. Again, this is consistent with past research on cognition for children with ASD. Memory for low-level materials is intact and memory for complex levels of organization is impaired (Fein, Dunn, Allen, Aram, Hall, Morris, & Wilson, 1996) and planning and organizational abilities are impaired (Happe, Booth, Charlton, & Hughes, 2006). Nick and Nate demonstrated increased difficulty on three-step problems as evidence by the number of incorrect responses on three step problems compared to one and two steps. This was not the case for Chris, who demonstrated no error pattern in number of steps required for the word problem.

Estimate

The next step in the strategy was to estimate. Chris quickly and efficiently estimated his answer. If the estimate did not match with the problem, he would quickly re-evaluate and change his hypothesis. Nate was able to estimate and was able to see that he was using the wrong operation to solve the problem. Many times he would go back to the hypothesis and change the operation symbols or add a step that he missed while developing his plan. Nate was unable to estimate even with multiple modeling and direct instruction of the concept during the intervention phase training condition. If the number was 235, Nick would estimate the number at 234 or 236. If the number was 9.99, Nick would estimate it at 9.98. Given his difficulties with the concept of estimating, this step was of little value to him and possibly caused errors as he checked his answer with the

estimate. The process of estimating was made more difficult as he did not use easier numbers to manipulate and his answer was always close to his estimate as the numbers only changed by a fraction. This finding is consistent with prior research indicating that children with ASDs have difficulties with abstract concepts (Donnelly, 2005) and desire for exactness (Griswold et al., 2002). Mesler (2004) removed the step of estimation when working with students who had spina bifida due to their difficulty with this step.

Compute

The next step in the strategy was to compute. When entering numbers in the calculator, all three participants were under the assumption that it did not matter what order they entered the number. While this rule applies to addition, it does not apply to division or subtraction. If the number on the calculator did not make sense in division or subtraction, they would quickly switch the order they entered the numbers. This finding is of concern. First, these students were taught a strategy that did not apply in all situations. Second, while this strategy works in earlier grades when manipulating whole numbers it does not apply to negative numbers and fractions. Third, students with autism demonstrate an adherence to a set of rules and may not change the rule to meet the demand of the new task (Barnhill, 2001). Another example of students being taught a rule that does not apply to higher order mathematics was apparent with Nick when he told the change agent that the largest number always had to be the dividend and the smallest number had to be the divisor because you cannot divide a number by a number that is larger. When shown that 4 divided by 100 is equal to .04 and that is how we get fractions,

he had a greater understanding. This is another example of rules that apply to learning basic math facts that do not apply to all mathematics. Chris had the greatest number of simple computational errors. Chris used mental math for most of his calculations even though he had access to a calculator. Towards the end of the study he had begun using the calculator, which may explain his decrease in computational errors. All three participants wrote the number sentence on their papers prior to using the calculator to solve the problem.

Check

The final step in the strategy is to check. Nate frequently moved quickly through this step. He would make sure his answer was close to his estimate and then make sure his numbers in the equations matched the word problem. Rarely, did he take the final step of making sure his answers were correct by re-doing the computation. Chris rechecked his computations and check his answer against the estimate but did not go back to the word problem to check his numbers. It appeared that he relied upon his memory of the numbers in the word problem and did not go back to the word problem to check his equation for accuracy prior to computing the solution. If his numbers were off by just a little the answer would still be close to the estimate even though it was wrong. This was the most frequent type of error that Chris made. Nick re-calculated the entire mathematical word problem. Because of his poor estimating skills and desire for exactness, it was hard for him to simply compare. As a result, the time it took Nick to solve the five word problems never decreased. At the end of the study it still took him 45

minutes to solve 5 word problems compared to 20 minutes for the other two participants. The goal of *Solve It!* is for the students to complete 10 problems in 60 minutes (Montague, 2001). The errors in checking may have been caused by the working memory deficits, set shifting and attention deficits seen with students who have ASDs including HFA/AS (Happe, Booth, Charlton, & Hughes, 2006).

The overall findings suggest that the Solve It! curriculum had an impact on the executive functioning of students with HFA/AS. It appears that the students demonstrated increased control of executive functions such as: memory/planning, including cognitive processes such as organization, working memory, and interference control; set shifting/mental flexibility, including cognitive processes such as perseveration, attention, and self monitoring; and inhibition/response control, including cognitive processes such as impulse control (Happe, Booth, Charlton, & Hughes, 2006). From this study, it was impossible to determine if executive measures increased as a result of using the strategy. It can only be assumed as a result of the increased ability to solve word problems when using the strategy. It could be that the structure of the cognitive processes reduced the cognitive load allowing more working memory for meta-cognitive strategies. Future studies could collect executive functioning measures on the participants to determine if there is a correlation between the measures and aspects of word problem solving ability.

Extension of Current Theory and Implications for Practitioners

The results of this study have implications for practitioners teaching students with HFA/AS. First students with HFA/AS do use strategies. Second, students with HFA/AS

do benefit from strategy instruction if tailored to meet the unique cognitive profile each student with HFA/AS may present. Third, students with HFA/AS who do not maintain the use of the strategy or internalize the strategy may need procedural facilitation. Lastly, teacher educators must provide effective instruction on how to teach cognitive strategy instruction.

Bebko & Ricuitto (2008) reported that students with HFA/AS use strategies. The current study provides further support of strategy use in mathematical word problem solving in middle schools students with HFA/AS. During the pre-intervention phase, all three participants were able to describe strategies they used to solve mathematical world problems related to the cognitive steps of *Solve It!*. The MPSA-SF indicated that all three participants used some level of re-reading, planning, and computing to solve mathematical word problems and all three participants had some knowledge of each of the cognitive strategies. It was apparent that the participants in the current study were applying mathematical rules without adapting the rules to meet the demands of the new task. Basically, the participants were using strategies that applied to low level mathematics but would no longer apply to higher-level mathematics and problems solving. Teachers in the mathematics classroom need to assess and determine what types of strategies children with HFA/AS are using. The effectiveness of the strategy can then be supported or adapted to best meet the need of the student with HFA/AS.

Cognitive strategy instruction has been shown to be an effective intervention with students who have HFA/AS in the areas of memory (Bebko & Riccuiti, 2000), test taking (Songlee, 2006; Songlee et al., 2008), social skills (Webb, Miller, Pierce, Strawser, &

Jones, 2004), reading comprehension (O’Conner & Klein, 2004), and writing (Delano, 2007). This is the first study extending the use of cognitive strategy instruction to the area of mathematical word problem solving for students with HFA/AS. The results of this study suggest that students with HFA/AS do benefit from cognitive/meta-cognitive strategy instruction in the area of mathematical word problem solving. However, great care needs to be taken to determine if students are able to maintain use of the strategy or if they may need procedural facilitation such as the *Solve It!* cue cards or the *Solve It!* multimedia academic story. For some students with HFA/AS, procedural facilitation may be warranted (O’Conner & Klein, 2004). Priming is an effective intervention to facilitate the use of procedures for students with autism (Koegel, Koegel, Frea, & Green-Hopkins, 2003). Teachers need to teach cognitive and meta-cognitive strategies to children with HFA/AS. By having a basic understanding of the academic and cognitive profile of children with HFA/AS, a teacher can choose strategies that meet the unique cognitive needs of children with HFA/AS. Teachers need to monitor the maintenance and generalization of the strategy use after the student has achieved mastery. If a student does not generalize or maintain use of the strategy, procedural facilitation strategies such as priming should be implemented. Primes can be developed in the form of video models, cue cards or checklists. However, if strategy use does not increase performance, once the prime is initiated, the teacher needs to adapt the type of prime the student is using. In the current study, the multimedia academic story served as a prime for all three participants. Given that the multimedia academic story is multimodal it can be expected to reach more students with different learning styles. It is suggested that teachers use this type of prime

and fade to primes that provide lower level of supports once the student is achieving at the mastery level.

The current research study extends the effectiveness of the *Solve It!* Problem Solving Routine to students with HFA/AS. Findings are similar to prior research on *Solve It* and students with learning disabilities (Montague, 1992; Montague & Bos, 1986; Montague, Applegate, & Marquard, 1993) and spina bifida (Mesler, 2004). The maintenance phase for the current study was similar to the findings for students with spina bifida (Melser, 2004) in that maintenance of strategy use was limited and differed from the findings for children with learning disabilities (Montague, 1992; Montague & Bos, 1986; Montague, Applegate, & Marquard, 1993). The secondary study indicates that the *Solve It!* curriculum can easily be modified into a prime to be used for procedural facilitation. Teachers can use *Solve It!* to teach all students the cognitive processes and meta-cognitive strategies that good problem solvers use. Once the strategy has been mastered, *Solve It!* can then be embedded in the curriculum and modeled in a variety of settings and activities. As demonstrated by Montague (1992) and in the study, a prime or refresher session increases performance back to intervention levels.

Montague (2009) evaluated the evidence in cognitive strategy instruction and mathematical word problem solving. The results of her review of the literature suggest that cognitive strategy instruction for mathematical problem solving does not meet criteria as an evidenced-based practice according the standards set forth by Horner et. al. (2005) and Gersten et al. (2005) because of the limited empirical studies that have been published on the topic. The results of this research study provide further support for

cognitive strategy instruction and mathematical problem solving as an evidenced-based practice.

Teacher educators must provide instruction on teaching strategies that reach all learners. In order to accomplish this goal, both special education and general education teacher educators should provide opportunities for pre-service teachers to practice merging explicit instruction with inquiry based learning in the mathematics classroom; teach pre-service teachers cognitive strategy instruction as well as how to embed the instruction throughout the curriculum; extend the pre-service learning opportunities through creative teaching methods such as video models and real classroom teaching video analysis prior to the internship; and, provide explicit feedback during teaching opportunities. As more children with disabilities are served in the general education setting, both special educators and general educators must understand strategies to reach all learners and be able to collaborate to support children with diverse learning needs such as children with HFA/AS.

Limitations

Although the *Solve It!* curriculum appears to be an excellent instructional fit for teaching students with HFA/AS mathematical word problem solving, there are several limitations to the study: (a) There were difficulties adhering to the concurrent multiple baseline, (b) the small sample limits generalization, (c) the study was conducted outside the mathematics classroom, and (d) the secondary study used technology that the teacher may not be able to access.

First, Tawney and Gast (1984) suggest that adhering to the constraints of the concurrent multiple baseline design across subjects can be problematic. This was the case in the primary study as Chris entered the baseline phase late. This late entrance compromises the concurrent multiple baseline, as the researcher was unable to compare the first participant in treatment to the other two who were still in baseline. For this study, the researcher was only able to compare the first participant in intervention to one participant in baseline.

Second, due to the small sample size in single subject research, generalization and external validity is limited (Kazdin, 1982). The participants had a diagnosis of HFA/AS; thus, it is unknown whether the study's findings could be replicated with children who have differential diagnoses of PDD-NOS or lower functioning autism. The study only included middle school students who demonstrated average computational skills but lower applied problem skills. It is not known if the intervention would be appropriate for varying age groups or students with poor computational skills. The focus of future research could demonstrate the age range in which *Solve It!* is beneficial and what computational level is necessary for *Solve It!* instruction to be effective. Chung and Tam (2005) provided support for the use of cognitive strategy instruction of middle school students with intellectual disabilities. Varying levels of cognitive ability are common among students with ASD as it is a spectrum disorder (APA, 2000)

Third, in the current study the change agent was the principal investigator as opposed to a classroom teacher; and the instruction was delivered in a one-on-one setting. Different results may be found when the intervention is delivered in an authentic

mathematics classroom and the environment contains the influence of classmates.

Environmental factors may not allow the teacher to provide as much direct instruction, modeling, and error analysis as was completed within this study. External distracters in the environment may also influence the students with HFA/AS ability to attend requiring prolonged instruction or procedural facilitation.

In the secondary study, the multimedia academic story was created with Microsoft Power Point and video images. The video and the academic story were merged into one video with Camtasia software. While this is a very low-tech process, teachers may not have the time or the resources to create the multimedia academic story. The video and the academic story were merged in this study. It is not certain if it was the video model, the academic story or the combination of the two that produced the results. Not knowing which piece caused the change limits teacher ability to use or create part of the multimedia story (the videos or the academic story) to use with their students. The multimedia academic story was delivered via a Touch IPOD. Many schools do not allow the use of any type of IPOD in the school setting. The cost of the Touch IPOD (\$299) may be prohibitive at this time; however, a teacher could use one Touch IPOD for many different multimedia academic stories and many different students.

Future Research

As with any single subject research study, replication is necessary to validate the effectiveness of the *Solve It!* curriculum as an intervention to increase the mathematical word problem solving ability for children with HFA/AS. Horner et al. (2005) suggests

five criteria of single subject research that need to be met to consider a practice evidenced-based. The five criteria are (a) the target behavior is operationally defined; (b) the context in which the intervention should be used is defined; (c) the practice is implemented with fidelity; (d) the results indicate a functional relationship between the independent and dependent variable; and (e) the functional relationship is replicated across subjects, researchers and settings (Horner et al., 2005). The current study meets all except the last criterion. While the strategy has been validated for children with learning disabilities, more research on the effectiveness of the strategy with children with HFA/AS is needed given the heterogeneity of the disorder.

The current study could also be replicated with students with autistic disorder versus students with HFA/AS. Some research suggests differences in verbal versus visual performance between students who have autistic disorder and Asperger's disorder. Modifications for the curriculum could be made based upon the findings of strengths and weakness of children with autistic disorder or Asperger's Disorder on the cognitive steps of the *Solve It!* strategy. Once these strengths and weaknesses are identified, the academic story could be further tailored to meet the needs if distinct differences or needs are identified.

Testing of the academic story to determine if the academic story, the video model, or the combination of the two produced the results is needed. All three participants felt that the multimedia academic story was too long. Determining which component of the intervention was effective would allow the researcher to possibly remove one piece to make the prime shorter in length.

Finally, the use of *Solve It!* to increase the percentage correct on mathematical word problems for students with HFA/AS should be replicated in the classroom setting. In order for a teaching intervention to be effective, it must work efficiently and effectively in the classroom setting by the classroom teacher. Students with HFA/AS present with attention and organization difficulties which may interfere with learning of the *Solve It!* strategy in the regular mathematics classroom due to the natural distracters that are present. In the present study, the multimedia academic story worked best for only one participant. The number of students needing this type of prime may increase in the regular education setting due to the natural distractions in the environment.

Overall Implications

The overall findings indicate that problem-solving skills must be taught and infused into the curriculum especially for those with executive functioning deficits such as HFA/AS. Under the mandate of mathematics reform, problem solving has become a skill that is infused in all areas of mathematics (NCTM, 2000). Yet researchers have suggested that middle school special educators spend only one hour per week on teaching problem solving (van Garderen, 2008). Using explicit instruction (Hudson, Miller and Butler 2006) in learning and applying cognitive strategies may give students with executive functioning deficits the support needed to make the connections between procedural learning (processes) and declarative learning (rote factual knowledge) which then may result in conceptual knowledge. Research suggests that students with HFA/AS have difficulty with making the connections to support conceptual learning (Happe, Booth,

Charlton, & Hughes, 2006; Solomon, Ozonoff, Cummings, & Carter, 2008)

Children with HFA/AS perform as well or better on many age-normed tasks, including basic mathematics, until a certain age when learning becomes more applied and complex, such as problem solving in mathematics (Goldstein, Minshew, & Siegal, 1994). The above average skill in basic computational ability (Dickerson Mayes & Calhoun, 2003a, 2003b; Minshew, Goldstein, Taylor, & Siegal, 1994) may give the illusion of mathematical competency very similar to decoding skills in young children with ASD, including HFA/AS, which give the illusion of high reading ability (Griswold et al. 2002). Teachers, especially in the early years, when children with HFA/AS may be outperforming their peers need to capitalize on the student's strengths in rote acquisition of skills and desire for procedures to teach to the student's deficits- conceptual knowledge. Teachers can use this time, when the child is ahead, to prepare for complex problem solving by building conceptual knowledge.

Knowing that a child has HFA/AS does not provide the teacher with enough information to build proper supports (Griswold et al. 2002). Teachers need to view the overall formal assessment reports and subtests for each domain. The subtest will give a teacher the basic strengths and weakness of a student. More importantly, a teacher must monitor the student with HFA/AS closely via curriculum based measures and error analysis. Supports, such as the multimedia academic story, need to be built upon the needs the child exhibits on the curriculum based measure and determined via error analysis (Griswold et al. 2002). Some students may need procedural facilitation to promote strategy use over time (O'Connor & Klein, 2004)

Even with the limitations and the need for future research, the results of the current study suggest *Solve It!* is an effective intervention for middle school students with HFA/AS. The results of this study further validated the use of *Solve It!* as an intervention for teaching children with difficulties in problem solving how to solve mathematical word problems. Cognitive Strategy Instruction is an appropriate intervention for students with HFA/AS as students with HFA/AS do use strategies spontaneously (Bebko & Ricciuti, 2008), are able to benefit from cognitive strategy instruction (Bebko & Ricciuti, 2000; Delano, 2007; O'Conner & Klein, 2004; Songlee et al., 2008; Webb, Miller, Pierce, Strawser, & Jones, 2004, and may need procedural facilitation to support the use, generalization and maintenance of the strategy (Bebko & Ricciuti, 2008).

APPENDIX A
ACADEMIC PROFILE STUDY CHARTS

Chart 1: *Characteristics of Subjects*

Study	N	CA	ASD Subtypes Cognitive Level	Gender	Diagnostician and Assessment Tool
Dickerson Mayes & Calhoun, 2003a	<i>n</i> = 116	3 to 15 years old Mean 6.7	Autism Low IQ < 80 High IQ > 80	82% male 18% female	DSM-IV Psychologist Child Psychiatrist
Dickerson Mayes & Calhoun, 2003b	<i>n</i> = 164	3 to 15 years old Mean 5.9	Autism Low IQ < 80 High IQ > 80	77% male 23% female	DSM-IV Psychologist Child Psychiatrist
Dickerson Mayes & Calhoun, 2008	<i>n</i> = 54	6 to 14 years old Mean 8.2	HFA IQ>70	89% male 11% female	DSM-IV Psychologist, confirmatory diagnosis by psychiatrist, psychologist, pediatric neurologist, or pediatrician Checklist for Autism in Young Children Pediatric Behavior Scale Clinical Observation
Goldstein, Minshew, & Siegel, 1994	<i>n</i> = 64 <i>n</i> = 46 matched controls	Two groups: <13 or > 14 years old Mean 16.11	Autism IQ >80	100% male 0% females	DSM-IV ADI ADOS
Griswold, Barnhill, Smith Myles, Hagiwara, & Simpson, 2002	<i>n</i> = 21	6 to 17 years old Mean: 10.0	AS/HFA IQ Full Scale 66-144	100% male 0% female	DSM-IV Physician, Psychiatrist, or psychologist
Minshew, Goldstein, Taylor, & Siegel, 1994	<i>n</i> = 54 <i>n</i> = 41 matched controls	Median age: 14 years old	Autism IQ>70	100% male 0% female	DSM-IV ADI ADOS

Note. DSM-IV= Diagnostic and Statistical Manual Fourth Edition; ADI= Autism Diagnostic Inventory; ADOS= Autism Diagnostic Observation Scale

Chart 2: *Research Design*

Study	Research Question	Type of Assessment Instrument	Tests	Statistical Analysis
Dickerson Mayes & Calhoun, 2003a	Delineate strengths & weaknesses to determine a difference as a function of age and IQ.	Intelligence Academic Achievement	Stanford Binet IV WISC –III Developmental Test of Visual Motor Integration WIAT WJ Tests of Achievement	<i>t</i> tests with a Bonferroni correction Pearson Correlation Coefficients
Dickerson Mayes & Calhoun, 2003b	To understand the differences in ability based upon age and IQ.	Intelligence Non-verbal intelligence Visual Motor Achievement	Bayley Mental Scale Stanford Binet Test of Visual motor Integration Leiter International performance scale Test of Non-verbal Intelligence WIAT WJ Tests of Achievement	Pearson Correlation Coefficients <i>t</i> tests
Dickerson Mayes & Calhoun, 2008	To determine if neuropsychological and learning profiles emerge and to compare findings from the WISC III and WIAT in previous research	Intelligence Academic Achievement	WISC-IV WIAT-II	<i>t</i> Tests Cohen’s <i>d</i> effect size ANOVA Bonferroni <i>t</i> tests Pearson Correlation Stepwise Linear Regression ANOVA
Goldstein, Minshew, & Siegel, 1994	To investigate age differences in the academic profile of people with HFA as compared to neurotypical controls	Academic Achievement	Detroit Tests of Learning-2 Woodcock Johnson Reading Mastery tests-R Kaufman Test of Educational Achievement	
Griswold, Barnhill, Smith Myles, Hagiwara, & Simpson, 2002	What are the academic characteristics of youth with AS?	Achievement Problem Solving	WIAT TOPS-R TOPS-A	Friedman Two Way analysis of Variance Post Hoc Comparisons

Minshew, Goldstein, Taylor, & Siegel, 1994	To investigate the differences in academic ability between HFA and controls.	Achievement	Detroit Tests of Learning-2 Woodcock Johnson Reading Mastery tests-R Kaufman Test of Educational Achievement	Independent Group <i>t</i> tests
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Note. WISC-III=Weschler Intelligence Scale for Children; WIAT= Weschler Individual Achievement Tests; TOPS-R=Test of Oral Problem Solving Revised; TOPS-A=Test of Oral Problem Solving for Adolescents

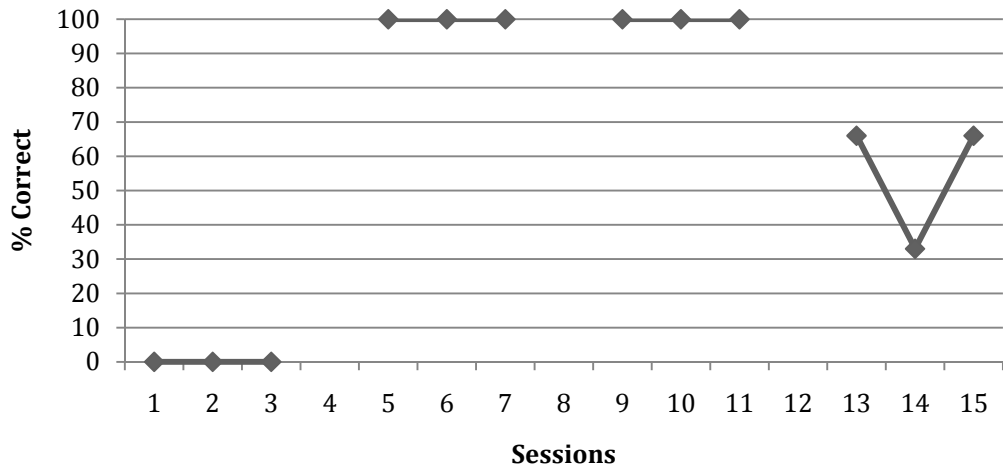
Chart 3 *Major Findings in Academic Achievement (HFA)*

Study	Profile strengths	Profile Weaknesses	Academic Implications	Research Question Answer
Dickerson Mayes & Calhoun, 2003a	Reading, math & writing were in average range and commensurate with IQ	Graphomotor Writing Attention Comprehension: social language & reasoning	7% qualified for reading SLD 22% qualified for math SLD 63% qualified for writing SLD Academic interventions may need to focus on attention, language, social skills, writing and graphomotor skills	The research delineates the strengths and weakness of children with HFA. The research suggests that there is a difference based on IQ and age.
Dickerson Mayes & Calhoun, 2003b	Math reading and spelling correlated with IQ	Written expression	Use visual strength while bypassing writing weaknesses Non-verbal and verbal intelligence gap closed between the age of 9-10. Therefore, early intervention should focus on verbal weakness	IQ increased up to the age of eight
Dickerson Mayes & Calhoun, 2008	Reading and Math were commensurate with IQ. Verbal and Visual Reasoning	Written Expression Attention Processing Speed Language comprehension and social reasoning	17% qualified for math learning disability 63% qualified for a writing learning disability 37% qualified for a reading learning disability Teach to the child's verbal and visual reasoning skills while compensating for the writing, attention, processing speed, language and social reasoning weaknesses	The WISC-IV and the WIAT-II appear to be an improved assessment instrument for children with HFA FSIQ was the best predictor of academic achievement Profile emerged: deficits in attention, graphomotor, and processing speed; strengths in verbal and visual reasoning
Goldstein, Minshew, & Siegel, 1994	Young Group: Decoding, Rote Mechanical Functioning, Normal performance in	Complex processing across domains Comprehension Oral directions Linguistically	People with HFA may perform as well or better than peers on many age-normed tasks until a certain grade level, beyond which they do	Three longitudinal age patterns emerged: 1. Some academic skills remain at or above average levels 2. Understanding and performing

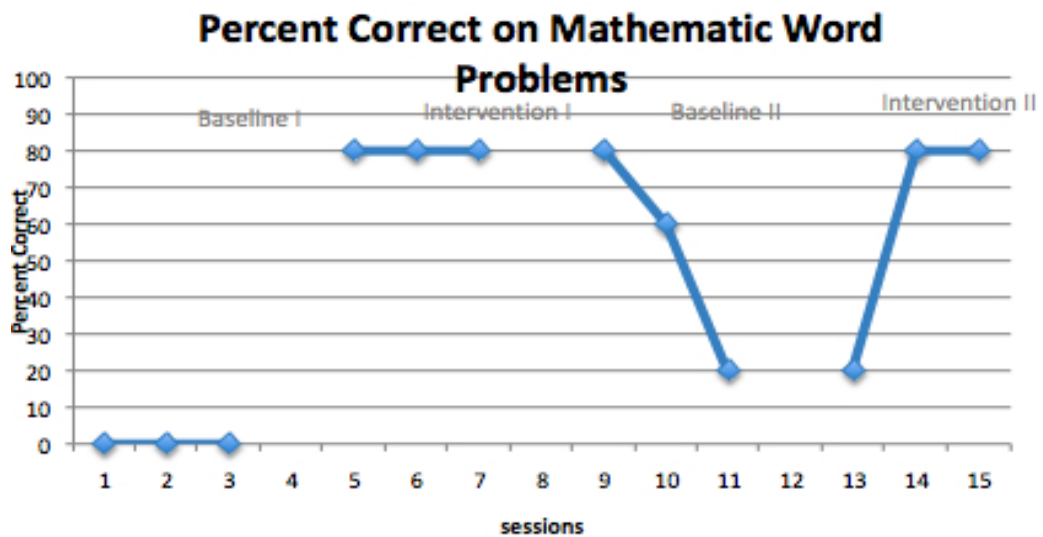
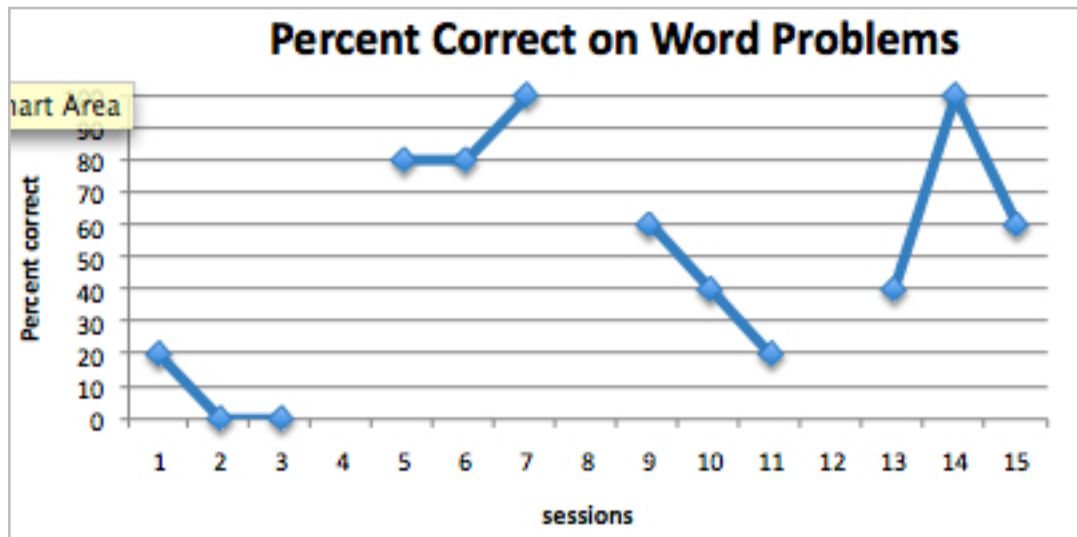
	early years	Complex material	substantially less well	linguistically complex materials were deficit in both age groups 3. Normal performance in early years but does not maintain over time
Griswold, Barnhill, Smith Myles, Hagiwara, & Simpson, 2002	Basic Reading Oral Expression Average Language Composite	Numerical Operations Listening Comprehension Reading Comprehension Written Expression Problem Solving	Huge Range of functioning, knowing that a child has AS has little value to the teacher Teachers need the individual item analysis of these tests to build the IEP Build student portfolios paired with formal assessment	Profile emerged, however, in-depth assessments may be needed to identify weaknesses and portfolio assessments are needed to determine student needs.
Minshew, Goldstein, Taylor, & Siegel, 1994	Basic ability to read, spell and perform mathematical calculations	Lowest subtests in arithmetic and comprehension Impaired comprehension and interpretive skills of instructions and text	Perform rote tasks and invoke simple associative processes The use of global scores to assess academic functioning in reading and mathematics may fail to identify deficits	There is a profile that is different than neuro-typical peers

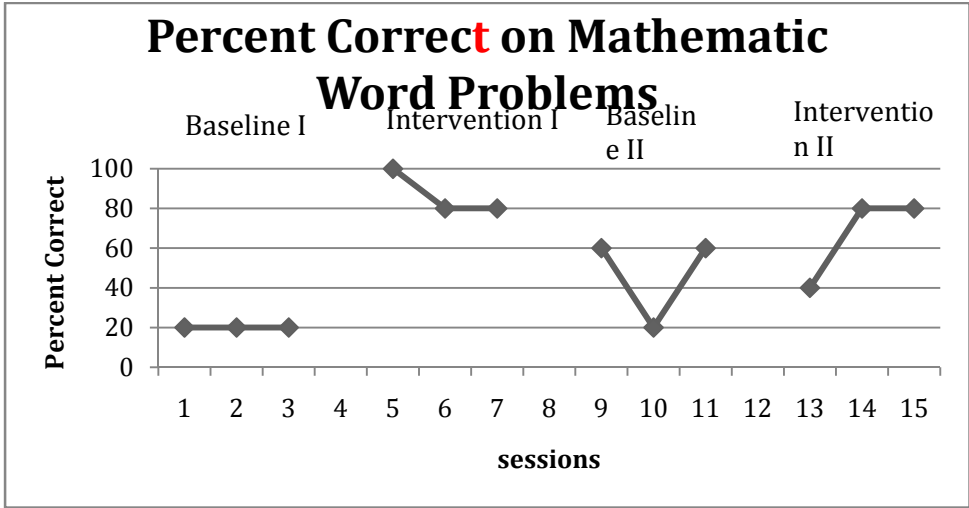
APPENDIX B
RESULTS OF PILOT STUDY 1

Solve It!: Percentage Correct on Word Problems



APPENDIX C
RESULTS OF PILOT STUDY 2





APPENDIX D
INSTITUTIONAL REVIEW BOARD 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

**Notice of Full Board Review and Approval
 of a New Protocol with Informed Consent Documentation**

From : UCF Institutional Review Board
 FW:00000001, Exp. 4/SAPCC IRB00000123

To : Peggy Schneider-Willey

Date : November 04, 2015

IRB Number: 15F-05-00004

Study Title: The Effects of a Modified Learning Strategy on the Multiple Step Mathematical Word Problem Solving Ability of Middle-School Students with High Functioning Autism or Asperger's Syndrome

Dear Researcher:

Your research protocol amendment was referred and approved by the majority of the IRB members present at the convened IRB meeting held on October 29, 2015. The expiration date is 10/29/2016. Having approved the amendments, clarifications and/or acknowledgment of modifications requested by the Board, you may now proceed with your research and begin enrolling participants and collecting data under the protocol. Your research was determined to be minimal risk for human subjects according to the federal definition. This study requires full board review and approval for renewal. The IRB has determined that the federal regulatory criteria at 45 CFR 46, 45 CFR 164, under 21 CFR 31 & 39 for IRB approval of research have been met.

All data, including all signed consent form documents, must be retained in a locked file cabinet for a minimum of three years post the completion of this research. Any list to the identification of participants should be maintained on a password-protected computer if electronic information is used. Additional requirements may be imposed by your funding agency, your department, or other entities. Access to data is limited to authorized individuals listed on any study personnel. Advise the IRB if you consider a subpoena for the release of this information, or if a breach of confidentiality occurs.

Also report any unanticipated problems or minor adverse events (within 3 working days). Do not make changes to the protocol methodology or consent form before obtaining IRB approval. Minor changes to this research may be approved by expedited review and should be submitted using the email to Amendment/Modification Request Form. To continue this research beyond the expiration date, a Continuing Review Form must be submitted 3 - 4 weeks prior to the expiration date. An Amendment/Modification Request Form cannot be used to extend the approved period of a study. Online submission of all forms at <http://irb.compliance.ucf.edu> is preferred. Failure to provide a continuing review request could lead to study suspension, a loss of funding and/or publication possibilities, or departing of non-compliance to sponsors or funding agencies. The IRB maintains the authority under 45 CFR 46.104(d) to observe or have a third party observe the consent process and the research.

On behalf of Tracy Diaz, Ph.D., UCF IRB Chair, this letter is signed by:

Electronic mailed to Justice Yankin on 11/04/2015 12:26:43 PM EST

Jamie Metuschin

APPENDIX E
SCHOOL DISTRICT APPROVAL

From: "Hammond, Martha A." <HammonM@ocps.k12.fl.us>
 Subject: **Research Request Form1.pdf - Adobe Acrobat Professional**
 Date: February 23, 2007 12:38:51 PM EST
 To: <pwhitby@mindspring.com>
 1 Attachment, 95.7 KB Save

Submit this form and a copy of your proposal to: Accountability, Research, and Assessment P.O. Box 271 Orlando, FL 32802-0271		Orange County Public Schools	Your research proposal should include: Project Title; Purpose and Research Problem; Instruments; Procedures and Proposed Data Analysis
		RESEARCH REQUEST FORM	
Requester's Name <u>Peggy Schacter Whitby</u>		Date <u>9-24-09</u>	
Address: Home <u>1407 Catherine St Orlando FL 32801</u>		Phone <u>407-580-6309</u>	
Business <u>Po Box 161250 Orlando FL 32816-1250</u>		Phone <u>407 8981562</u>	
Project Director or Advisor <u>Dr. Wienke</u>		Phone <u>407 823 2598</u>	
Address <u>Po Box 161250 Orlando FL 32816-1250</u>			
Degree Sought: (check one)		<input type="checkbox"/> Associate	<input type="checkbox"/> Bachelor's
		<input checked="" type="checkbox"/> Doctorate	<input type="checkbox"/> Master's
		<input type="checkbox"/> None	<input type="checkbox"/> Specialist
Project Title <u>The Effects of a modified learning strategy on the mathematical word problem solving ability of middle school students w/ Autism</u>			
ESTIMATED INVOLVEMENT			
PERSONNEL/CENTERS	NUMBER	AMOUNT OF TIME (DAYS, HOURS, ETC.)	SPECIFY/DESCRIBE GRADES, SCHOOLS, SPECIAL NEEDS, ETC.
Students	<u>4-6</u>	<u>30 min 15 days</u>	<u>15 min 3 days 30 min 10 days</u>
Teachers	<u>8-12</u>	<u>No</u>	<u>time other than regular school day</u>
Administrators			
Schools/Centers			
Others (specify)			
Specify possible benefits to students/school system: <u>Participating schools will receive the curriculum pack. Teachers will learn an evidenced based strategy, students may increase skill.</u>			
ASSURANCE			
Using the proposed procedures and instrument, I hereby agree to conduct research in accordance with the policies of the Orange County Public Schools. Deviations from the approved procedures shall be cleared through the Senior Director of Accountability, Research, and Assessment. Reports and materials shall be supplied as specified.			
Requester's Signature <u>[Signature]</u>		RECEIVED SEP 26 2008	
Approval Granted: <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		Date: <u>10-3-08</u>	
Signature of the Senior Director for Accountability, Research, and Assessment <u>[Signature]</u>			

Please mail to home address.

10 days school day

NOTE TO REQUESTER: When seeking approval at the school level, a copy of this form, signed by the Senior Director,

APPENDIX F
PARENT/GUARDIAN CONSENT DOCUMENTATION

Dear Parents and Guardians,

My name is Peggy Schaefer Whitby. I am an autism specialist and a doctoral candidate at the University of Central Florida. My research interests are in developing academic interventions for children with high-functioning autism and Asperger's syndrome. I am currently working on my dissertation which includes testing a validated learning strategy for increasing the percentage correct on mathematical word problem solving. This strategy has been used with children with learning disabilities, but has not been validated for children with autism. The strategy is a good instructional fit for children with high-functioning autism and Asperger's syndrome as it provides the structure and organization components which many children with high-functioning autism lack while utilizing their visual strengths.

Your child's teacher has agreed to participate in this study involving children with high-functioning autism/ Asperger's syndrome and the use of a modified learning strategy to increase student's ability to solve mathematical word problems. Your teacher and school have suggested that your child may be an ideal candidate for this study.

If you are interested in participating in this study or would like to learn more about the study, please sign the consent and return the form. Once the consent is returned, the principle researcher will contact you and describe the pre-study assessments, intervention, and maintenance procedures. As a parent or guardian, you may withdraw your child from this study at any time.

Thank you for your consideration in this important research. It is my belief that students with high-functioning autism and Asperger's syndrome can be high contributing members of society if given the proper educational interventions.

Sincerely,

Peggy Schaefer Whitby
Autism Specialist
Doctoral Candidate
University of Central Florida

Consent Form

Please read this consent document carefully before deciding to participate in *The effects of a modified learning strategy on the percent correct on mathematical word problem solving of middle school students with high-functioning autism or Asperger's syndrome.*

Purpose:

To determine if:

- the use of *Solve It!* word problem solving curriculum increases the percent correct on word problems for children with high-functioning autism or Asperger's syndrome.
- the use of an multimedia academic story will increase the percent correct during maintenance and to assist with generalization to the mathematics classroom setting.
- the use of *Solve It!* increases the self perceptions of students with high-functioning autism and Asperger's syndrome as mathematical word problem solvers.

What you will do in this study:

- Allow your child to participate in pre-assessment measures to determine if you are eligible for the study. Measures include the Woodcock Johnson Test of Achievement, the Autism Diagnostic Inventory-revised, and a review of school records and pertinent medical records.
- Allow the principal researcher to provide mathematics instruction, outside the mathematics classroom daily for three weeks during the intervention.
- Allow the principal researcher to collect maintenance data during the school day for three weeks after the end of intervention. This will occur three times a week outside of the mathematics classroom.

Time Required:

- The time required to complete the study is included in your child's current day. The student will not be removed from core content classes. Training will occur during a learning strategies class period.

Risks:

- There is minimal risk
- There is a slight possibility that the confidentiality of your child's mathematic abilities may be compromised as data is being collected. Measures will be implemented to limit the risk.
- Any information gathered will be kept in a locked cabinet and accessed only by the primary investigator.

- Any use of the data for research purposed will be coded so that student information remains confidential.

Benefits

- Student may increase their percent correct on mathematical word problem solving
- Student may increase grades in mathematics
- Student will be practicing the strategy on FCAT word problems. FCAT scores may be impacted by the use of the strategy.
- Teacher will have access to an evidenced based problem solving strategy should they choose desire to use it in the future.

Whom to contact about your rights in the study:

Research at the University of Central Florida involving human participants is carried out under the oversight of the Institutional Review Board (UCF). For information about participants' rights please contact: Institutional Review Board, University of Central Florida, Office of Research & Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901.

If you have any questions or concerns regarding the assessment process, please contact: Peggy Schaefer Whitby at 407-580-6309 or pschae@mail.ucf.edu.

_____ I have read the procedure described above.

_____ I have received a copy of this description.

_____ Telephone Number _____
 Parent Date _____

_____ Date _____
 Principle Investigator

Consent Form

PLEASE READ THIS CONSENT DOCUMENT CAREFULLY BEFORE DECIDING TO PARTICIPATE IN *THE EFFECTS OF A MODIFIED LEARNING STRATEGY ON THE PERCENT CORRECT ON MATHEMATICAL WORD PROBLEM SOLVING OF MIDDLE SCHOOL STUDENTS WITH HIGH-FUNCTIONING AUTISM OR ASPERGER'S SYNDROME*

Purpose:

- To determine if the use of *Solve It!* word problem solving curriculum increases the percent correct on word problems for children with high-functioning autism or Asperger's syndrome

What you will do in this study:

- Allow the principal investigator to teach the *Solve It! Problem Solving Routine* to the selected students daily for three weeks.
- Students will not be pulled from the content area courses for instruction.
- All sessions will be video taped for fidelity of implementation. Only the principal researcher will be video taped. No students will be on the video.
- During the regular education math class or varying exceptionality class, the teacher will assess all students with FCAT word problems, three times a week.
- Participant data will be provided to the researcher
- Peer data will be graded by a teacher as in a typical day and a mean percent correct will be calculated and given to the researcher.
- Correct responses will be provided to the teacher

Time Required (for the teacher):

15 minutes three times a week in the general education setting or varying exceptionality setting.

Risks:

- Risk of loss of confidentiality in mathematical performance is present due to the nature of data collection. Measures are taken to limit the risks.
- Any information gathered will be kept in a locked cabinet and accessed only by the primary investigator.
- Any use of the data for research purposed will be coded so that student information remains confidential.
- **Benefits:**
- Student may increase their percent correct on mathematical word problem solving
- Student may increase grades.

- Teacher will have access to an evidenced based problem solving strategy should they choose desire to use it in the future.

The parent/guardian has the right to withdraw at anytime without consequence or penalty.

Whom to contact about your rights in the study:

Research at the University of Central Florida involving human participants is carried out under the oversight of the Institutional Review Board (UCF). For information about participants' rights please contact: Institutional Review Board, University of Central Florida, Office of Research & Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901.

If you have any questions or concerns regarding the assessment process, please contact: Peggy Schaefer Whitby, Primary Investigator, at (407) 560-6309 or pschaeffe@mail.ucf.edu.

_____ I have read the procedure described above.

_____ I voluntarily agree to participate.

_____ I have received a copy of this description.

_____ I understand that the information obtained cannot be used for Eligibility for Exceptional Student Services or educational decision-making.

Teacher:

Date

Principal Investigator

Date

APPENDIX G
STUDENT ASSENT DOCUMENTATION

Student Assent

Please read this consent document carefully before deciding to participate in The effects of a modified learning strategy on the percent correct on mathematical word problem solving of middle school students with high-functioning autism or Asperger's syndrome

Purpose:

To determine if:

- the use of *Solve It!* word problem solving curriculum increases the percent correct on word problems for children with high-functioning autism or Asperger's syndrome.
- the use of an multimedia academic story will increase the percent correct during maintenance and to assist with generalization to the mathematics classroom setting.
- The use of *Solve It!* increases the self perceptions of students with high-functioning autism and Asperger's syndrome as mathematical word problem solvers.

What you will do in this study:

- Participant in pre-assessment measures to determine if you are eligible for the study. Measures include the Woodcock Johnson Test of Achievement, the Autism Diagnostic Inventory-revised, and a review of school records and pertinent medical records
- Participate in daily mathematics instruction, outside the mathematics classroom daily for three weeks during the intervention.
- Complete 5 mathematical word problems three times a week during the school day for three weeks after the end of intervention. This will occur three times a week outside of the mathematics classroom.
- Participate in an interview pre and post intervention

Time Required:

- The time required to complete the study is included in your current day. You will not be removed from core content classes. Training will occur during a learning strategies class period.

Risks:

- There is minimal risk
- There is a slight possibility that the confidentiality of your child's mathematic abilities may be compromised as data is being collected. Measures will be implemented to limit the risk.
- Any information gathered will be kept in a locked cabinet and accessed only by the primary investigator.

- Any use of the data for research purposed will be coded so that student information remains confidential.

Benefits

- You may increase their percent correct on mathematical word problem solving
- You may increase grades in mathematics
- You will be practicing the strategy on FCAT word problems. FCAT scores may be impacted by the use of the strategy.
- Teacher will have access to an evidenced based problem solving strategy should they choose desire to use it in the future.

Whom to contact about your rights in the study:

Research at the University of Central Florida involving human participants is carried out under the oversight of the Institutional Review Board (UCF). For information about participants’ rights please contact: Institutional Review Board, University of Central Florida, Office of Research & Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901.

If you have any questions or concerns regarding the assessment process, please contact: Peggy Schaefer Whitby at 407-580-6309 or pschae@mail.ucf.edu.

_____ I have read the procedure described above.

_____ I have received a copy of this description.

Student

Date

Principle Researcher

Date

APPENDIX H
SOLVE IT! PROBLEM-SOLVING ROUTINE MATERIALS

Math Problem Solving Assessment

Name _____

Grade _____

Date _____

Part A

Directions

- 1) Read the three problems to the student as examples of word problems.
- 2) Read the interview questions.
- 3) Write the student's response to each item in the space provided beneath the descriptors. If the response is unclear or seems incomplete on the open-ended items (5, 7, 8, 9, 10), probe for additional information using nonspecific probes such as:

- Tell me more.
- Describe what you mean.
- Give an example.
- Anything else?
- What else do you do?
- Please explain that.

($x \div = - +$) ($x \div = - +$) **Appendix** ($x \div = - +$) ($x \div = - +$)
A-9

Math Problem Solving Assessment (cont.)

Script

Examiner: Say, "Here are three examples of math word problems. [Show the problems in student activity sheets that follow.] I will read them to you. You do not need to solve them."

Read the mathematical word problems:

- Bill and Shirley are arranging the chairs for a class play. They brought 252 chairs from the storeroom to the auditorium. Their teacher told them to make rows of 12 chairs each. How many rows will they have?
- Four friends have decided they want to go to the movies on Saturday. Tickets are \$2.75 each for students. Altogether they have \$8.40. How much more money do they need?
- Chain sells for \$1.23 a foot. How much will Farmer Jones have to spend for chain in order to enclose a 70 foot by 30 foot patch of ground, leaving a 4 foot entrance in the middle of each of the 30 foot sides?

Say, "Now I would like you to answer the following questions. I will write your answers."

PERCEPTION OF MATH PERFORMANCE

1) Describe your math skills.

___ very poor

___ poor

___ average

___ good

___ very good

Math Problem Solving Assessment (cont.)

2) Describe your math grades.

___ very poor

___ poor

___ average

___ good

___ very good

3) Describe how well you solve math word problems.

___ very poor

___ poor

___ average

___ good

___ very good

ATTITUDE TOWARD MATH

4) Do you like math?

___ Not at all

___ $\frac{1}{4}$ of the time

___ $\frac{1}{2}$ of the time

___ $\frac{3}{4}$ of the time

___ Always

5) Why or why not?

Math Problem Solving Assessment (cont.)

6) Do you like to solve math word problems?

Not at all

$\frac{1}{4}$ of the time

$\frac{1}{2}$ of the time

$\frac{3}{4}$ of the time

Always

7) Why or why not?

KNOWLEDGE OF MATH PROBLEM SOLVING STRATEGIES

8) Tell me what you remember about being taught how to solve math word problems?

9) What do you do to solve math word problems like the examples I showed you?

10) A strategy is a general plan or a specific activity people use to solve problems. Tell me about any strategies you use to solve math word problems. (List all strategies suggested by the student.)

($\times \div = - +$) ($\times \div = - +$) **Appendix** ($\times \div = - +$) ($\times \div = - +$)
A-9

Math Problem Solving Assessment (cont.)

Part B

This section has two parts:

- The student completes three word problems, one at a time.
- The examiner poses questions to the student.

Part B-1

Examiner: [Show word problems to student (see attached student activity sheets.) Say, "Now I would like you to solve these problems:

- Bill and Shirley are arranging the chairs for a class play. They brought 252 chairs from the storeroom to the auditorium. Their teacher told them to make rows of 12 chairs each. How many rows will they have? [Answer: 21 rows, 1 step]
- Four friends have decided they want to go to the movies on Saturday. Tickets are \$2.75 each for students. Altogether they have \$8.40. How much more money do they need? [Answer: \$2.60, 2 steps]
- Chain sells for \$1.23 a foot. How much will Farmer Jones have to spend for chain in order to enclose a 70 foot by 30 foot patch of ground, leaving a 4 foot entrance in the middle of each of the 30 foot sides? [Answer: \$236.16, 3 steps]

If you have trouble reading or understanding words, ask me for help. Tell me when you finish the problem."

[Give the problems to the student one at a time. When the student has finished all of the problems, place the problems in front of the student for reference.]

Math Problem Solving Assessment (cont.)**Part B-2**

[Begin questioning. Write the student's response to each item.]

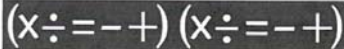
11) How do you read math word problems? [knowledge of reading]

12) How many times do you read math word problems? [use of reading]

13) As you read, how do you help yourself understand the problem? [knowledge of reading]

14) If you do not understand something about the problem, what do you do? [use of reading]

15) What questions do you ask yourself while you are reading math word problems? [control of reading]



Appendix
A-9



Math Problem Solving Assessment (cont.)

16) What questions do you ask yourself when you finish reading math word problems? [control of reading]

17) What else do you do when you read math story problems? [knowledge of reading]

18) How do you help yourself remember what the problem says? [knowledge of paraphrasing]

19) Do you put what you read into your own words? [use of paraphrasing]

20) How do you do this? Now I would like you to put problem #3 into your own words. [use of paraphrasing]

21) When you put the problem into your own words, how do you know what you said is correct? [control of paraphrasing]

Math Problem Solving Assessment (cont.)

22) Do you ever make a drawing of the problem or see a picture of the problem in your mind? Have student clarify by using the following probes:

- What kind of a picture?
- How often do you use drawings or pictures?
- When do you make drawings of problems?
- Under what conditions do you make drawings or see pictures in your mind?
- Which problems?
- Draw a picture of one of the problems.

[use of visualization]

23) What do you do to make a picture in your mind?
[knowledge of visualization]

24) How do your pictures help you solve math word problems? [control of visualization]

$(x \div = - +)$

$(x \div = - +)$

Appendix
A-9

$(x \div = - +)$

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Math Problem Solving Assessment (cont.)

25) What else do you do when you visualize? [knowledge of visualization]

26) How do you make a plan to solve a math word problem? [knowledge of hypothesizing]

27) How do you use your plan to help you solve math word problems? [use of hypothesizing]

28) How do you know which operations to use (such as adding, subtracting, multiplying, or dividing)? [control of hypothesizing]

29) How do you decide how many steps are needed to solve a math word problem? [control of hypothesizing]

30) What is estimation? [knowledge of estimation]

Math Problem Solving Assessment (cont.)

31) Estimation is making a prediction about the answer using the information in the problem. How does estimation help in solving math word problems? [knowledge of estimation]

32) How do you estimate, imagine, or predict the answer before you complete the operations for a math word problem? [use of estimation]

33) How do you compare your estimate with your answer? [control of estimation]

34) What goes on in your head as you compute? [knowledge of computation]

35) What do you do when you compute answers to word problems? [use of computation]

36) How do you know your computation is correct? [control of computation]

Math Problem Solving Assessment (cont.)

37) What is checking? [knowledge of checking]

38) How do you check that you have correctly completed a math word problem? [control of checking]

39) How do you check math word problems? [use of checking]

Examiner: Say, "I have one more question for you."

40) Now that you have thought about what you do when you solve math word problems, tell me about the problem solving strategies you use when you solve math word problems. [knowledge of MPS strategies]

Math Problem Solving Assessment (cont.)**Observations**

Record any pertinent observations.

Math Problem Solving Assessment (cont.)**Student Activity Sheet**

Bill and Shirley are arranging the chairs for a class play. They brought 252 chairs from the storeroom to the auditorium. Their teacher told them to make rows of 12 chairs each. How many rows will they have?

$(x \div = - +)$ $(x \div = - +)$ **Appendix** $(x \div = - +)$ $(x \div = - +)$
A-9

Math Problem Solving Assessment (cont.)**Student Activity Sheet**

Four friends have decided they want to go to the movies on Saturday. Tickets are \$2.75 each for students. Altogether they have \$8.40. How much more money do they need?

 $(x \div = - +)$ $(x \div = - +)$ Appendix
A-9 $(x \div = - +)$ $(x \div = - +)$

Math Problem Solving Assessment (cont.)**Student Activity Sheet**

Chain sells for \$1.23 a foot. How much will Farmer Jones have to spend for chain in order to enclose a 70 foot by 30 foot patch of ground, leaving a 4 foot entrance in the middle of each of the 30 foot sides?

Cognitive Processes

Read (for understanding)

Paraphrase (your own words)

Visualize (a picture of a diagram)

Hypothesize (a plan to solve the problem)

Estimate (predict the answer)

Compute (do the arithmetic)

Check (make sure everything is right)

Cognitive Processes and Self-regulation Strategies

Read (for understanding)

Say: Read the problem. If I don't understand, read it again.

Ask: Have I read and understood the problem?

Check: For understanding as I solve the problem.

Paraphrase (your own words)

Say: Underline the important information. Put the problem in my own words.

Ask: Have I underlined the important information? What is the question? What am I looking for?

Check: That the information goes with the question.

Visualize (a picture of a diagram)

Say: Make a drawing or a diagram.

Ask: Does the picture fit the problem?

Check: The picture against the problem information.

$(x \div = - +)$ $(x \div = - +)$ **Appendix** $(x \div = - +)$ $(x \div = - +)$
1-2

Cognitive Processes and Self-regulation Strategies

Hypothesize (a plan to solve the problem)

Say: Decide how many steps and operations are needed. Write the operation symbols (+, -, x, and /).

Ask: If I do ____, what will I get? If I do ____, then what do I need to do next? How many steps are needed?

Check: That the plan makes sense.

Estimate (predict the answer)

Say: Round the numbers, do the problem in my head, and write the estimate.

Ask: Did I round up or down? Did I write the estimate?

Check: That I used the important information.

Compute (do the arithmetic)

Say: Do the operations in the right order.

Ask: How does my answer compare with my estimate? Does my answer make sense? Are the decimals or money signs in the right places?

Check: That all the operations were done in the right order.

Cognitive Processes and Self-regulation Strategies

Check (make sure everything is right)

Say: Check the computation.

Ask: Have I checked every step? Have I checked the computation?
Is my answers right?

Check: That everything is right. If not, go back. Then ask for help if I need it.

$(x \div = - +)$ $(x \div = - +)$ **Appendix** $(x \div = - +)$ $(x \div = - +)$
1-2

Student Cue Cards

Read (for understanding)

Say: Read the problem. If I don't understand, read it again.

Ask: Have I read and understood the problem?

Check: For understanding as I solve the problem.

Paraphrase (your own words)

Say: Underline the important information. Put the problem in my own words.

Ask: Have I underlined the important information? What is the question? What am I looking for?

Check: That the information goes with the question.

Student Cue Cards

Visualize (a picture or a diagram)

Say: Make a drawing or a diagram.

Ask: Does the picture fit the problem?

Check: The picture against the problem information.

Hypothesize (a plan to solve the problem)

Say: Decide how many steps and operations are needed. Write the operation symbols (+, -, x, and /).

Ask: If I do ____, what will I get? If I do ____, then what do I need to do next? How many steps are needed?

Check: That the plan makes sense.

($\times \div = - +$) ($\times \div = - +$) **Appendix** ($\times \div = - +$) ($\times \div = - +$)
I-3

Student Cue Cards

Check (make sure everything is right)

Say: Check the computation.

Ask: Have I checked every step? Have I checked the computation? Is my answer right?

Check: That everything is right. If not, go back. Then ask for help if I need it.

$(x \div = - +)$ $(x \div = - +)$ **Appendix** $(x \div = - +)$ $(x \div = - +)$
I-3

APPENDIX I
EXAMPLES OF MATHEMATICAL WORD PROBLEMS

Date _____ Class Period _____

Student Name _____ Student ID # _____

Teacher's Name _____ School _____ Grade _____

1) On the day the Winston family arrived at the Olympic Games, there was a total of 426,000 visitors. The day before, there were 414,500 visitors. How many visitors were there at the Olympic Games on those two days?

2) Anne and Susan were looking for articles for their science notebook. Anne found 14 articles and Susan found 11. Then, Susan spilled a glass of soda and ruined 6 of the articles. How many articles were left?

Date_____

Student Name_____ School_____

3) There were five people in the Wong family and seven people in the Smith family. The admission charge to the theatre was \$6.50 per person. What was the total admission price?

4) In art class Tara mixed 1 liter of blue paint, 2 liters of red paint, and one-half liter of white paint together in a bucket. How many milliliters of paint did Tara mix in the bucket?

F. 0.0035 milliliters

G. 3.5 milliliters

H. 350 milliliters

I. 3500 milliliters

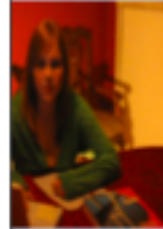
Date_____

Student Name_____ School_____

5) Three friends went to the movies. They bought tickets for \$3.00 each. They also shared two bags of popcorn, which they bought for \$2.50 each. How much money did they spend total?

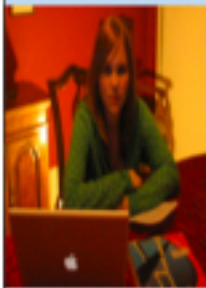
APPENDIX J
MULTIMEDIA ACADEMIC STORY

How to Solve Math Word Problems A Story for Middle School Math Students



At school I go to math class. Many times we have to solve word problems. My teacher likes it when I work on the problems and get the right answer. I like to get the right answer. I know I can get the right answer if I follow my steps to solve word problems.

Read the Problem



My teacher likes it when I read to understand the problem. I know I can read to understand the problem!

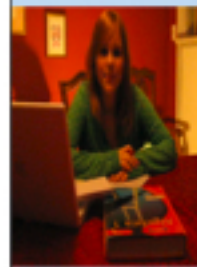
SM: "Read the problem!" Then go ahead and read the problem. Think about what you are reading.

ASK: "Do I understand what I read?" If not, go back and read again.

CHECK: Look at the problem again. Does it match what you think it means?

Reading a math problem, is just like reading my favorite book... I need to think about what I am reading.

Paraphrase



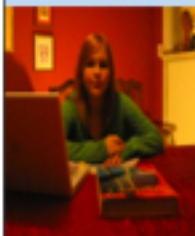
Next, my teacher likes it when I paraphrase. To paraphrase is to say the problem in my own words.

SM: Underline the important information. Put the problem in my own words.

ASK: Have I underlined the important words? What is the question?

CHECK: That the information goes with the question. I know I can paraphrase to help me understand the problem.

Visualize



My teacher likes it when I visualize the problem. I can do this by drawing a picture. I know I can draw a picture or diagram to help me visualize the problem.

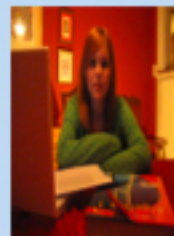
SM: Make a drawing or diagram. Show the relationship(s) between the parts.

ASK: Does the picture fit the problem? Did I show relationships?

CHECK: The picture against the problem. Does it make sense?

I know I can visualize the problem by drawing a picture. This helps me understand the problem.

Hypothesize



My Teacher likes it when I hypothesize a plan to solve a problem. To do this I think of a plan to solve the problem. I know I can come up with a plan to solve the problem.


SM: Decide how many steps and operations are needed.

ASK: Do I need to add, subtract, multiply or divide? How many steps are there?

CHECK: That the plan makes sense.

Making a plan guides me in solving the problem. I know I can make a plan and get the right answer!

Estimate



Next, my teacher wants me to estimate the answer. To estimate, I look at all my information, round the numbers up or down and try to figure out what the answer should be close to. I know I can estimate the answer.

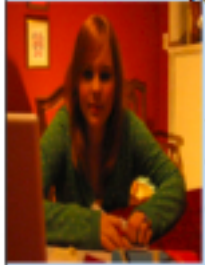
SAY: Round the numbers, do the problem in my head, and write the estimate.

ASK: Did I round up and down? Did I write my estimate?

DO/DO: That I used the important information from the problem.

Estimating gives me a guide to what my answer should be close to. I know I can estimate my answer!

Compute




My teacher likes it when I compute each step in the problem. If I compute each step carefully, I will get the right answer. I know I can compute the answer!

SAY: Do the operations in the right order.

ASK: How does my answer compare with the estimate? Does my answer make sense?

CHECK: That all of the operations were done in the right order. I know I can compute the answer!

Check



My teacher likes it when I check my work. To check my work, I look for mistakes. If I made a mistake I can correct it and get the right answer. I know I can check my work!

SAY: Check the plan to make sure it is right. Check each step of the computation to make sure it is right.

ASK: Have I checked every step? Have I check the computation? Is my answer right?

DO/DO: That everything is right. If not go back and fix it!

I know I can check my work. My teacher likes it when I check my work. Checking my work helps me get the answers right. If I check everything I will catch my mistakes. I know I can check my work!

APPENDIX K
SCRIPTED LESSONS

Lesson 2: Strategy Mastery Check

Preparation

- **Prepare transparencies of Practice Problems 1, 2, and 3.** Make transparencies (or record on flip chart paper) of the Practice Problems in Appendices I-4, I-5, and I-6.
- **Display Master Chart.** This is the same chart that was used in Lesson 1 and is found in Appendix I-2.

Sample Script

[Check strategy mastery.] You are beginning to learn the *Solve It!* strategy. This strategy will help you improve your problem solving skills. It is important that you continue to improve and do even better. It is also important that you continue to use the strategy every time you need to solve problems in school and outside of school. When might you need to solve a math problem outside of school? [Elicit responses—store, measuring, etc. Record student responses on the chalkboard or flip chart paper.]

Now I want you to watch me solve a problem using the entire strategy.

Use the overhead projector or flip chart paper. Read the following math problem aloud (Practice Problem 1):

José and Nancy are selling greeting cards to raise money for the school camping trip. Together they sold cards totaling \$88.50. Nancy sold \$67.00 worth of cards. How much money did Jose make selling cards?

During modeling, use as a routine the expression, "Now I will say to myself..." Use this routine when first modeling the strategy. Later, students will verbalize the words SAY, ASK, CHECK or the teacher will verbalize them for the students. The goal is to eventually have students automatically self-instruct, self-question, and self-check. Self-cueing will consist of remembering the processes.

Read the problem for understanding. Now I will say to myself, "Read the problem." [Read the problem.] If I don't understand it, read it again. [Read the problem again.] "Now I will ask myself, "Have I read and understood the problem?" [Yes.] Now I will check myself by checking for understanding as I solve the problem."

Paraphrase. Now I will say to myself, "Put the problem into my own

($\times \div = - +$)

Lesson 2

(continued)

words." [Two youngsters sold cards totaling \$88.50. One child sold cards for \$67.00. How much did the other child sell?]

Now I need to underline the important information.

[Underline the following:

- Together
- \$88.50
- Nancy sold \$67.00 worth.]

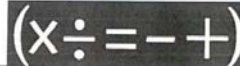
Now I will ask myself, "Have I underlined the important information?" [Yes.] What is the question? [How much money did José make selling cards?] What am I looking for? [The amount of money that José made.] Now I will check myself by checking that the information goes with the question. I have the total amount and the amount that Nancy sold. I need to find the amount that José sold. [Model.]

Visualize. Now I will say to myself, "Make a drawing or a diagram." [Draw the problem on the chalkboard or on flip chart paper.] Now I will ask myself, "Does the picture fit the problem?" [Yes.] Now I will check myself by checking the picture against the problem information. [Model check-

ing the picture against the problem information.]

Hypothesize. We will set up a plan to solve the problem. Now I will say to myself, "Decide how many steps and operations are needed." [For example, one step, subtraction, etc.] Write the operation symbols for the problem on the transparency, chalkboard, or flip chart paper. Now I will say to myself, "If I subtract the amount that Nancy sold from the total amount sold, I will get the amount that José sold." Now I will ask myself, "How many steps are needed?" [The answer is one step, subtraction.] Now I will check myself by checking that the plan makes sense. If not, I will ask for help. [Model.]

Estimate. Next, we estimate or predict the answer. Now I will say to myself, "Round the numbers, do the problem in my head, and write the estimate." [Round up, 70; round up 90; $90 - 70 = 20$.] Now I will ask myself, "Did I round up and down?" [Round up only.] I also ask myself, "Did I write the estimate?" [The answer is, "Yes."] Now I will check myself by checking that I used the important information. [Model.]



Lesson 2

(continued)

Compute. Next I will compute, or do the arithmetic. Now I will say to myself, "Do the operations in the right order." [Complete the arithmetic for the problem.] Now I will ask myself, "How does my answer compare with my estimate?" [It should be very close.] I ask myself, "Does my answer make sense?" [It should.] I also ask myself, "Are the decimals or money signs in the right order?" [Check to make sure the answer is, Yes."] Now I will check myself by checking that all the operations were done in the right order. [Model.]

Check. Next I review my answer and make sure everything is correct. Now I will say to myself, "Check the computation." [Model checking the computation.] Now I will ask myself, "Have I checked every step?" [The answer should be, "Yes, I have checked every step."] I also ask myself, "Have I used the right numbers and checked the computation?" [Yes.] Finally, I ask, "Is my answer right?" Now I will check myself by checking that everything is right. If not, I will go back. Then, I will ask for help if I need it. [Model.]

Ask for questions. Reinforce the students for participating in the discussion.

[Present the next problem, Practice Problem 2, which is a two-step problem.]

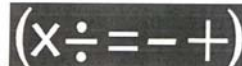
Now watch me solve this one. [Use the same instructional routine that was used with the first problem.]

[Show Practice Problem 2.]

On Monday, my father bought 14 gallons of paint for the house. On Tuesday, he bought 12 more gallons of paint. After painting the house, he returned 3 gallons to the store. How much paint did he use?

[Model the *Solve It!* approach.]

Read the problem for understanding. Now I will say to myself, "Read the problem." [Read the problem.] If I don't understand it, I will read it again. [Read the problem again.] Now I will ask myself, "Have I read and understood the problem?" If not, I will read it one more time. [Model.] Now I will check myself by checking for understanding as I solve the problem. [Model.]



Lesson 2

(continued)

Paraphrase. Now I will say to myself, "Put the problem into my own words." Dad bought 14 gallons and 12 gallons of paint and then took back 3 gallons. How much paint did he use? I underline the important information. [Underline the words: bought 14 gallons, bought 12 more, and returned 3.] Now I will ask myself, "Have I underlined the important information?" [The answer should be, "Yes."] I then ask myself, "What is the question?" [How much paint was used?] Next, I ask myself, "What am I looking for?" [The number of gallons of paint used.] Now I will check myself by checking that the information goes with the question. I have the number of gallons he bought and the number he returned. I need to find the total number of gallons used.

Visualize. Now I will say to myself, "Make a drawing or a diagram." [Draw the problem on the transparency, chalkboard, or flip chart paper.] Now I will ask myself, "Does the picture fit the problem?" [Yes.] Now I will check myself by checking the picture against the problem information. [Model.]

Hypothesize. Now I will set up a plan to solve the problem. I will say to myself, "Decide how many steps and operations are needed." [Two

steps are needed: add and subtract.] I write the operation symbols. [Write + and - on the transparency, chalkboard, or flip chart paper.] Now I will ask myself, "If I add the two amounts he bought and then subtract the gallons returned, will I get the number of gallons used?" I ask myself, "What do I do next?" [Nothing because I am finished.] Now I will ask myself, "How many steps are needed?" [Two.] Now I will check myself by checking that the plan makes sense. If not, I will ask for help. [Model.]

Estimate. I predict the answer. To do this, I will say to myself, "Round the numbers, do the problem in my head, and write the estimate." [Round up, 15; down, 10; $15 + 10 = 25 - 5 = 20$ about 20 gallons used.] Now I will ask myself, "Did I round up and down?" [Yes.] I also ask myself, "Did I write the estimate?" [Yes.] Now I will check myself by checking that I used the important information. [Model.]

Compute. Now I do the arithmetic. I will say to myself, "Do the operations in the right order." [Do the arithmetic.] Now I will ask myself, "How does my

($\times \div = - +$)

Lesson 2

(continued)

answer compare with my estimate?" [It should be very close.] I ask myself, "Does my answer make sense?" [Yes.] If decimals or money signs are used, I make sure they are in the right order. [In this problem, none are needed.] Now I will check myself by checking that all the operations were done in the right order. [Model.]

Check. Finally, I make sure everything is right. Now I will say to myself, "Check the computation." [Check it.] Now I will ask myself:

- "Have I checked every step?" [Yes.]
- "Have I used the right numbers?" [Yes.]
- "Have I checked the computation?" [Yes.]
- "Is my answer right?" [Yes.]

Now I will check myself by checking that everything is right. If not, I will go back. Then I will ask for help if I need it. [Model.]

Ask for questions. Reinforce students for participation.

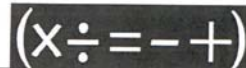
[Present Practice Problem 3.]

All of the eighth grade classes are planning a picnic in the park. There are 1,044 students. Each bus holds 58 people. How many buses are needed?

Now we will use the strategy and solve this problem together. I will help you if you need help. We will do it out loud. I will call on different people for each strategy. [As you work through each step, ask students to direct you.] Now we will practice the strategy.

[Complete the problem. Answer: 18. Steps: 1]

Some of you have memorized the **Solve It!** processes. Excellent. By tomorrow, I would like everyone to memorize the seven processes just as they appear on your cards. Now, tell me the strategy. [Group and individual rehearsal until class ends.]



Lesson 6: Mastery Lessons

[Note: These activities should be conducted as needed.]

Preparation

- **Prepare Student Activity Sheet.** [Student Activity Sheets and answer keys are found in **Appendices S-7 through S-20.**] Make enough copies for each student. *Note:* Answer keys follow each activity sheet. Use the same instructional routine as outlined in this lesson when presenting each of the student activity sheets. At the end of the mastery lessons, administer another posttest.]
- **Prepare the posttest.** Make enough copies for each student. *Note:* Answer keys follow the posttest.
- **Display Master Chart.** This is the same chart that was used in Lesson 1 and is found in **Appendix I-2.**

Sample Script

[Use group rehearsal and then individual rehearsal in this lesson.]

Today, we are going to continue using **Solve It!** to complete word problems. Let's review the processes. Say them with me. [Students say the processes in unison.]

[Show the Student Activity Sheet you are working with. *Note:* The answer key follows each activity sheet in the Appendix. Pair students and distribute the Student Activity Sheet. Students take turns telling their partners what to do. Monitor the students and provide feedback as needed.]

[As a variation, distribute the words problems individually. Model the correct solutions after the students complete each problem. Ask students to compare their answers with yours.]

Ask for comments and questions. Probe to find out how comfortable students are using the **Solve It!** approach.

[Show another Student Activity Sheet. Have students solve one-, two-, and three-step problems individually. Encourage them to refer to their cue cards or the Master Chart.]

Share answers and ask for a show of hands as to who solved each problem correctly. For those problems where students were not successful, model solving the problem at the chalkboard. Ask students to explain why their solution was incorrect.

(X ÷ = - +)

APPENDIX L
INTERVENTION RATING PROFILE-15

INTERVENTION RATING PROFILE-15

The purpose of this questionnaire is to obtain information about your reaction to the classroom intervention developed during your meeting with you the consultant. Please circle the number (1 - 6) which best describes your agreement or disagreement with each the following statements about the intervention developed for the referred child.

	Strongly Disagree	Disagree	Slightly disagree	Slightly Agree	Agree	Strongly Agree
1. This is an acceptable intervention for the child's mathematical word problem solving ability.	1	2	3	4	5	6
2. Most teachers would find this intervention appropriate for other problem solving s as well as the one identified.	1	2	3	4	5	6
3. This intervention should prove effective in changing the child's mathematical word problem solving ability.	1	2	3	4	5	6
4. I would suggest the use of this intervention to other teachers.	1	2	3	4	5	6
5. The child's problem solving is severe enough to warrant the use of this intervention.	1	2	3	4	5	6
6. Most teachers would find this intervention suitable for the mathematical word problem solving ability identified.	1	2	3	4	5	6
7. I would be willing to use this intervention in the classroom setting.	1	2	3	4	5	6
8. This intervention would not result in negative side-effects for the child.	1	2	3	4	5	6

9. This intervention would be appropriate for a variety of children.	1	2	3	4	5	6
10. This intervention is consistent with those I have used in classroom settings.	1	2	3	4	5	6
11. The intervention is a fair way to handle the child's mathematical word problem solving ability.	1	2	3	4	5	6
12. This intervention is reasonable for the mathematical word problem solving ability identified.	1	2	3	4	5	6
13. I like the procedures used in this intervention.	1	2	3	4	5	6
14. This intervention is a good way to handle this child's mathematical word problem solving ability.	1	2	3	4	5	6
15. Overall, this intervention would be beneficial for the child.	1	2	3	4	5	6

APPENDIX M
TREATMENT FIDELITY CHECKLIST

***Solve It!* Observation Tool**

Teacher: _____ School: _____ Grade Level: _____

Date of Observation: _____ Time of Observation: _____ Course Name: _____

Number of Students with Disabilities: _____ Lesson Topic: _____

Number of Students: _____ Please List Other Professionals in Classroom: _____

LESSON 2 – STRATEGY MASTERY VERBALIZATION

Code the occurrence of each instructional component using the following keys:
e YES = The behavior is observed. *e* NO = The behavior is not observed.

Preparation

Did the teacher: Coding Notes

Prepare practice problem (Page 157)?	Y N	
Display Master Charts?	Y N	

Implementation

Did the teacher: Coding Notes

Elicit responses about problem solving in real world?	Y N
Model problem solving using process modeling by: Problem (Page 157)	Y N
Reading the problem?	Y N
Paraphrasing?	Y N
Visualizing (emphasizing relationships among problem parts)?	Y N
Hypothesizing?	Y N

Estimating?

Y N

Computing?

Y N

Checking?

Y N

Did the teacher: Coding Notes

Provide group (student and instructor) strategy rehearsal?	Y N	
Provide individual strategy rehearsal?	Y N	

Researcher notes:

--

APPENDIX N
STUDENT WORK SAMPLES

Directions: **Read** the problem. **Think** about solving the problem. Then **solve** the problem.

Date _____

Student Name _____ School _____

3
5) Three friends went to the movies. They bought tickets for \$3.00 each. They also shared two bags of popcorn, which they bought for \$2.50 each. How much money did they spend total?

R ✓
P ✓
V ✓
H ✓
E ✓
C ✓
C

Popcorn | \$2.50
tickets | \$3.00

3.00
9.00

\$12.00

5.00
9.00

14.00

Directions: **Read** the problem. **Think** about solving the problem. Then **solve** the problem.

Date _____

Student Name _____

School _____

5) Three friends went to the movies. They bought tickets for \$3.00 each. They also shared two bags of popcorn, which they bought for \$2.50 each. How much money did they spend total? *? How many tickets*

		<i>how many</i>	<i>price each</i>
R ✓	Tickets	3	\$3.00
P ✓	bags	2	\$2.50
V ✓			First: $3 \times \$3.00$
H ✓			Second: $2 \times \$2.50$
E ✓			Third: add
C ✓		3.10	2.50
C		$\times 2$	$\times 3$
		\$6.20	\$7.50

2.50	3.00
$\times 2$	$\times 3$
5.00	9.00

7.50
$+ 6.20$
$\hline \$13.70$

9.00
$+ 5.00$
$\hline \$14.00$

Directions: **Read** the problem. **Think** about solving the problem. Then **solve** the problem.

Date _____

Student Name _____ School _____

Nathaniel
5) ~~Mr. Black~~ needs 9 gallons of brown paint at \$12.95 a gallon. He needs to buy three brushes at \$1.51 each. How much does he spend in total?

R ✓
P ✓
V ✓
H ✓
e ✓
n ✓
u ✓

$$\begin{array}{r} 99 \text{ / } 12.95 \times 9 \\ \hline 30 \text{ / } 151 \times 3 \end{array}$$

$$\begin{array}{r} 116.55 \\ - 45.38 \\ \hline 121.08 \end{array}$$

1) A camera has a regular price of \$85.95. Carmen found the same camera on sale for \$15.95 less than the regular price. What is the sale price?

85.95
- 15.95

69.95

$$\begin{array}{r} 85.95 \\ - 15.95 \\ \hline 69.95 \end{array}$$

$e = 74$

Directions: **Read** the problem. **Think** about solving the problem. Then **solve** the problem.

Date _____

Student Name _____ School _____

R
P
V
H
e
c
c

3)
Bert bought one box of 356 beanbag toys for \$180. He made a profit of \$87 after selling all the toys. Each toy was sold at the same price. Use the equation below to find t, the selling price of one toy.

$$356t - 180 = 87$$

What was the selling price of one toy?

$$180 + 87 = 267$$
$$36 \overline{) 267}$$
$$0.75 \text{ \textdollar}$$

4) Henry bought a steel pen for his puppy for \$43.29. He also spent \$2.79 for a brush. He gave the clerk \$47.00. How much change did he receive?

$$92 \text{ \textdollar}$$

B
V
P
V
V
H
e
c
c

$$\begin{array}{r} 43.29 \\ + 2.79 \\ \hline 46.08 \end{array}$$
$$47.00 - 46.08 = 92 \text{ \textdollar}$$

~~92 \text{ \textdollar}~~

Directions: **Read** the problem. **Think** about solving the problem. Then **solve** the problem.

Date _____

Student Name _____ School _____

3) Bert bought one box of 356 beanbag toys for \$180. He made a profit of \$87 after selling all the toys. Each toy was sold at the same price. Use the equation below to find t , the selling price of one toy.

$$356t - 180 = 87$$

$$+180 \quad +180$$

$$\hline 356t = 267$$

What was the selling price of one toy?

$$356t = 267$$

$$\div 356 \quad \div 356$$

$$\hline t = 0.75$$

R ✓
P ✓
V ✓
H ✓
E ✓
C ✓
C ✓

4) Henry bought a steel pen for his puppy for \$43.29. He also spent \$2.79 for a brush. He gave the clerk \$47.00. How much change did he receive?

Pen	\$43.29
Brush	+2.79
<hr/>	

$$47.00$$

$$- 43.29$$

$$\hline 3.71$$

$$+ 2.79$$

$$\hline 6.50$$

R ✓
P ✓
V ✓
H ✓
E ✓
C ✓
C ✓

3.92e

46.08
.92

Directions: **Read** the problem. **Think** about solving the problem. Then **solve** the problem.

Date _____

Student Name _____ School _____

3) Bernie bought a bird feeder for \$5.98 and some bird seed for \$2.10. He gave the clerk \$9.00. How much change did he receive?

Handwritten student work for problem 3:

RL
PL
VL
+L
EL
CL
L

$$\begin{array}{r} 5.986 \\ + 2.100 \\ \hline 8.086 \end{array}$$

X 8

$$\begin{array}{r} 9.00 \\ - 8.086 \\ \hline 0.914 \end{array}$$

c = \$1.92

+/-

4) The Nature Club members planned to hike a total of 175 miles. They hiked 42 miles the first day, 39 miles the second day, and 21 miles the third day. How many miles did they have left to hike?

Handwritten student work for problem 4:

RL
PL
VL
+L
EL
CL
L

	Day 1	Day 2	Day 3	
Miles	42	39	21	= 0
Goal	175			

$$\begin{array}{r} 175 \\ - 100 \\ \hline 75 \end{array}$$

+/-

1) On the day the Winston family arrived at the Olympic Games, there was a total of 426,000 visitors. The day before, there were 414,500 visitors. How many visitors were there at the Olympic Games on those two days?

RV ✓
 PV ✓
 VV ✓
 HV ✓
 EV ✓
 CV ✓
 CV ✓

First day	426,000
second day	414,500

might have to add.

420,000	+	410,400
830,400 e		

940,500

2) Anne and Susan were looking for articles for their science notebook. Anne found 14 articles and Susan found 11. Then, Susan spilled a glass of soda and ruined 6 of the articles. How many articles were left?

RV ✓
 PV ✓
 VV ✓
 HV ✓
 EV ✓
 CV ✓
 CV ✓

Anne	14
Susan	11
ruined	6

12 e
+10
22
-5
17

19

CBM Form 3Y2

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