EFFECTS OF PEER-MEDIATED INSTRUCTION ON MATHEMATICAL PROBLEM SOLVING FOR STUDENTS WITH MODERATE/SEVERE INTELLECTUAL DISABILITY

by

Luann Ley Davis

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Approved by:

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Dr. Fred Spooner

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Dr. Diane M. Browder

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Dr. Ya-yu Lo

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Dr. Drew Polly

ABSTRACT

LUANN LEY DAVIS Effects of peer-mediated instruction on mathematical problem solving for students with moderate/severe intellectual disability. (Under the direction of DR. FRED SPOONER).

The No Child Left Behind Act (NCLB, 2006) set a precedent that established even higher expectations for all students, including those with disabilities. More recently, the National Governors Association Center for Best Practices and the Council of Chief State School Officers developed a common set of state standards for proficiency in English language arts and mathematics known as the Common Core State Standards (CCSS, 2010). The CCSS in mathematics define and detail the content expectations and standards for mathematical practices for grades K-12. Their intent is to provide a rigorous, focused, and structured set of standards to prepare students in the 21st century to be college and career ready upon exiting the high school system. To meet these increased expectations, this investigation sought to determine the effects of peer-mediated schema based instruction on the number of correct steps of a task analysis to solve the *change* problem type of mathematical word problems with middle school students with moderate/severe intellectual disabilities (MS/ID). Additionally, this study investigated the effects of peer-mediated schema based instruction on the number of correct mathematical problems solved, the ability of students with MS/ID to discriminate between addition and subtraction in word problems for the *change* problem type, and if students with MS/ID were able to generalize the learned mathematical skills to an unfamiliar peer. Finally, this study examined the effects of peer-mediated instruction on both tutors' and tutees' social attitudes and perceptions of one another before and after the study was completed. The findings of this study demonstrated a functional relation between peer-mediated schema-based instruction (SBI) on the number of correct steps of a task analysis. Results also provided several implications for practice, offers suggestions for future research in this area, and discusses the social and academic benefits of using peer-mediated instruction for students with MS/ID.

DEDICATION

First, all thanks for this life I've been given goes to God. You are my constant stream of strength and blessing, and my life is dedicated to serving You.

Second, it is with my deepest gratitude and appreciation that I dedicate this dissertation to my amazing husband, Jasper, and my brilliant daughter, Jessica. The phrase 'unconditional love' does not do justice for the continued love and support you have given me. I will spend a lifetime trying to reciprocate all you both have given. Jasper, you have sacrificed so much to help me reach my dreams; late nights, early mornings, countless hours alone waiting, editing, checking references, and more than I can list. You have continued to lift me to new heights with a loving heart. You are the greatest man in the world, and I'm so blessed to have you to share my life. Jessica, you are the reason I set out on this journey. Since you were born, it has always been my goal to set an example of hard work, determination, and perseverance. You have gone far beyond following my lead, and I could not be more proud of the amazing person you have become. You both are the 'wind beneath my wings' and I am blessed beyond measure. I also dedicate this dissertation to my mom and dad whose patient love, encouragement, and continued support went beyond measure.

Finally, this dissertation is for all the young people living with disabilities and their families who have forever changed my life. I will spend the rest of my professional career working on your behalf. You are my inspiration, and I hope to share all the lessons you have taught me.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

Since the 1954 Supreme Court decision in the case of Brown *vs*. the Board of Education, where schools were mandated to end segregation of students based on race, the movement toward inclusion for all students and ending segregation has been laborious. It was not until the Education for All Handicapped Children Act of 1975 (PL 94-142), approximately 21 years later, that Congress took action to require all national educational systems to include students with disabilities. This act promoted a new shift in educational emphasis from a basic access to the general curriculum through the least restrict environment (LRE) to educational systems now being accountable to provide all students with equitable access and opportunity to participate in the general education curriculum as well as the general education classroom. Now called the Individuals with Disabilities Improvement Education Act (IDEA, 2004), this momentous piece of federal legislation requires that students with disabilities are to be taught alongside their peers without disabilities to the greatest extent possible. In 2001, the No Child Left Behind Act (NCLB, 2006) set a precedent that established even higher expectations for all students, including those with disabilities. Schools are required to annually test all students to monitor their academic progress and all students must meet the adequate yearly progress (AYP) standards.

More recently, the National Governors Association Center for Best Practices and the Council of Chief State School Officers developed a common set of state standards for proficiency in English language arts and mathematics known as the Common Core State Standards (CCSS, 2010). The CCSS in mathematics define and detail the content expectations and standards for mathematical practices for grades K-12. Their intent is to provide a rigorous, focused, and structured set of standards to prepare students in the 21st century to be college and career ready upon exiting the high school system. Even though college and full-time employment may not be realistic goals for all students with moderate/severe intellectual disability (MS/ID), all students deserve to be provided with better post-secondary opportunities such as living independently, being gainfully employed, and/or attending college if they choose. The CCSS's are intended to raise the educational standards for all students and this gives rise to increased challenges for teachers of students with MS/ID. Although they provide structure for practitioners, the CCSS's do not detail how instruction should take place, the intervention methods, or the strategies used to provide instruction to students with MS/ID.

Grade aligned mathematics for students with moderate and severe disabilities. To meet federal guidelines and remediate the challenge of aligning mathematics for students with MS/ID, researchers have sought out to investigate and determine evidence-based practices to alleviate this challenge. Curriculum for students with severe disabilities has been evolving to match the requirements of current public law that also includes the development of alternate assessments as a means of accountability for progress towards standards (Browder et al., 2004). Students with MS/ID are given alternate assessments in English language arts (ELA) and mathematics to measure their progress towards meeting these standards. Recent studies have shown that students with moderate to severe disabilities can learn grade aligned academic content based on academic standards through the use of evidence-based practices (Browder, Trela, & Jimenez, 2007; Browder, Spooner, Ahlgrim-Delzell, Harris, & Wakeman, 2008; Collins, 2007; Fuchs & Fuchs, 2007; Fuchs, Fuchs, Finelli, Courey, & Hamlett, 2004; Sell, 1987; McDonnell & Ferguson, 1989; Spooner, Knight, Browder, & Smith, 2011).

Existing research verifies evidence-based practices and details how to provide access to and extend academic content standards for students with MS/ID (Browder, Ahlgrim-Delzell, Courtade-Little, & Snell, 2006; Browder et al., 2012; Saunders, Bethune, Spooner, & Browder, 2013); however, many teachers may not be aware of what resources are available or how to utilize them in the classroom due to the research-to-practice gap. Practitioners are aware this deficit exists and are asking for instructional strategies and support models to provide students with MS/ID greater access to the general curriculum (Cushing, Clark, Carter, & Kennedy, 2005; Giangreco, Halvorsen, Doyle, & Broer, 2004) and to meet the current CCSS expectations. To determine successful strategies, additional research is needed to determine effective instructional procedures for teaching grade-aligned mathematics content, specifically those aligned to the CCSS. There is also a need to teach mathematical problem solving skills to students with MS/ID, beyond basic number recognition and operations, and measurement skills of time and money as a means of accessing the general curriculum content. There should be focus that is not only on learning the content, but also on access to the general education setting. According to Ryndak and Alper (1996, 2003) students with MS/ID should receive instruction in inclusive educational settings to achieve this goal. While the number of students with MS/ID receiving instruction in inclusive education settings has steadily increased over the past decade (U.S. Department of Education, 2001, 2005), the reality is that only 11% of students with intellectual disability are fully included for 79% or more of the school day (Smith, 2007). Research is also needed to examine the instructional strategy of using peer-mediated instruction to move students with MS/ID towards inclusive settings by providing them with mathematical problem solving skills.

Existing evidence demonstrates that students with MS/ID can learn basic mathematics. In a comprehensive review of literature, Browder et al. (2008) found 68 empirical studies that taught mathematical skills to 493 individuals with moderate and severe intellectual disabilities. Of those 68 studies, 93% of them addressed the standards of Numbers and Operations. The authors reported that the majority of studies addressed content on measurement (e.g., money, purchasing, and time) and numbers and operations (e.g., calculations, number identification, and counting). The authors stressed the need for future research to investigate additional strategies to teach mathematics to students with MS/ID that: (a) targets other mathematics standards, such as algebra; (b) focuses on skills that required higher level thinking, such as problem solving; (c) includes specific subgroups of students with MS/ID; and (d) is consistent with the preferences and needs of students with MS/ID.

Mathematical word problems can be challenging and cause difficulty for many students because not only do they require calculation, but also comprehension of linguistic information (Fuchs, Seethaler, et al., 2008). Students with MS/ID often lack both the reading and calculation skills to attempt mathematic problems that are typical of the general mathematics curriculum, that include the three problem types of group, compare, and change. Teaching calculation without teaching problem solving only shows students how to apply these skills, but does not teach them when or why to apply these skills. Problem solving has been identified by many mathematics teachers as the cornerstone of mathematical learning (National Council of Teachers of Mathematics

[NCTM], 2000). There are five studies that have addressed the NCTM standard of mathematical problem solving for students with ASD or MS/ID (Creech-Galloway, Collins, Knight, & Bausch, 2013; Miser, 1985; Neef, Nelles, Iwata, & Page, 2003; Root et al., 2015; Saunders, 2014; Spooner, Saunders, et al., 2015) and all but the Miser (1985) study included the use of a task analysis to teach a step-by-step procedure to solve the problem and provided systematic prompting and feedback.

Federal legislation requires schools to report adequate yearly progress (AYP) in reading/language arts and mathematics for all students, including those with significant cognitive disabilities, who participate in alternate assessments aligned with grade level content standards (NCLB, 2006). Moreover, the Individuals with Disabilities Education Act (IDEA, 2004) requires all students have access to the general curriculum. Special educators need successful methods for teaching general education mathematical content to students with MS/ID while making the content relevant and meaningful. Systematic instruction through SBI can be a viable approach to provide special educators with the methodology to provide successful instruction.

Teaching mathematical problem solving using schema based instruction.

There is research that has identified schema based instruction (SBI) as an effective method for teaching mathematical problem solving to students with high incidence disabilities (Fuchs et al., 2004; Jitendra, Griffen, Deatline-Buchman, & Sczesniak, 2007; Xin & Zhang, 2009); however, it has only recently been applied to students with autism spectrum disorder (ASD) and MS/ID (Neef, Nelles, Iwata, & Page, 2003; Root, Browder, Saunders, & Lo, 2015; Saunders, 2014; Spooner, Saunders, & Ley Davis, 2015). A schema is an outline or a structure for solving a problem that can be represented through pictures, diagrams, number sentences, or equations (Marshall, 1995; Powell, 2011). SBI has four essential components: (a) identification of the word problem structure to determine the problem type, (b) the use of visual representations to represent the structure of the problem type to organize the information from the word problem, (c) explicit instruction on the schema based problem solving heuristic, and (d) instruction on metacognitive strategy skills. In SBI the student selects or creates a diagram that fits the structure of the word problem, uses the diagram to solve the problem, and completes the number sentence with the solution (Jitendra & Hoff, 1996).

Rockwell, Griffin, and Jones (2011) conducted the first study that utilized SBI to teach mathematical problem solving to a student with ASD. The participant was a 10-year-old female student with ASD without comorbid ID. She was taught to use schematic diagrams to solve three types of word problems (group, change, and compare). After the student had mastered solving all three problem types with the unknowns in the final position (i.e., the whole in group problems, change amount in change problems, and difference in compare problems), one training session was given on generalization to unknowns in the other positions. The student was able to generalize word problem solving with the unknown in the initial and medial positions.

Only one study to date has used SBI to teach problem solving to a student with moderate ID. Neef and colleagues (2003) used a multiple baseline across behaviors design to teach a 19-year-old man with an IQ of 46 to solve change-addition and change-subtraction problems by teaching precurrent behaviors, which included teaching the student to identify component parts of the word problem, including the initial set, the change set, key words to identify the operation, and the resulting set. In addition to identifying the components, the student learned to fill out a schematic diagram with the information from the problem. Teaching precurrent behaviors was successful as the student produced the correct solutions and increased the number of correct solutions from a mean of 1.2 to 8.0 out of 10 possible points. However, this study only included one participant with MS/ID and only addressed one problem type.

Three recent studies that have investigated the use of modified SBI to teach problem solving to students with MS/ID and ASD have demonstrated that it is effective for this population when additional supports are provided (Root et al., 2015; Saunders, 2014; Spooner, Saunders, et al., 2015). Saunders (2014) taught three elementary male students with ASD and moderate ID to solve group and change problems using modified SBI delivered through computer-based video instruction. All three students were able to master the *group* problem type and one student mastered the *change* problem type. Recently, Root et al. (2015) taught three elementary male students with ASD and moderate ID to solve *compare* problems through SBI with both virtual and concrete graphic organizers and manipulatives. All three students mastered solving compare problems, with a demonstrated higher rate of learning during the virtual condition for two of the students and indicated a preference for the virtual condition for all three students. Both studies utilized technology to provide an alternate means of access to the text (e.g., student controlled read-aloud) and learning materials (e.g., virtual graphic organizers and manipulatives). However, these two studies only targeted students with ASD and none with MS/ID.

Most recently, Spooner, Saunders, et al. (2015) used a multiple probe across participants design for three middle school students with MS/ID to investigate the effects of real-life simulated video modeling on the *change* problem type for mathematical word problem solving. Students were presented with real-life video simulations to solve a variety of mathematical problems that relate to activities in which they may engage outside of the school setting. The videos modeled real-life mathematical simulations based on a variety of thematic units, such as (a) pet store, (b) grocery store, (c) household chores, (d) sporting goods store, (e) outside chores, and (f) thrift store. This study included two types of videos: a model video in which actors model solving real life problem using the method described; and the other where the video sets up the context, but requires the student to solve the problem. The results of this study demonstrated a change in level and trend from baseline to intervention for all three students. This study's purpose was to teach students to recognize the underlying structures in mathematical problem solving using real-life video simulations that can be easily generalized to situations students will encounter in everyday life. Although this study demonstrated a successful way to provide mathematical problem solving instruction to students with MS/ID, it did not specifically use SBI.

The strategies emerging from these studies could be combined with evidence-based practices for teaching mathematics to students with ASD and/or MS/ID (Browder et al., 2008) to develop an effective method for mathematical problem solving that align to mathematical standards. Although these three studies showed great promise, two of these studies included only participants with ASD and the third did not specifically use SBI. None of the studies used peers to deliver instruction, which would provide the catalyst towards students with MS/ID moving towards inclusion. A solution would be the use of peers to deliver SBI to teach mathematical problem solving to students with

MS/ID, which is believed to be the first study to examine these components for this population.

Peer-delivered instruction. One strategy that has been shown to be successful in providing access to general education mathematics is peer instruction. Peer instruction encompasses both inclusionary practices and equitable access to general education curriculum, general education classrooms, and adequate progress monitoring. Referred to as peer tutoring, peer-mediated instruction, or peer instruction (Carter & Kennedy, 2006; Cushing & Kennedy, 1997, 2004), peer-mediated instruction is a strategy where one student (the tutor) assumes responsibility for providing instruction to another (the tutee; Greenwood, Carta, & Hall, 1988) and provides benefits for both students involved (Rohrbeck, Ginsburg-Block, Fantuzzo, & Miller, 2003). Current research has demonstrated that peer instruction can be used to teach academic skills to students with varying needs across grade levels and tutoring programs (Carter & Kennedy, 2006; Carter & Pesko, 2008; Hudson, 2013; Hudson, Browder, & Jimenez, 2014; Jimenez, Browder, Spooner, & DiBiase, 2012).

Peer instruction has been used to teach academic areas such as language arts, social studies, science, and mathematics using both same-age peers and cross-age peers. In a comprehensive review of reading research that covered a span of 15 years, McMaster, Fuchs, and Fuchs (2007) found that classwide peer tutoring improved reading performance for students from kindergarten to high school who were identified as high, average, and low performing and those students with disabilities. Simpkins, Mastropieri, and Scruggs (2009) conducted a study to compare traditional instruction (i.e., teacher-led instruction and discussion, textbook reading, followed by worksheet exercises) and differentiated curricular enhancements. They found that the differentiated curricular enhancement group with peer instruction had higher test scores. The use of peer instruction to teach academics is promising. Although studies have been successful in teaching mathematic problem solving to students with mathematical disabilities (mild disability) using model based word story grammar (Xin, Wiles, & Lin, 2008) and using peer-mediated instruction to teach discrete science skills to students with MS/ID in a general context (Jimenez et al., 2012), the lack of studies that use peer-mediated instruction to teach chained skills for mathematical problem solving with generalization to the general education context is sparse (Browder et al., 2008).

Jameson, McDonnell, Polychronis, and Reisen (2008) taught same-age peers to embed systematic prompting and feedback in the context of a general education lesson. They were able to demonstrate that three general education peers could use constant time delay (CTD) procedures within a general education classroom (i.e., health; arts and crafts class) with students with severe developmental disabilities and that the students with disabilities could master the skills being taught while in the general education setting. Generalization within general education settings can be promoted by training peer tutors to use an intervention protocol and providing opportunities in general education mathematical classes for students to use their emerging skills (Carter, Sisco, Melekoglu, & Kurkowski, 2007; Cushing et al., 2003). Several studies have demonstrated that students with MS/ID can learn skills through the use of peer supports (Carter et al., 2007; Cushing & Kennedy, 1997; Kamps, Locke, Delquadri, & Hall, 1989; Miracle, Collins, Schuster, & Grisham-Brown, 2001; Werts, Caldwell, & Wolery, 1996).

Okilwa and Shelby (2010) conducted a review of the literature to examine the effects of peer tutoring on academic performance of students with disabilities in grades 6-12 using the criteria of (a) original studies, (b) published in peer-reviewed journals between 1997 and 2007, (c) investigated peer tutoring in special education students in Grades 6 through 12, and (d) implemented peer tutoring as an intervention and measured the effect on the academic outcomes of students with disabilities. Their findings revealed that peer tutoring had a positive academic effect on students with disabilities in Grades 6-12, regardless of disability type. Peer tutoring was reported as effective for students with disabilities in both general education and special education settings. Additionally, they found that peer tutoring implemented across subject areas (i.e., language arts, mathematics, science, and social studies) also showed positive academic effects. Each of the 12 studies implemented peer tutoring in at least one content area (e.g., language arts, math, science, and social studies).

A recent study by Hudson et al. (2014) investigated the effects of a peer-delivered system of least prompts and adapted grade-level science read-alouds on correct listening comprehension responses for participants with moderate ID. Their intervention package included prompts in which selected text was read again to remove the difficulties comprehending text that non-readers experience. Participants were able to dictate the amount of assistance they received from peer tutors by asking for help only when needed, and self-monitored their independent correct responses. The science text was adapted from fourth grade science material that was currently being used by the general education fourth grade class. A question template was used to create both factual recall and inferential questions. A multiple probe design across participants was used to determine a functional relation between the system of least prompts intervention and listening comprehension. Outcomes indicated that the intervention was effective for teaching listening comprehension for all participants; however, intervention effects did not generalize to untrained lessons. Although these studies show promise, there remain questions surrounding the use of peer-mediated instruction to specifically teach students with MS/ID to generalize skills to novel/untrained contexts (e.g., simulated real-life video mathematical problems) and there are no studies addressing mathematical problem solving.

Although studies exist that utilize peers to deliver academic instruction as well as studies using SBI to teach mathematical word problem solving to students with learning disabilities, there currently are none combining these strategies for students with MS/ID. Additionally, there have been no studies to date that have included both the use of peer-mediated instruction and the systematic techniques of SBI to teach mathematical problem solving to students with MS/ID.

Purpose

The purpose of this study was to investigate the effects of peer-mediated schema based instruction on the number of correct steps of a task analysis to solve the *change* problem type of mathematical word problems with middle school students with MS/ID. An additional purpose of this study was to determine the effects of peer-mediated schema based instruction on the number of correct mathematical problems solved with MS/ID. This study also examined the ability of students with MS/ID to discriminate between addition and subtraction in word problems for the *change* problem type. Additionally, this study sought to determine if students with MS/ID were able to generalize the learned mathematical skills to an unfamiliar peer. Finally, this study investigated the effects of peer-mediated instruction on both tutors and tutees social attitudes and perceptions of one another before and after the study was completed.

The independent variable was peer-mediated schema based mathematical word problem solving instruction. Middle school peers (peer-tutors) without disabilities were nominated by the schools honors mathematics teacher and selected based on meeting the specified eligibility criteria. The peer-tutors were trained by the experimenter to use a system of least prompts procedure to embed trials for correct responses within a schema based mathematical lesson. Peer-tutors used the system of least prompts for a total of two trials during each mathematical lesson. The sessions occurred in the students' home school with generalization probes taken on the students' ability to generalize these skills with an unfamiliar peer following each phase change during the intervention condition. Peer tutors were assigned by gender with both peer tutors alternating instruction for each session.

The primary dependent variable was the number of correct steps of a task analysis with middle school students during peer-tutor delivered instruction. The experimenter added the total number of correct responses on each step of the task analysis, graphed that number using a multiple probe across participants design, and used visual analysis to direct the intervention. The second dependent variable was to determine the effects of peer-mediated schema based instruction on the total number of mathematic problems answered correctly by the tutee (student with MS/ID) for each session and was graphed cumulatively. The third dependent variable was to examine the tutees ability to discriminate between addition and subtraction in word problems for the *change* problem type. This was determined by the experimenter adding together all the correct discriminations from each session and graphing the results cumulatively. Additionally, this study sought to determine if tutees are able to generalize the learned mathematical skills to novel/unfamiliar problems given by an unfamiliar peer. A peer of the opposite gender served as the unfamiliar peer tutor during the generalization probe. A generalization probe was conducted following the peer tutee reaching the mastery criteria of getting all steps on the task analysis correct for two consecutive sessions for that phase of the intervention condition. All other procedures remained the same for the generalization probe with the exception of the unfamiliar peer of the opposite gender delivering the mathematical word problem.

The final dependent variable was to examine the effects of peer-mediated instruction on both tutor and tutees social attitudes and perceptions of one another before and after the study was completed. An attitudes and perceptions survey was given to the selected tutors and to the tutees prior to the implementation of the study, and once again following the conclusion of the study. Results were reported qualitatively.

Significance of the Study

Research reveals that the academic accomplishments of students with MS/ID increase through interaction with typically developing peers in an integrated environment, and increases their ability to meet the goals of their individual education programs (IEPs, Brinker & Thorpe, 1984; Westling & Fox, 2009). Moving students with MS/ID towards inclusive education remains the ultimate goal, and serves as a viable strategy to assist general and special educators in providing meaningful and effective content instruction to students with MS/ID. If students with MS/ID are ever going to be transportable to an inclusive setting, there must be alternate modes to deliver instruction aside from the use of adults/teachers. The use of peers to deliver instruction can serve as a catalyst to move students with MS/ID towards inclusion.

The current study is likely the first of its kind demonstrating how to successfully use evidence-based teaching methods (i.e., task analytic instruction, total task presentation, least intrusive prompting system, peer-mediated instruction, and modified SBI) to teach mathematical problem solving to this population. Currently, the use of SBI for students with ASD and/or MS/ID to learn mathematical word problem solving is just emerging (Root et al., 2015; Saunders, 2014; Spooner, Saunders, et al., 2015). There currently are no studies that have investigated the use of peer-delivered SBI instruction to teach mathematical problem solving to students with MS/ID. For this reason, this investigation provides the first study to examine the use of peer-mediated instruction to teach mathematical problem solving to students with MS/ID.

The purpose of this study was to examine the effects of using peer-mediated instruction to teach mathematical word problem solving to students with MS/ID, and if students are able to generalize the mathematical problem solving skills to an unfamiliar peer to support the limited research on inclusionary practices for students with MS/ID. Further, this study evaluated the perceptions and attitudes that students with and without disabilities have of one another both before and after this study. This study was significant in that it served to demonstrate that students with MS/ID have the capacity to learn mathematics with peer supports, when given the opportunity.

Research Questions

The following research questions were addressed:

1. What are the effects of peer-mediated, schema based instruction on the number of steps of a task analysis completed independently correct by students with MS/ID?
2. What are the effects of peer-mediated, schema based instruction on the number of correct mathematical problems solved by students with MS/ID?
3. What are the effects of peer-mediated, schema based instruction on students' ability to discriminate between addition and subtraction in word problems for the *change* problem type for students with MS/ID?
4. What are the effects of peer-mediated, schema based instruction on the generalization of the learned mathematical skills to an unfamiliar peer on mathematical problems for students with MS/ID?
5. What are the effects of peer-mediated, schema based instruction on both peer-tutors and peer-tutees social attitudes and perceptions of one another?

Delimitations

This study was conducted in a large, urban school district with large special education and mathematics curricula departments that provides support to classroom teachers that smaller school district may not have. The novel nature of this study prompted the experimenter to choose to target the more challenging *change* problem type only for this investigation. The other problem types of group and compare were not addressed in this study. Students in this study were selected based on the prerequisite skills of having mastered early numeracy skills (such as identifying numbers to 10, counting with 1:1 correspondence, creating sets to 10, and early addition skills). The results may not be applicable to students who have not yet mastered these prerequisite skills. Conversely, the mathematical word problems included numbers from a relatively limited range (1-9) and the results may not be applicable to students that have mastered single-digit addition and/or subtraction. The inclusion of five peer tutors and four peer tutees was relatively small. The results may not be generalizable to the larger population as a whole. Additionally, all students were in middle school and this may affect generalization to other grade level populations.

Definition of Terms

The terms that were used in this study with their definitions are presented in this section. The terms chosen for defining in the section are critical for comprehending the implementation procedures and results of this study.

Academic Skill – a skill that can be aligned to a national common core content standard.

Accommodation or Adapted – alterations to context or content that seek to include using specific teaching techniques, such as audio or other formats as an alternative to print, technology, graphic organizers, and pictorial representation; and changing the amount of input, time-frame for learning, and levels of support for individual students' needs (Koga & Hall, 2004).

Chained Task – a specific sequence of discrete responses where each response in the chain serves as the stimulus for the next response; the sequence of behaviors must be performed correctly and in a specific sequence (e.g., mathematical word problem solving) to produce a terminal outcome (correct answer). Teaches complex skills that allow individuals to function more independently; provides a way to add new behaviors to an existing behavioral repertoire (Spooner, 1984).

Inclusion – a practice in which students with disabilities are served primarily in the general education classroom under the responsibility of the general education teacher with the necessary supports for academic and social achievement (Mastropieri & Scruggs, 2007). Inclusion allows all students with disabilities to participate in the general education curriculum as well as in regular classes with their typically developing peers to the maximum extent possible (Osgood, 2005; Westling & Fox, 2009). Villa and Thousand (2003) describe it as “the principles and practice of considering general education as the placement of first choice for all learners" (p. 20).

Least Intrusive Prompting System (LIPS) - a prompting strategy where the instructor progresses through a prompting hierarchy from the assumed least intrusive prompt to the most intrusive prompt necessary to obtain a correct response from the student (e.g., independent, gestural, verbal, modeling, then physical), beginning by allowing the child an opportunity to respond correctly to the natural cue or question posed without any prompt being given (i.e., the controlling prompt) and effectively allows the child to successfully and correctly respond during each learning opportunity (Browder & Spooner, 2011). In this study, when a student responded incorrectly or failed to respond at any point in the prompting hierarchy for all steps in the task analysis with the exception of the critical step 9 (solve) the instructor immediately moved to the next prompt in the prompting hierarchy and continued through the hierarchy until the student responded correctly. The ultimate goal of the system of least prompts is for the child to provide a correct response before a prompt is given. Other common terms used include least-to-most prompting, system of least prompts, and increasing assistance.

Mathematical Problem Solving - any task or activity for which the students have no prescribed answer (Van De Walle, 2004). As applied to mathematics, there are three components: (a) begins at the student's current level, (b) problematic or engaging aspect of the problem is related to mathematics students will learn (c) requires justification and explanation for the methods used to solve (Van De

Walle, 2004). In this study, the participant attempted to solve simple mathematical problems that are derived from "real world" problems with the expectation that generalizations to more complex problems will become possible.

Peer Support Interventions - (i.e., peer-mediated instruction, peer-delivered instruction) – involves one or more peers without disabilities providing academic and social support to a student with disabilities (Cushing & Kennedy, 2004). Peers are taught to (a) adapt class activities to facilitate student participation, (b) provide instruction related to IEP goals, and (c) provide frequent feedback to students with disabilities (Cushing & Kennedy, 1997). Studies suggest peer strategies can provide support for students with severe disabilities in the general education setting. Carter and Kennedy (2006) recommend: (a) adapting class activities to facilitate their participation; (b) contributing to the attainment of IEP goals; (c) supporting behavior intervention plans, when appropriate; (d) providing frequent, positive feedback; (e) modeling age-appropriate and contextually relevant communication skills; and (f) facilitating interactions with other students in the class.

Repeated Trials – allowing the student to perform the task(s) correctly a number of times until mastery of the skills is reached.

Schema Based Instruction (SBI) - A schema is an outline or a structure for solving a problem that can be represented through pictures, diagrams, number sentences, or equations (Marshall, 1995; Powell, 2011). SBI has four essential components: (a) identification of the word problem structure to determine the problem type, (b) the use of visual representations to represent the structure of the problem type to organize the information from the word problem, (c) explicit instruction on the schema based problem solving heuristic, and (d) instruction on metacognitive strategy skills. In SBI the student selects or creates a diagram that fits the structure of the word problem, uses the diagram to solve the problem, and completes the number sentence with the solution (Jitendra & Hoff, 1996).

Students with severe disabilities – as individuals who have cognitive disabilities consistent with intelligence quotient (IQ) below 50-55 or a severe developmental disability that limits their functional ability to this range (Collins, 2007).

Students with significant cognitive disabilities – individuals who: (a) require substantial modifications, adaptations, or supports to meaningfully access the grade-level content; (b) requires intensive individualized instruction in order to acquire and generalize knowledge; and (c) are working toward alternate achievement standards for grade-level content (Browder & Spooner, 2011).

Time Delay – a procedure used to teach discrete. The instruction introduces the response with an immediate prompt (e.g., saying the word) and the learner repeats each word while looking at the sight word flash card. Over successive trials, small increments of time (e.g., 3 seconds, 5 seconds) are inserted between showing the sight word to the learner and giving the prompt. Typically, after some trials, the learner will anticipate the correct answer and learn the correct responses with near errorless responding (Wolery, Ault, & Doyle, 1992).

CHAPTER 2: REVIEW OF THE LITERATURE

The establishment of friendships between students with disabilities and their nondisabled peers has been one of the most important outcomes sought by school inclusionary efforts (Haring & Breen, 1989; Sailor, 1989; Strully & Strully, 1985). To make strides towards inclusionary practices, strategies that are practical and effective should be used. Systematic instruction is one such strategy with potential for use with general curriculum. This chapter reviews the literature that surrounds the evolution of systematic instruction and how it came to be recognized as an evidence-based practice for students with MS/ID. Next, this chapter reviews literature in mathematics instruction for students with MS/ID and current studies investigating mathematical word problem solving. Finally, this chapter presents a review of literature on the use of peers to deliver instruction and its promise as a strategy to deliver instruction on mathematical word problem solving for students with MS/ID. The purpose of this chapter is to provide the foundation for a strategy of mathematical word problem solving for students with MS/ID that is practical and effective through the use of peer-delivered instruction and evidence-based systematic instruction.

Literature to date on mathematical content instruction for students with MS/ID has been limited. While existing literature is promising, little has been demonstrated to promote mathematical academic outcomes for this population. More research is needed in the area of mathematical problem solving skill acquisition to expand current general curriculum access within naturally occurring settings (i.e., inclusive classrooms). Because students with MS/ID often have intensive support needs (Kennedy & Horn, 2004), when combined with the higher expectations and the challenges associated with this population, peer-mediated strategies offer a means to meet these expectations and challenges.

Peer-mediated instruction could be the catalyst to promoting academic content instruction, especially for mathematical problem solving because of the classroom dynamics (e.g., working in pairs, learning dyads, cooperative learning groups). There remains a need to determine the effectiveness of strategies that are viable for peers to use to provide instruction to one another for academics, specifically mathematical problem solving. There are multiple challenges in providing mathematical word problem solving to students with MS/ID. This study introduces three solutions as seen in the theory of change in Figure 1 as a proposed method to effectively teach mathematical word problem solving to this population of students. Components of the theory of change include: (a) using systematic instruction as an evidence-based practice (EBP) for students with MS/ID, (b) teaching mathematical word problem conceptual skills with schema-based instruction to students with MS/ID, and (c) using peer-mediated instruction to deliver instruction.

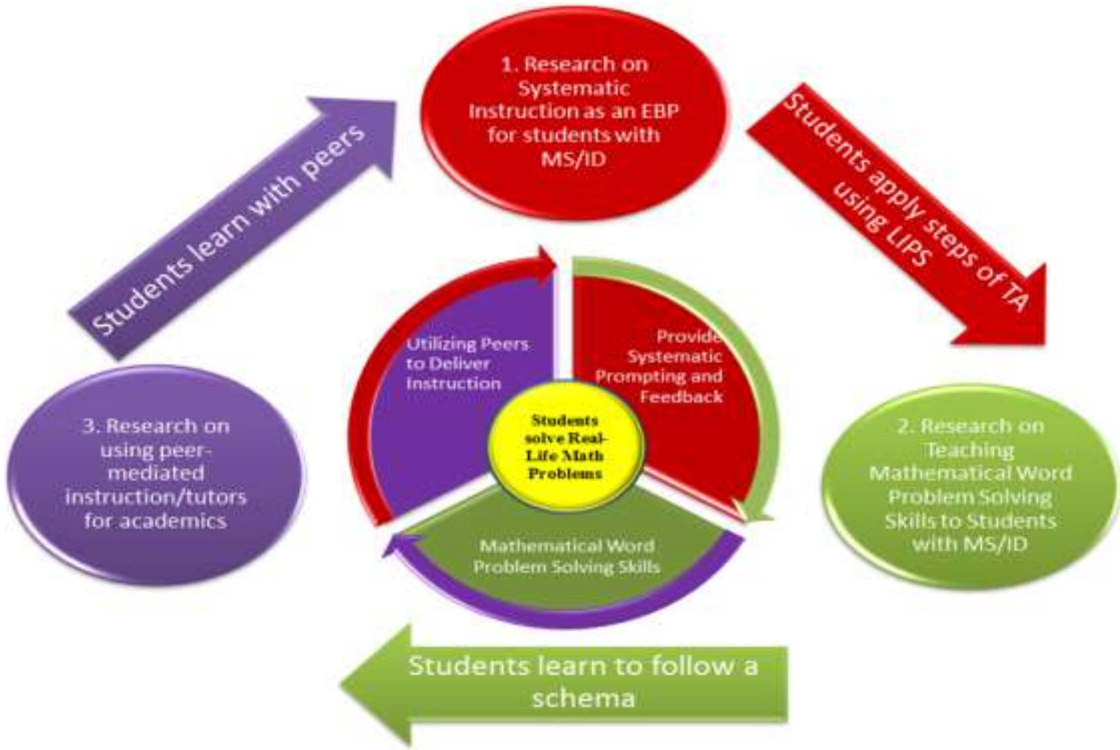

Figure 1: Theory of change for using peers to teach mathematical problem solving to students with ID.

Systematic Instructional Practices as Evidence-based Strategies for Teaching Students with MS/ID

The primary goal of teaching is to promote student progress through effective instructional strategies. The range of strategies available to increase student progress varies widely. It is imperative to use strategies that have been demonstrated through research to be effective. One of the most powerful variables influencing students' learning is the method of instruction (Browder & Spooner, 2011). Systematic instruction has been validated through high-quality research to be effective for teaching students with MS/ID, making them evidence-based. There have been three major pieces of literature to describe and validate evidence-based practices in the field of special education ("Criteria," 2005; "Evidence-Based," 2009; "Implementation Science," 2013). In the first of a three part series on EBPs, the authors of "Criteria," (2005) set the foundational context for the development of guidelines for defining quality indicators for research methodologies used in special education (e.g., qualitative methodologies, Brantlinger, Jimenez, Klinger, Pugach, & Richardson, 2005; group and quasi-experimental methods, Gersten et al., 2005; single-case designs, R. H. Horner et al., 2005). Second, Cook, Tankersley, and Landrum (2009) expanded upon the first article by including a set of examples on applying the quality indicators using strategies that were delineated by Browder, Ahlgrim-Delzell, Spooner, Mims, and Baker (2009). Third, Cook and Odom (2013) examined the history, extent, and limitations of EBPs in effort to describe the development and current status of implementation of science as applied in special education. In this article, the authors emphasize and detail the importance of quality implementation, stressing that EBPs are bounded by the quality, reach, and maintenance of their implementation. Similarly, Spooner (2003) provided a foundational piece of literature in the area of severe disabilities by editing a collection of contributions that addressed perspectives on defining scientifically based. These collective bodies of work in the area of severe developmental disabilities lead to the predominant methodology that has been used to substantiate research outcomes through single-case design research (e.g., Browder et al., 2009; R. H. Horner et al., 2005; McDonnell & O'Neill, 2003; Spooner & Browder, 2003).

Evidence-based Practices in Special Education

Evidence-based education uses instructional approaches that have been shown to be effective by rigorous bodies of research, that aim to improve the quality of instruction, and that increase successful student outcomes in general and special education ("Criteria," 2005; Slavin & Lake, 2008). According to Courtade, Test, and Cook (2015), the basic foundation in the identification and application of evidence-based reforms is found in four notions: (a) some practices are generally more effective than others at causing improved learner outcomes; (b) ineffective practices are commonly used; (c) high-quality, experimental (i.e., internally valid) research is the most reliable way for identifying which practices are most effective; and therefore, (d) the application of practices identified as effective on the basis of high-quality experimental research can yield improved student outcomes. A number of different standards exist for identifying EBPs in special education (e.g., Council for Exceptional Children [CEC], 2014; What Works Clearinghouse [WWC], 2011) also have established standards that can be used in the area of severe intellectual disability. The standards proposed by R. H. Horner et al. (2005) and Gersten et al. (2005) are most commonly used for identifying EBPs in special education and for learners with severe intellectual disability. It is important to note, however, that although these EBP standards all differ in many specific ways, they all share the same basic approach of (a) applying a set of quality indicators to group experimental and/or single-subject studies to identify studies of acceptable quality, and then (b) applying predetermined standards to studies of acceptable quality to determine the evidence-based status of a practice. EBPs for learners with MS/ID in the areas of reading, mathematics, science, and general academics can be found in the professional literature (e.g., mathematics, Browder et al., 2008; Spooner, Root, Browder, & Saunders, 2016; reading, Browder, Wakeman, et al., 2006; academic skills in general education, Hudson, Browder, & Wood, 2013; science, Spooner, Knight, Browder, Jimenez, & DiBiase, 2011; general academic skills: Spooner, Knight, Browder, & Smith, 2011).

Quality Indicators to Identify Evidence-based Practices in Special Education

The initial work on identifying quality indicators and procedures to assess practices across different research methodologies (e.g., group designs, single-case designs, qualitative designs, "Criteria," 2005; "Evidence-based," 2009), and recent contributions (e.g., Cook & Odom, 2013; B. Cook, Tankersley, Cook, & Landrum, 2008; Courtade, Test, & Cook, 2015) have substantiated the evidence-based practice movement in special education. The comprehensive reviews (mathematics, Browder et al., 2008; reading, Browder, Wakeman, et al., 2006; general education, Hudson et al., 2013; science, Spooner, Knight, Browder, Jiménez, et al., 2011; academic skills, Spooner, Knight, Browder, Smith, 2011; Spooner, Root et al., 2016) examined investigations using the Gersten et al. (2005) criteria for group designs and the R. H. Horner et al. (2005) criteria for single-case designs. Collectively, it emerged that in vivo instruction (teach real applications in real-life settings), systematic instruction (e.g., system of least prompts, time delay, specific praise, & error correction), and giving students many opportunities to respond were found to be evidence-based practices. Not only do we know that students with MS/ID can learn academic skills, but also that systematic instruction is effective in teaching skills for this population. Systematic instruction is an overarching instructional approach which is defined and replicable consisting of components like identifying a target behavior, task analysis, transfer of stimulus control, prompting and fading, acquisition to programming for generalization (Snell, 1983, 1993; Spooner & Browder, 2003). There are literature reviews that clearly delineate systematic instruction as an evidence-based practice.

Systematic instruction in special education. Systematic instruction is defined as a repeatable, predictable, organized process which reflects currently accepted best practices using performance data to make educated modifications to instruction (Snell, 1983). Systematic instruction also focuses on teaching specific, measurable responses that may either be discrete or a chained task, and that are established through the use of defined methods of prompting and feedback based on the principles and research of applied behavior analysis (ABA). Browder and Spooner (2011) identified five basic components of systematic instruction: (a) instructing students in social meaningful skills; (b) defining target skills that are observable and measurable; (c) using data to demonstrate that skills were acquired as a result of the intervention; (d) using behavioral principles to promote transfer of stimulus control, including differential reinforcement, systematic prompting and fading, and error correction; and (e) producing a behavior change that can be generalized to other contexts, skills, people and/or materials (Collins, 2007; Snell, 1983, 1993; Stokes & Baer, 1977; Wolery, Bailey, & Sugai, 1988).

Systematic instruction is based in the principles of behavior analysis, and has been successfully used with individuals with developmental disabilities dating back to a study conducted by Fuller (1949) where a “vegetative” individual was taught to raise his arm through the use of operant conditioning. The use of systematic instruction over the past 67 years has made it the predominant instructional procedure to teach functional skills. For example, it has been used to teach tooth brushing (R. D. Horner & Keilitz, 1975), using a public telephone (Test, Spooner, Keul, & Grossi, 1990), riding a bus (Neef, Iwata, & Page, 1978), and safely crossing the street (Vogelsberg & Rusch, 1979).

A critical component of systematic instruction is the use of systematic prompting combined with a method of fading, since the goal of instruction is for the student to respond without the prompting stimulus (i.e., transfer of stimulus control, Browder & Spooner, 2011; Terrace, 1963a; Terrace, 1963b; Touchette, 1971). Knowing that systematic instruction has an extensive history of effectiveness in teaching functional skills to students with MS/ID (Billingsley & Romer, 1983; Snell, 1983, 1993; Spooner, 1984; Wolery & Gast, 1984), the next logical step has been to investigate systematic instruction to teach academic content to students with MS/ID. A strong foundational base is available that provides clear evidence that systematic instruction is an evidence-based practice that has demonstrated its effectiveness in providing academic instruction for students with MS/ID, and can be applied to teaching mathematical problem solving.

Time delay to teach discrete skills and chained tasks. Time delay is an effective strategy to teach both discrete skills and chained tasks (Collins, 2007; Schuster, Morse, Ault, Crawford, & Wolery, 1998; Wolery, Ault, & Doyle, 1992). Time delay is a method for transferring stimulus control by systematically increasing the delay interval that students have to make a correct response before the controlling prompt is provided (Snell & Gast, 1981; Terrace, 1963ab; Touchette, 1971). Two types of time delay found in the literature are progressive time delay (PTD) and constant time delay (CTD). PTD gradually increases the delay interval by a specified number of seconds (e.g., 0-s, 1-s, 2-s, 3-s, and so on) over subsequent trials; whereas CTD always begins with a 0-s delay for a specified number of trials (i.e., typically one or two) and then increases the delay interval to a specified number of seconds for subsequent instructional trials (Collins, 2007).

Simultaneous prompting to teach discrete skills and chained tasks. Simultaneous prompting also can be used to teach both discrete skills and chained tasks (Morse & Schuster, 2004). In simultaneous prompting, the instructional cue is delivered and the controlling prompt immediately follows, often in the form of a model prompt (Morse & Schuster, 2004; Snell & Brown, 2011). Both prompted and independent correct responses are reinforced. One difference between simultaneous prompting and the other types of systematic instructional strategies is that a probe session is conducted prior to every training session in simultaneous prompting to help determine when to fade prompts (Schuster, Griffen, & Wolery, 1992).

Least intrusive prompting to teach discrete skills and chained tasks. Least intrusive prompting also has been used to teach discrete skills and chained tasks in mathematics (Ault, Wolery, Doyle, & Gast, 1989; Collins, 2007; Doyle, Wolery, Ault, Gast, & Wiley, 1988). The least intrusive prompting system (LIPS) also is referred to as least-to-most prompting, system of least prompts, or increasing assistance. LIPS is a prompting strategy where the instructor progresses through a prompting hierarchy, from the assumed least intrusive prompt to the most intrusive prompt necessary to obtain a correct response from the student, (e.g., independent, gestural, verbal, modeling, then physical) beginning by allowing the child an opportunity to respond correctly to the natural cue or question posed without any prompt being given (i.e., the controlling prompt) and effectively allows the child to successfully and correctly respond during each learning opportunity (Browder & Spooner, 2011). If a child responds incorrectly or failed to respond at any point in the prompting hierarchy the instructor will immediately move to the next prompt in the prompting hierarchy and continues through the hierarchy until the student responds correctly (Collins, 2007). The ultimate goal of the system of least prompts is for the child to provide a correct response before a prompt is given.

Literature on Systematic Instruction as an Evidence-based Practice in Mathematics

In the area of mathematics, Browder et al. (2008) reviewed research on teaching mathematics from 1975-2005 to learners with significant cognitive disabilities. The authors identified 68 studies that focused on teaching mathematics skills and included at least one individual with a significant cognitive disability. Of the 68 studies identified, 54 used a single-subject design. The authors applied a subset of R. H. Horner et al.'s (2005) quality indicators (four indicators related to the dependent variable, method, procedural fidelity, baseline and experimental control) and determined 19 studies met all the modified criteria while an additional 15 met most (three of four) of the modified criteria. R. H. Horner et al.'s (2005) quality indicator (QI) criteria were applied to the 34 studies and the authors determined the following EBPs for teaching mathematics: (a) systematic instruction; (b) in vivo instruction (e.g., using money to make a purchase); and (c) numerous opportunities to respond. There were not enough high or acceptable quality group experimental studies identified to identify EBPs based on studies using that research design. This meta-analysis of mathematics identified systematic prompting with immediate feedback, the use of a task analysis, and generalization to real-life contexts to be EBPs for mathematics. With this in mind, Browder and Spooner (2011) note the most important outcome students with MS/ID can receive from mathematics instruction is to learn to solve problems. Regardless if the problem involves quantitative analysis, spatial reasoning, or linear relationships, students with MS/ID need to learn to (a) identify the problem; (b) to represent the problem; and (c) to solve the problem (Browder & Spooner, 2011). The specific operations of mathematics can be taught using systematic instruction of a task analysis for the mathematical operation, and once solved, can then be applied to real-life contexts.

To update and extend the previous literature reviews in identifying systematic instruction EBPs, Spooner, Knight, Browder, and Smith (2011) reviewed single-subject research studies between 2003-2010 that focused on teaching academic content (i.e., literacy, mathematics, science, social studies) to students with severe developmental disabilities. The authors applied the R. H. Horner et al. (2005) quality indicator criteria to studies that met initial search criteria and identified 18 studies that met “high quality” or “acceptable” criteria under the NSTTAC (2010) decision rules (Test et al., 2009). The 18 studies were then analyzed to determine if specific practices used could be deemed evidence based according to the R. H. Horner et al. criteria. Reported results indicated that (a) time delay procedures and (b) task analytic instruction are EBPs for teaching academics to this population of learners.

Hudson, Browder, and Wood (2013) also conducted a review to extended the previous evaluations of teaching academic skills to learners with severe intellectual disability by analyzing research to identify EBPs for teaching academic content (e.g., literacy, mathematics, science, social studies, art, health) within general education settings. The majority of the studies reviewed by Browder, Ahlgrim-Delzell, et al. (2006) and Browder et al. (2008) as well as Spooner, Knight, Browder, Jimenez, et al. (2011) and Spooner, Knight, Browder, and Smith (2011) took place outside of general education classrooms (e.g., special education classrooms, cafeteria, community), whereas Hudson et al. (2013) reviewed research published between 1975 and 2012 and were able to identify 17 single-subject studies that included learners with MS/ID in a general education settings. Of the 17 studies, 12 met all indicators for quality research (R. H. Horner et al., 2005) and 5 fell into the category of quality with reservation (i.e., study failed to address one to two of the quality indicators). The authors applied R. H. Horner et al.'s (2005) QI standards for EBPs and found that using the systematic instruction strategy of embedded-trial instruction with the use of constant time delay was an EBP for teaching academics to students with MS/ID in general education settings. Although this literature review was able to determine the use of embedded trial instruction using constant time delay as an evidence-based practice, only 4 of the 17 studies included investigated instruction related to mathematics.

Additionally, Hart Barnett and Cleary (2015) synthesized 11 studies that taught mathematical skills to students with ASD. Although the authors did not use the aforementioned quality indicators of EBPs, they reported from this review of mathematics interventions that there is empirical support for cognitive strategies including verbal and self-regulation strategies (Montague, 2008; Montague & Dietz, 2009), visual-spatial strategies with diagrams (van Garderen, 2007) as well as meta-cognitive strategies (Xin & Jitendra, 1999) for enhancing students' mathematic performance. Authors pointed out that studies have been limited primarily to students with diagnosed learning disability and could be expanded to evaluate their effectiveness for students with ASD, knowing that many also contend with mathematical learning difficulties. The authors concluded that students with ASD can benefit from instruction on mathematical content. They also noted that these skills can increase independence in completing mathematical problems and students can use these skills to solve real world problems in community settings. Although this synthesis provided insight on mathematical practices for individuals with ASD, only a few participants also had a MS/ID, therefore generalizability of the results gleaned from their review remain limited for this population.

Most recently, Spooner, Root, et al. (2016) examined the degree to which students with MS/ID were taught mathematical skills. Recognizing it has been 10 years since the data collection for the Browder et al.'s (2008) meta-analysis was concluded, the authors sought to update, expand, and analyze teaching mathematics to students with MS/ID as mathematical instruction continues increasing in focus with new instructional practices emerging. Authors located literature from 2005-2015 and found 34 studies (29 single-case and 5 group experimental). This review continued the Browder et al. (2008) categorization of the results by aligning them with NCTM standards. Of the 34 studies identified, most taught the NCTM standard of numbers and operations, and included 20 single-case and four group design studies that received a rating of high or adequate quality using the National Technical Assistance Center on Transition (NTACT, 2015; http://www.transitionta.org/) indicator criteria. Different from the Browder et al. (2008) analysis, a Tau-U statistic was used to evaluate effective size for the single-case studies (range .05 to 1.1, mean of .85) in this review. This updated review of mathematics not only identified systematic instruction as an EBP, but new instructional procedures of technology-aided instruction, manipulatives, and explicit instruction also were found to be EBPs in teaching mathematics to students with MS/ID.

Systematic instruction to teach mathematical word problem solving. Results of the Browder et al. (2008) meta-analysis showed that systematic instruction with prompt fading procedures, such as constant time delay and least intrusive prompts, and in vivo instruction were found to be evidence-based practices for teaching mathematics to students with MS/ID. Systematic instruction with response prompting procedures has been identified as an evidence-based practice for teaching mathematics content to students with MS/ID and has been used in numerous studies to teach functional mathematics skills with an emerging base of research teaching NCTM's content standards (Browder et al., 2008). Systematic instruction can be used to teach both discrete skills and chained tasks (Snell & Brown, 2011). A discrete skill is composed of one response that has a definite beginning and ending and can be counted as correct or incorrect. Examples of mathematical discrete skills include matching a numeral to a quantity (e.g., 1:1 correspondence), labeling a numeral, or identifying a symbol. A chained task is a series of discrete behaviors that are joined together sequentially to create one task (Gollub, 1977). Examples of mathematical chained tasks include analyzing a bar graph, solving an algebraic equation, and solving a word problem. Three types of systematic instruction that are used to teach the chained task of mathematics to students with MS/ID include time delay, simultaneous prompting, and the system of least prompts, also called least intrusive prompts.

Systematic instruction to teach discrete skills in mathematics. Studies have demonstrated the effectiveness of systematic instruction on teaching discrete skills in mathematics to students with MS/ID and students with ASD. As example, Skibo, Mims, and Spooner (2011) used a multiple probe across participants design to teach three elementary students with MS/ID to identify numbers 1-5 using LIPS (i.e., verbal, model, physical) and response cards. In this study, the response cards were preprinted cards with numerals and symbols to represent the numerals for students to hold up in order to display their answer to a question presented by the teacher. All three students met mastery (i.e., 11/15 independent correct responses) and were able to maintain the skill for at least one additional probe upon discontinuation of the instruction.

Systematic instruction to teach chained tasks in mathematics. Mathematical problem solving is innately a chained task and can increase the challenges of instruction and learning as it has an increase in the cognitive demands required during problem solving. Chained tasks require a specific sequence of discrete responses, each of which produces a stimulus change that serves as a conditioned reinforcer for the response that produced it, and as a discriminative stimulus for the next response in the chain (Cooper, Heron, & Heward, 2007; Kayser, Billingsley, & Neel, 1986; McDonnell & McFarland, 1988; Spooner, 1984). In order to solve a mathematical word problem, a student has to perform a series of discrete behaviors to arrive at the correct solution. Depending on the learner, the steps to learning how to understand the concept of mathematical word problem solving (or the task analysis) could include: (a) read the problem, (b) determine known and unknown information, (c) determine the operation (addition or subtraction), (d) perform the operation, and (e) identify the unknown information or solve the problem. When a mathematical fact is not memorized, explicitly teaching the steps to solving the problem provides the student with the skills and chained sequence to correctly solve the problem.

There are three basic ways chained tasks are taught: (a) forward chaining, (b) backward chaining, and (c) total task presentation (Browder & Spooner, 2011; Spooner, 1984). Total task presentation is a process for solving the word problem by teaching each step of the task analysis to mastery prior to moving on to the next step until the task is completed. For example, until the student was able to read/access the problem without assistance to a set mastery criterion, they would not move on to the next step of determining the known and unknown information. After mastery of the first step, the student would be taught how to determine known and unknown information. This process would continue until all steps of the chain have been mastered for each time the task is presented. Using a task analysis with total task presentation to teach a mathematical word problem that is presented with a theme, or schema, can further reduce the cognitive load and greatly increase student success in mathematical problem solving.

A limited number of studies have investigated the effects of systematic instruction on teaching chained tasks in mathematics to students with moderate ID. Jimenez, Browder, and Courtade (2008) used a multiple probe across participants design to teach three high school students with moderate ID to solve algebraic equations using a nine-step task analysis and LIPS. Students used a concrete representation (i.e., graphic organizer), which included an equation template and a number line, and manipulatives to help solve the problems. The researchers used a 0-s and a 4-s constant time delay and LIPS to teach students to complete each step of the task analysis. Two students were able to acquire all nine steps to solve the equations independently, and one student was able to master eight out of nine steps when she completed the problems while following the actual task analysis. Two of the three students were able to generalize the skills to novel materials and to the general education mathematics classroom.

More recently, Collins, Hager, and Galloway (2011) used a multiple probe across mathematics tasks replicated across participants design to teach three middle school students with moderate ID how to compute sales tax using an 11-step task analysis and CTD for one student who could write and an eight-step task analysis and CTD for the two students who could not write. This study focused on teaching skills in three different content areas: language arts, science, and mathematics; however, the specific mathematical skill addressed was teaching order of operations using multiplication and division through computation of sales tax. The researchers used CTD of 0-s and a 3-s to teach the students to complete each step of the task analysis. The student who could write met the mastery criterion of performing all the steps correctly, whereas the two students who could not write did not meet mastery due to time constraints and the school year ending. This study demonstrated that a student with a moderate ID can learn core mathematics content (e.g., order of operations) while applying it to a functional skill (e.g., computation of sales tax).

Both studies demonstrate that task analytic instruction combined with constant time delay and LIPS can be used to teach chained skills, such as solving algebraic problems; however, three of the six participants in the studies were not able to master solving the entire chained task (Collins et al., 2011; Jimenez et al., 2008). When solving mathematical word problems, it is critical to perform the entire chain for the student to obtain the correct answer knowing the goal is for the student to generalize the skill to real-world settings. Learning some of the steps to solving a mathematical word problem holds little worth if the student cannot perform the skill completely with accuracy. One of the most poignant limitations of these two studies is that the participants were taught how to solve the mathematical problem, but not necessarily when or how to apply the strategies to real-world situations (e.g., sales tax)R. To address the issue of completing a mathematical word problem, the EBP of using graphic organizers to enhance instruction has been found effective.

Graphic Organizers to solve mathematical word problems. The use of graphic organizers and manipulatives has been shown to be an evidence-based practice (Browder et al., 2008; Spooner, Root, et al., 2016). Graphic organizers provide additional support to assist students in actively participating in the problem-solving process and can be used for a variety of mathematics, including plotting points on a plane, completing a bar graph, and solving algebraic equations (Browder & Spooner, 2011). Studies have been conducted that demonstrate evidence of the effectiveness of using graphic organizers and manipulatives in mathematics (Jayanthi, Gersten, & Baker, 2008; Ives & Hoy, 2003; Maccini & Hughes, 1997). In a review of literature on teaching algebra to students with disabilities, Gagnon and Maccini (2001) found that the use of graphic organizers and manipulatives was a successful intervention that aided in three things in particular, including (a) the process of solving a mathematical problem and attaining the solution, (b) the process of reviewing background knowledge and explicit instruction in problem representation and solution, and (c) self-monitoring procedures. Graphic organizers have been used for students with MS/ID to support learning independent living skills, such as using an adaptive shopping list with a number line to help with estimating the amount of money need to help student gain independence in purchasing (Gaule, Nietupski, & Certo, 1985). Although research supports the use of graphic organizers to teach mathematics to students with mild disabilities (Jayanthi et al., 2008; Ives & Hoy, 2003; Maccini & Hughes, 1997), the application of a variety of mathematical graphic organizers (not just number lines) for students with MS/ID is lacking. Recently, the combination of using systematic instruction with graphic organizers and manipulatives to enhance instruction in teaching mathematical problem solving has been shown to be effective for students with ASD (Root et al., 2015; Saunders, 2014); however, it has not been investigated for its effectiveness for students with MS/ID.

Summary of Systematic Instructional Practices as Evidence-based Strategies for Teaching Students with MS/ID

It is clear that systematic instruction is an EBP to deliver instruction to students with MS/ID. The primary goal of teaching is to promote student progress through effective instructional strategies. The range of strategies available can vary widely and to increase student progress, it imperative to use strategies that have demonstrated through research to be effective. Systematic instruction has been validated through research to be effective for teaching students with MS/ID, making them evidence-based. Using systematic instruction has great potential in providing effective instruction to teach mathematical concepts through mathematical problem solving for students with MS/ID. There remains a need to go beyond functional skills and early numeracy skills. Combining the use of a task analysis for the total task chaining procedure of mathematical problem solving with the steps being supported through LIPS, explicit feedback, graphic organizers and manipulatives is warranted for further investigation. To date, there are no other studies that have evaluated the use of these strategies, with instruction provided through peers, to teach mathematical problem solving to students with MS/ID.

Teaching Mathematical Problem Solving (MPS) to Students with MS/ID

One of the most challenging issues facing educators today is the emphasis of high quality instruction for students with MS/ID. The need for high quality instruction to meet the rising expectations presented to practitioners continues to be an issue that concerns legislatures, researchers, practitioners, and parents. Since the passage of the No Child Left Behind Act of 2001 (NCLB, 2006) and other pieces of relevant legislation (e.g., IDEA reauthorization, 2004), the emphasis is on teaching and making adequate yearly progress on standards-based, academic content skills (literacy/language arts, mathematics, and science) for all students, including those with MS/ID using evidence-based practices. Recent studies have demonstrated that students with MS/ID can learn academic skills with support of effective instructional strategies (literacy/language arts, Browder et al., 2009; mathematics, Browder et al., 2008; general curriculum, Browder, Ahlgrim-Delzell, et al., 2006; academics, Spooner, Knight, Browder & Smith, 2011; science, Spooner, Knight, Browder, Jimenez, et al., 2011).

Increased Expectations for Students with MS/ID in Mathematics

According to the National Mathematics Advisory Panel (NMAP, 2008), students who demonstrate proficiency in mathematics should possess, among other things, an understanding of key mathematical concepts. An ability to automatically retrieve arithmetic facts is one of the skills that is indicative of success later in life is mathematical computation (NMAP, 2008). To increase independence, employability options, and overall quality of life for student with MS/ID as they transition into adulthood, competency in mathematics becomes a necessary skill. Historically, the emphasis for this population has been on providing instruction to teach computation, with and without using a calculator, and basic early numeracy skills. With states adhering to the Common Core State Standards in Mathematics (CCSSM), there is greater emphasis on the need to develop effective, evidence-based strategies to teach mathematical word problem solving to students with MS/ID. Application of mathematical facts to solve problems is one of the most fundamental goals for mathematics education (NMAP, 2008) and is considered a distinct stage of understanding in cognitive models of learning (Bloom, 1956; Thurber, Shinn, & Smolkowski, 2002). Bloom (1956) defined application of learning as the ability to apply the appropriate abstraction without having to be shown how to use it in that situation. For mathematics, this learning is often assessed by having the student complete a mathematical word problem that contains a newly learned fact (Jitendra et al., 2007). Word problems are effective ways to measure application of mathematical facts because they involve students' ability to accurately connect meanings, interpretations, and relations to the mathematic operations (Van de Walle, Karp, & Bay-Williams, 2010).

Understanding the importance mathematical problem solving has on future success of students with MS/ID, it is critical that the focus shift from basic computation skills that are acquired through memorization and rote learning, to conceptual understanding that can be applied to all aspects of daily life. Students need a way to connect to, and experience the problem to be solved in mathematics and research suggests that stories (or word problems) can provide a natural schema to allow student to organize facts (Anderson, Spiro, & Anderson, 1978; Zambo, 2005). The National Reading Panel (NRP, 2000) asserts that mathematics instruction should motivate students to solve problems that are meaningful to them in setting in and outside of school, and the use of literatures provide a meaningful context to embed mathematical problems. The NRP's (2000) principle that effective mathematical instruction building on what students already know implies that stories that are written within a context familiar to students can provide a framework, or schema, that allows the students to naturally organize the information to solve the problem (Anderson et al., 1978). Pugalee (2007) suggested that stories can provide a meaningful context for students to generalize the facts and problems to typical situations in their lives. The process of following a story to solve a mathematical problem not only can provide opportunities for students to practice early literacy skills by referencing text to identify facts, but can assist in identifying the nature of the problem to be solved (Browder & Spooner, 2011). Creating real-life word problem stories to solve mathematical problems can create a linkage to their background knowledge, thus reducing their cognitive load and increasing the pace of progress and likelihood of correctly solving the problem.

To date, there has been a paucity of training for mathematical word problem solving in practical settings within the context of relevant applications to real-world activities or situations to make these skills meaningful and personally relevant. The skills need to align with appropriate standards-based grade-level content and have a positive effect on the immediate and future quality of life (Hunt, McDonnell, & Crocket, 2012). Although there are demonstrated benefits of incorporating content standards when designing mathematics instruction for students with MS/ID, current research on how to purposefully incorporate content standards is limited.

The mathematical problem solving skills that students with MS/ID typically struggle with include metacognition, executive functioning, semantic language, and working memory. To address these challenges, researchers in the field of special education have delineated strategy instruction and instructional supports for mathematical problem solving which have been shown to be effective. A literature base exists that demonstrates how developing the way students think about mathematics can be used to design instruction and teach conceptual problem solving, as well as provide the foundation for current mathematical problem solving strategies (Fennema, 1972; Fennema, Carpenter, & Peterson, 1988, 1989).

Literature on Mathematical Problem Solving

There is a considerable amount of literature on teaching functional mathematics to students with MS/ID (e.g., Browder & Grasso, 1999; Collins, 2011; Mastropieri, Bakken, & Scruggs, 1991; Xin, Grasso, DiPipi-Hoy, & Jitendra, 2005); however, empirical evidence for teaching academic mathematics directly related to NCTM's five content standards is extremely limited. There also is a crucial need to examine the NCTM standards of geometry, data analysis/probability, and algebra. The scope and sequence regarding all five of the content standards needs to be addressed, with consideration given to the significance of mathematical concept learning. Most studies addressing mathematics instruction for students with MS/ID focused on basic skills, and targeted only a few primary-level skills within each NCTM standard. It is not an expectation for student with MS/ID to master all of the skills within a standard; however, these skills should be prioritized to ensure the range of scope and sequence are integrated throughout instruction. It is possible to teach more complex problem solving skills, which still have personal relevance, through applications to real-world problems. Finally, there is a need for additional instructional strategies in mathematics to teach students with MS/ID.

Foundational research demonstrates evidence that students with MS/ID can learn number identification and counting (Lalli, Mace, Browder, & Brown, 1989; Matson & Long, 1986; Morin & Miller, 1998), geometry skills, such as matching shapes (Hitchcock & Noonan, 2000; Mackay, Soraci, Carlin, Dennis, & Strawbridge, 2002), and data analysis through recording changes in their own behavior (Blick & Test, 1987). This research provided insight regarding the development of effective instruction and the need to identify effective instructional strategies for students with MS/ID. Understanding that students with MS/ID can learn mathematics, the next step is determining what to teach and how it should be taught.

Research on problem solving aligned to the CCSSM. One of the first studies to investigate number conservation was conducted by Campbell, Gadzichowski, and Pasnak (2004) where authors studied the effects of teaching number conservation to a 21-year-old person with ASD. Authors stated the participant was identified as having a mental age commensurate with that of a 4-year-old child. Authors used a learning set of 105 mathematical problems to promote generalization, and a "fade-out" procedure was used to make mastery of the problems as easy as possible. Combination of these techniques produced the first recorded success in teaching number conservation to a person with severe disabilities. Mastery of this concept required concrete operational thought and until this study, was not thought to be possible for persons with severe disabilities. Although this study included only one adult individual, it demonstrated that individuals with MS/ID can perform at this cognitive level, and has opened the door to emerging research to determine the generality and limits of the potential of other individuals with severe cognitive disabilities in attaining mathematical skills aligned to the CCSSM.

More recently, Jimenez and Staples (2015) investigated the effect of systematic early numeracy skill instruction on grade-aligned 4th and 5th grade Common Core mathematical skill acquisition for three 4th and 5th grade students with a significant intellectual disability. Students were taught early numeracy skills (e.g., number identification, making sets to five items, simple addition) using theme based lessons, systematic prompting and feedback, manipulatives and graphic organizers. Researcher created a task analysis of four Common Core mathematics standards to identify the early numeracy skills needed to access the standard. Authors used a multiple probe across students design to examine the effects of the early numeracy instruction on the number of steps completed on each of the grade-aligned mathematical standards task analysis. The results indicated a functional relation between the early numeracy skill instruction and students independent correct responses on grade-aligned math. Although very promising with a significant contribution to the limited research in this area, there remains a need to provide mathematical concept skills beyond number identification, making sets to five items, and simple addition.

Mathematical Word Problem Instruction

Van de Walle (2004) suggested that learning to solve mathematical story problems is the basis for learning to solve real-world mathematical problems. Van de Walle (2004) noted that what students learn about mathematics depends almost entirely on the experiences teachers provide every day in the classroom and identified three key behaviors of mathematics teachers: (a) understand deeply the mathematics content they are teaching; (b) understand how students learn mathematics, including a keen awareness of the individual mathematical development of their own students and common misconceptions; and (c) select meaningful instructional tasks and generalizable strategies that enhance learning. When students understand the relationships between a situation and a context, they are going to know when to use a particular approach to solve a problem (Van de Walle, 2004; Van de Walle, Karp, & Bay-Williams, 2010).

Donlan (2007) explains that there can be numerous challenges that are characteristic of students with disabilities, such as working memory deficits, attention deficits, difficulty with language comprehension, early numeracy deficits, and difficulty with self-regulation; thus, problem solving can be very difficult for students with MS/ID. This is not to say that students with MS/ID are unable to learn problem solving; rather, they simply need sound instructional practices based on empirical research to do so. Schema-based instruction (SBI) is one method that has shown to decrease cognitive load requirements and improve problem solving in students with high incidence disabilities by teaching students to identify the underlying problem solving structure before solving the problem (Fuchs et al., 2006; Jitendra & Hoff, 1996).

Schema-based instruction to teach mathematical word problem solving. The use of SBI has demonstrated effectiveness at ameliorating these difficulties in students with learning disabilities and students who are at risk for mathematics failure (Fuchs et al., 2004; Jitendra, Dupuis, & Lein, 2014; Jitendra, et al., 2013; Powell, 2011; Xin & Zhang, 2009). A *schema* provides a framework for solving a problem (Marshall, 1995). SBI systematically and explicitly teaches a number of strategies to scaffold students' learning (Jitendra & Star, 2011). SBI is composed of four critical elements: (a) identifying the underlying problem structure to determine problem type (e.g., change, group, or compare); (b) use of visual representations (e.g., schematic diagrams) to organize the information from the problem that represents the underlying structure of the problem type; (c) explicit instruction on the schema-based problem-solving heuristic (problem schema identification, representation, planning, and solution); and (d) metacognitive strategy knowledge instruction, which includes activities like analyzing the problem, self-monitoring of strategy use, and checking the outcome (Griffin & Jitendra, 2009; Jitendra et al., 2013; Powell, 2011). SBI relieves the dependency on working memory and helps students visually map out the problem structure in order to solve problems successfully. In addition, it offers students strategies to solve a variety of problems with an appropriate amount of flexibility, while monitoring the process of problem solving.

The SBI approach to problem solving has been shown to be much more effective than the direct-translation strategy, commonly known as the “key word strategy.” The key word strategy teaches students to find the numbers, key words, and solve the problem; however, it often misleads students and results in systematic errors (Hegarty, Mayer, & Monk, 1995; Jitendra & Star, 2011; Jitendra & Xin, 1997). The conceptual understanding of word problem solving, which requires comprehending the action language and referential meaning, especially as problems get more complex, shows the need for SBI over traditional approaches, such as the key word strategy.

A study by Rockwell, Griffin, and Jones (2011) was pivotal in the development of the present study. The study investigated the effects of SBI on word problem solving of three problem types (i.e., group, change, and compare) on a fourth grade female student with autism and mild ID using a multiple probe across behaviors (problem types) design. The student was explicitly taught to discriminate problem types using schematic diagrams and to solve the addition and subtraction word problems using the mnemonic "RUNS" (i.e., "Read the problem," "Use a Diagram," "Number sentence," and "State the answer"). Scripted lessons, based on a direct instruction approach, were used for each instructional session. Two dependent variables were measured, including practice sheets which were used as a formative assessment during training phases to guide the pace of instruction, and problem-solving probes which were used to measure treatment effects. For all practice sheets and probes, the problem situations had unknowns in the final position and no extraneous information was included. Generalization probes measured the student's ability to solve problems with unknowns in the initial and medial position. Results showed that the student was able to achieve perfect scores (6 out of 6 possible points) across all three problem types. The participating student met mastery during generalization for two of three problem types, but failed to reach mastery in one change problem probe due to a calculation error. The student also was able to maintain the skill with perfect scores for group and change problems and averaged 5 out of 6 possible points for compare problems. Rockwell (2012) replicated Rockwell et al. (2011) study with two male students with ASD (7-year-old; 2-year-old) with the findings being similar for both students. Each achieved perfect scores (6 out of 6 possible points) for all three problem types. One student continued to have perfect scores in both generalization and maintenance phases, and the other student continued to have a perfect score during generalization but fell slightly during the 8-week follow-up period. Clearly, this instructional methodology was effective; however, more research on mathematical problem solving is needed to include students with MS/ID to determine its effectiveness with this population as well.

Research on SBI for students with moderate ID. Only one published study to date has used SBI to teach problem solving to a student with moderate ID. Neef et al. (2003) used a multiple baseline across behaviors design to teach a 19-year-old man with an IQ of 46 to solve change-addition and change-subtraction problems by teaching pre-current behaviors, which included teaching the student to identify component parts of the word problem, including the initial set, the change set, key words to identify the operation, and the resulting set. In addition to identifying the components, the student learned to fill out a schematic diagram with the information from the problem. Teaching pre-current behaviors was successful in yielding accurate current behaviors (correct solutions) as the student increased the number of correct solutions from a mean of 1.2 to 8.0 out of 10 possible points. This study only included one participant with a moderate ID and only addressed one problem type (change).

Research on modified SBI for students with ASD and MS/ID. Three recent studies that have investigated the use of SBI to teach problem solving to students with ASD and MS/ID have demonstrated that it is effective for this population when additional supports are provided (Root et al., 2015; Saunders, 2014; Spooner, Saunders, et al., 2015). Understanding that students with MS/ID may lack the reading skills to independently access the word problem and the computational fluency to solve the problem, an instructional package was developed to address this challenge. First, Saunders (2014) investigated the effects of modified SBI delivered through computer-based video instruction (CBVI) on the acquisition of mathematical problem solving skills, as well as the ability to discriminate problem type, to three elementary-aged students with ASD and moderate ID using a single-case multiple probe across participants design. The study also examined participant's ability to generalize skills to a paper-and-pencil format. Results showed a functional relation between modified SBI delivered through CBVI and the participants' mathematical word problem solving skills, ability to discriminate problem type, and generalization to novel problems in paper-and-pencil format. The findings of these studies provide several implications for practice using systematic instruction combined with modified SBI and other evidence-based practices to teach higher order mathematical content to students with MS/ID. Next, Root et al. (2015) taught three male elementary students with ASD and moderate ID to solve *compare* problems through SBI with both virtual and concrete graphic organizers and manipulatives. All three students mastered solving compare problems, with a demonstrated higher rate of learning during the virtual condition for two of the students and indicated a preference for the virtual condition for all three students. Both studies utilized technology to provide an alternate means of access to the text (e.g., student controlled read-aloud) and learning materials (e.g., virtual graphic organizers and manipulatives). Both studies expanded the SBI research by including students with ASD and showed that students with ASD can master problem solving using a graphic organizer, TA, and LIP. The students were able to maintain their skills and generalize to novel problem types through SBI; however, neither of these studies addressed students with MS/ID or the use of peers to deliver instruction.

Finally, Spooner, Saunders, et al. (2015) used a multiple-probe across participants design for three middle school aged students with MS/ID to investigate the effects of real-life simulated video modeling on the *change* problem type for mathematical word problem solving. This study's purpose was to teach students to recognize the underlying structures in mathematical problem solving using real-life video simulations that can be easily generalized to situations students will encounter in everyday life. Students were presented with real-life video simulations to solve a variety of mathematical problems that relate to activities in which they may engage outside of the school setting and solve using a finger-counting strategy. The videos modeled real-life mathematical simulations based on a variety of thematic units, such as: (a) pet store, (b) grocery store, (c) household chores, (d) sporting goods store, (e) outside chores, and (f) thrift store. This study included two types of videos: a model video in which actors model solving real life problem using the method described; and the other where the video sets up the context, but requires the student to solve the problem. The results of this study demonstrated a change in level and trend from baseline to intervention for all three students. This study was effective in delineating an effective method for students with MS/ID to solve mathematical problem solving; however, it did not investigate the use of peers to deliver instruction.

Summary of Teaching Mathematical Problem Solving to Students with MS/ID

Recent studies have shown that students with MS/ID can learn grade aligned academic content based on academic standards through the use of evidence-based practices (Browder et al., 2007, 2008; Collins, 2007; Fuchs & Fuchs, 2007; Fuchs, Fuchs, Finelli et al., 2004; McDonnell, 1987; McDonnell & Ferguson, 1989). With this in mind, we must also remember that federal legislation requires schools to report adequate yearly progress (AYP) in reading/language arts and mathematics for all students, including those with MS/ID who participate in alternate assessments aligned with grade level content standards (NCLB, 2006). Moreover, the Individuals with Disabilities Education Act

(IDEA, 2004) requires all students have access to the general curriculum. Special educators need effective and practical strategies for teaching general education mathematical content to students with MS/ID while making the content relevant and meaningful. Systematic instruction through SBI can be a viable approach to provide special educators with the methodology to provide successful instruction in mathematical problem solving. Although the literature shows great promise for using systematic instruction to deliver mathematical problem solving concept instruction to students with ASD, mathematical problem solving instruction for students with MS/ID remains an area that has been untouched. One solution would be to utilize peers to deliver SBI with systematic instruction to teach mathematical problem solving to students with MS/ID.

Using Peer-mediated Instruction for Academic Instruction

The impact of peer interaction on the lives of adolescents with MS/ID is essential as interaction with general education peers may play a role in academic, functional, and social skill development, as well as contribute to increased social competence, attainment of educational goals, friendship development, and enhanced quality of life (Carter & Hughes, 2005). Within the context of peer relationships, adolescents practice and refine social skills; access support systems, shared activities, and companionship; and learn peer norms and values (e.g., Hartup & Stevens, 1999; Rubin, Bukowski, & Parker, 1998). Typically, adolescents spend proportionately more of their time with their peers as they get older, intensifying the influence of peer interaction on adolescent development (Hartup & Stevens, 1999).

Peer support arrangements involve inviting one or more peers to provide social and/or academic support to a classmate with a severe disability while receiving supervision and guidance from one or more adults (Carter & Kennedy, 2006; Carter, Cushing, & Kennedy, 2009). The literature on teaching students with MS/ID is primarily based on the use of one-to-one adult-delivered supports (Giangreco, Halvorsen, Doyle, & Broer, 2004). Giangreco and Broer (2007) point out the potential repercussions of using individually assigned paraprofessionals to support inclusion at the secondary level. The level of support provided by adults in the classroom can compete with the goals of social and academic inclusion by impeding student learning and growth (Carter & Kennedy, 2006). To alleviate this issue, the well-researched use of classroom peers can be an effective strategy. Currently, there is an emerging body of literature to support peer-mediated instruction as an evidence-based strategy to assist students with MS/ID within the general education classroom with social and academic outcomes (Carter & Kennedy, 2006; Carter, Sisco, Melekoglu, & Kurkowski, 2007; Cushing, Clark, Carter, & Kennedy, 2005).

Literature on Peer-mediated Instruction

The research base for using peer-mediated instruction spans nearly 50 years and convincingly demonstrates that this strategy is effective (Cloward, 1967; Cohen, Kulik, & Kulik, 1982; Jimenez et al., 2012; Scruggs, Mastropieri, & Marshak, 2012). Frequently, the strategy peers have been trained to implement is constant time delay (CTD) prompting (Miracle et al., 2001; Wolery, Werts, Snyder, & Coldwell, 1994). The use of CTD procedures to teach students with severe disabilities has shown to be effective, easy to implement, and more efficient than other errorless strategies (Browder et al., 2009; Schuster, Morse, Ault, Crawford, & Wolery, 1998) for training discrete skills. Research has been conducted teaching peers to use CTD to instruct students with disabilities to identify sight word vocabulary (Miracle et al., 2001; Wolery et al., 1994); generalize the reading of cooking labels (Collins, Branson, & Hall, 1995), and prepare food (Godsey, Schuster, Lingo, Collins, & Kleinert, 2008). In 1994, Wolery et al. investigated the effect of a CTD procedure delivered by peers in an inclusive elementary school classroom. The CTD procedure was found to be effective in promoting positive learning outcomes for students with moderate ID. Additionally, peers were able to implement the procedure with high procedural fidelity. Although CTD has been demonstrated to be an effective strategy for teaching discrete skills, training peers to use a task analysis to provide instruction for a chained task (e.g., mathematical word problem solving) to students with MS/ID has very limited research.

When leveraging resources, educators are faced with the challenge of meeting student needs and often use adult-delivered support (e.g., paraprofessionals, teacher aides) and/or peer-delivered support to provide the instructional support students with MS/ID may need. To evaluate the effectiveness of each, Shukla, Kennedy, and Cushing, 1999) compared the effects of peer-delivered versus adult-delivered support on the social interaction of participants with moderate to profound intellectual disabilities and their general education peers. In the peer-delivered support condition, general education peers adapted assignments, provided systematic instruction related to Individualized Education Program (IEP) goals, facilitated socialization with classmates, implemented behavior support plans, and sat next to the participant, all under the supervision of the special educator. In the adult-delivered support condition, the special educator, rather than a general education peer, engaged in these activities. The peer-delivered support condition was associated with more frequent and longer durations of social interaction than the adult-delivered support condition. Moreover, Shukla et al. (1999) showed that a greater variety of social support behaviors were exhibited during the peer-delivered support condition.

Social benefits of using peer-mediated instruction. The evidence of effective interventions to increase social interaction among adolescents with MS/ID can be clearly seen in the comprehensive review of literature conducted by Carter and Hughes (2005). Authors sought to extend the literature by synthesizing empirical investigations between 1975 and 2004. As the first comprehensive review to examine the efficacy of interventions directed at increasing social interaction among adolescents with ID and their general education peers in secondary schools, authors aimed to delineate effective interventions and offer recommendations for future research and practice. A total of 26 articles meeting criteria were included for review and analysis to produce a systematic and detailed methodological review of this literature. Each of the included articles was coded and analyzed using the following variables: (a) intervention components and primary results, (b) participant characteristics, (c) school settings and contextual variables, (d) measures of social interaction, (e) observation procedures and measurement reliability, (f) experimental design, and (g) additional measures (i.e., generalization, social validity, treatment integrity). Authors found that although both skill-based and support-based interventions were effective at increasing peer interaction with participants with a range of level of intellectual disabilities (i.e., mild to profound), differential effects were reported for several types of interventions. Though collateral skill instruction and peer training interventions increased social interaction across a range of participants, communication book instruction, social interaction skill instruction, and peer support arrangements were demonstrated to be effective primarily among participants with severe intellectual disabilities. The effectiveness of general education participation and assigning roles to general education peers primarily was demonstrated with participants with severe to profound intellectual disability. Self-management interventions were found to be effective predominantly with participants with moderate intellectual disability, although these students also were reported to have secondary disabilities and engage in significant challenging behaviors (e.g., aggression, self-injurious behavior, destruction). Instructional groupings were primarily evaluated with adolescents with mild intellectual disability, with only one study (Cushing, Kennedy, Shukla, Davis, & Meyer, 1997) that demonstrated the impact of these groupings with students with MS/ID. Almost all of the reviewed interventions were highly successful at producing substantial increases in participants' social interaction behaviors, suggesting that these interventions constitute powerful tools for dramatically improving social outcomes. Authors suggest that as a result of this literature review, when considering whether to employ a given type of intervention, educators should consider its appropriateness in light of relevant student needs and characteristics (e.g., communication book interventions for students with concomitant communication deficits, assigning social rather than tutoring roles for students who have few friendships), as well as the intervention's appropriateness for the school setting (e.g., collateral skill instruction delivered in nonacademic settings, instructional groupings established in academic classrooms). Although this review provided much needed information regarding the importance of using peer-mediated instruction for social skill building, there were no studies that met quality indicators in using peers to deliver academic instruction. Much of the research included students with mild/moderate disability demonstrating a lack of empirical investigations for students with MS/ID. There also was a lack of reported generalizations regarding the appropriateness of an intervention for students with certain characteristics should be treated as tentative pending systematic replication to make the use of peers to deliver academic content a sustainable practice.

More recently, Carter et al. (2007) conducted an investigation aimed at improving social and academic outcomes for high school students with severe disabilities in core academic classrooms. Understanding the need for additional research to promote successful peer interactions, researchers also investigated the secondary effects of student academic engagement. Using a delayed multiple baseline across participants design with four peer support students and four high school students with MS/ ID, a 1-min time sampling procedure was implemented to collect data on engagement over a 14-week period. Resulted demonstrated that the use of peer supports increased the social interactions and academic engagement of the students with MS/ID.

Benefits of peer-mediated instruction to teach academics. Early literature demonstrates that peer-mediated instruction has been effective in teaching academic skills to students with MS/ID. In one of the first studies to use peer-mediated instruction, Kamps et al. (1989) used peers as the primary teacher and the classroom teacher as a supervisor. Researchers used a multiple baseline design across tasks to evaluate the effects of peer-delivered instruction on academic learning (i.e., money skills, expressive language, and oral reading/comprehension skills) of students with autism. Two elementary students with autism (aged 9 and 11 years; IQs of 50) and two students without disabilities from the fifth grade participated in the study. Tutors received extensive training on teaching the tasks (i.e., twelve 30-min tutoring sessions occurred followed by individual tutoring sessions) and demonstrated successful performance in training before tutoring. Tutors were allowed to select the activities that correlated to the targeted skills from a planned list, and allowed to decide when to provide models, prompts, feedback and consequences. The tutoring sessions occurred three times a week for 30 min within the special education classroom (i.e., 20 min teaching followed by 10 min social time). Kamps et al. (1989) found that students with autism learned academic skills from peers and peer tutors allowed more academic instructional time for students with autism. Limitations of the study included the great amount of time invested in training the peer tutors, the separate setting used for peer-delivered intervention, and the lack of connection to grade-level core academic content.

McDonnell, Thorson, Allen, and Mathot-Buckner (2000) studied the effects of partner learning during spelling for students with severe disabilities and their peers. Using a multiple baseline across subjects design, the effects of partner learning on the spelling performance, academic responding, and competing behavior of three students with severe disabilities and three of their classmates without disabilities was examined. Students attended two elementary schools, where members of three different grade-level classes were enrolled in different general elementary classes. Students were assigned to partner learning triads by their general education teacher with one triad in each class that included the student with severe disabilities and two classmates without disabilities. All students in the class received two, 20-min partner learning sessions each week where each member of the triad was asked to spell words, present words to be spelled, provide feedback to the speller, and check the spelling accuracy. The roles of the tutors (students without disabilities) and tutees (students with disabilities) were rotated among the triad following each trial with adaptations made as necessary to accommodate the academic and communication skills of the students with severe disabilities. Partner learning on spelling accuracy was assessed through weekly spelling tests and partner learning on academic responding and competing behavior were assessed using the MS-CISSAR (Carta, Greenwood, Schulte, Arreaga-Mayer, & Terry, 1988). Results of weekly spelling tests indicated that partner learning led to improved spelling accuracy for students with severe disabilities and did not negatively affect the spelling accuracy of their peers. Partner learning also led to improved rates of academic responding and reduced rates of competing behavior for five of the six students. The authors also noted that the tutors spelling accuracy did not increase as they already had near perfect spelling scores; however, they did not go down either and this is important as many general and special education teachers had expressed their concerns that the use of peer tutors that are intended to support the needs of students with severe disabilities in general education classes may negatively impact the tutors scores, as well as reduce the quality of the educational services that tutees receive. These findings suggest just the opposite and support the use of peer tutors in the general education classroom for students with severe disabilities.

In a corresponding study to the previous one, McDonnell, Mathot-Buckner, Thorson, and Fister (2001) investigated the effects of three elements including classwide peer tutoring, multi-element curriculum, and accommodations on the academic responding and competing behaviors of three students with severe disabilities. The multi-element curriculum included a pre-algebra class for student 1, a physical education class for student 2, and a history class for student 3. The accommodations were tailored to address the individual needs of each student with disabilities. The participants included three students with MS/ID that served as the tutees, three students without disabilities to serve as tutors, one special education teacher, and three general education teachers. To determine the effectiveness of classwide peer tutoring program on the academic responding, competing behaviors, and performance on weekly subject-area posttests of three peers without disabilities who were enrolled in the same classes, were also examined. The primary dependent measures included the levels of academic responding and competing behaviors of students with MS/ID (tutees) and their peers without disabilities (tutors). Weekly post-test scores on the content presented by the general education teachers also were collected and reported. A multiple probe across students design was used to show that the package increased rates of academic responding and reduced rates of competing behaviors for the three students with MS/ID. The findings suggested that a classwide peer tutoring program combined with a multi-element curriculum and accommodations improved rates of academic responding and reduced rates of competing behavior for two of the three peers without disabilities. The weekly post-test scores suggested that the tutors (peers without disabilities) also benefitted academically from the class wide peer tutoring program. Although benefits were reported for both the tutors and tutees, the generalization and sustainability of using peers to deliver classwide academic instruction cannot be determined. The participating teachers agreed to collaborate under the support of the researchers, but it was undeterminable if this procedure could be replicated in another school, or if the teachers sustained the practice beyond the study.

Peer-mediated instruction to teach chained tasks. In the first inclusive study to investigate a chained task, Collins, Branson, Hall, and Rankin (2001) evaluated the least intrusive prompting system (LIPS) in combination with a task analysis on letter writing for students with moderate disabilities in a secondary composition class. Four components of letter writing (i.e., date, greeting, body, and closing) were taught using an 11-step task analysis and LIPS. Collins et al. (2001) found that the general education teacher and the peer tutors were able to implement the LIPS with a task analysis to effectively teach students with MS/ID to write letters. The training took between 7-26 sessions and together the general education teacher and peers were able to implement the LIPS with a task analysis intervention effectively.

In a more recent study, Godsey et al. (2008) included peers to teach a chained task. Using a multiple probe across subjects and behaviors design, the researchers evaluated the effects of a peer-delivered constant time delay (CTD) intervention in combination with task analyses on food preparation for secondary students with moderate ID. Four male students aged 15, 16, 17, 20 years old with moderate ID participated in this investigation. In addition to moderate ID, one student in this study also had a diagnosis of Down syndrome, and another moderate hearing impairment and severe visual impairment. Eleven students (two male, nine female; aged 16-18 years) enrolled in the same high school participated as the peer tutors. The peer tutors received two 90-min training sessions in which the tutors learned to implement the CTD procedure and to record student responses. Peers were required to demonstrate accurate data collection, perform the steps of the intervention with at least 90% accuracy, and score at least 90% correct on a written test to participate. One peer failed to meet criteria for participation.

Peer tutors delivered the intervention in pairs, alternating between prompter and data collector. Peers also collected reliability data on the independent and dependent variables. Food preparation task analyses included making a milkshake (27 steps), grilled cheese sandwich (32 steps), toaster waffle (27 steps), and frozen orange juice (25 steps). The first session was conducted at 0-s delay; all others at 5-s delay and was scored based on the number of correct steps completed on the task analysis. Results indicated all students learned to prepare all chained food tasks and maintained skills up to 22 sessions after meeting criterion and peer tutors generalized the skills acquired during training across different students and different tasks within the cooking curricular area with chained tasks. Peer tutors reliably implemented CTD procedures for chained task instruction using a task analysis; however, they failed to consistently deliver descriptive verbal praise after correct responses (Collins et al., 1995; Jameson et al., 2008). A limitation of this research was that two peer tutors were needed to deliver the intervention. Although this study showed that peer-delivered instruction can be used to teach a chained-task, its primary focus was not specifically on academics.

Peer-mediated instruction using CTD. Jimenez et al. (2012) conducted an investigation to examine the effects of peer-mediated time-delay instruction to teach inquiry science and use of a knowledge chart to students with moderate intellectual disability in an inclusive setting. Participants included six general education peers and five students with moderate ID. The general education peers (tutors) implemented an embedded constant time-delay procedure during three science units. Using a CTD procedure, students with moderate ID learned to self-direct the use of a knowledge chart (i.e., K = what do you Know; W = What do you want to know; H = How will you find out; L = what did you Learn; KWHL) across lessons and science units through peer-mediated instruction within the general education science classroom. The general education students (tutors) were trained on the peer-mediated instructional method through a 1-hr training workshop where they were trained to (a) embed a minimum of three learning trials per each science response (two science words, two science pictures, two word/picture matches, two concept statements) using CTD, and (b) embed trials to self-monitor science behaviors using a KWHL chart. The peers (tutors) used a checklist to self-monitor trials given to students with moderate ID (tutees), checking off each trial as they embedded it during the lesson. The peers (tutors) were assessed for procedural fidelity during the training on implementation of the time-delay procedure and use of the self-monitoring checklist. Results demonstrated that all five students with moderate ID (tutees) increased the number of correct science responses across all science units. Three of the students required additional support by the special education teacher to reach mastery; however, all six peers were able to implement the intervention with high fidelity, while maintaining science grades at pre-intervention levels. High levels of social validity were reported by all participants and this study has great promise for replication to other academic areas, including mathematics.

Peer-mediated instruction using LIPS. In 2014, Hudson et al. conducted an investigation to evaluate the effects of using a peer-delivered system of least prompts package and read-alouds of adapted fourth grade science and social studies chapters to teach comprehension. Participants included two students with moderate ID, and one student with moderate ID and severe physical impairments (i.e., student used a wheelchair for ambulation and a yes/no response on an eye gaze board for communication). Two peer tutors delivered scripted lessons individually to students (tutees) during literacy workshop in the general education classroom. The peer tutor scripts contained the SLP intervention embedded within a read-aloud of the adapted science or social studies chapter that was currently being taught to students without disabilities in the fourth grade class. At predetermined points in the read-aloud, the peer stopped to ask one of six comprehension questions created for the chapter. Four questions required students to recall a fact from the page just read (i.e., literal recall) and two questions required inference (i.e., the answer required additional information from the student). To support students' responding of inferential questions, the prompts contained "think alouds" that modeled for students how to arrive at a correct response when the answer was not directly stated on the page. Students were given opportunities to ask for help after each question and received more information each time they did so (i.e., system of least prompts), as well as a six-item response board and the adapted academic chapter to support their responding.

Results demonstrated that over the four different science lessons given during the intervention, all participants (tutees) increased the number of points earned for correct responses from the first day of intervention to the intermittent probe sessions. This study adds to the growing number of experimental studies that demonstrate the effectiveness of peer-delivered instruction for teaching academics to students with MS/ID in a general education classroom setting. It also adds to the research supporting the use of shared story reading to anchor instruction and background knowledge. A third promising skill that emerged from this study is that students with MS/ID can learn to direct the amount of assistance they receive during instruction and can monitor their own independent correct responses therefore increasing their independence and self-determination skills. This study validates the use of peer-mediated instruction to deliver instruction to students with MS/ID; it did not address teaching chained tasks or the use of a task analysis to further promote self-monitoring.

Summary of Using Peer-mediated Instruction for Academic Instruction

Increases in academic engagement as a result of using peer-mediated instruction are promising and lend researchers to further investigate how to increase engagement as it is a prerequisite for learning, and is highly correlated with improved academic achievement (Carter & Kennedy, 2006). It has been well-documented that peer support interventions improve the academic engagement and social interactions of participating students (e.g., Carter, Moss, Hoffman, Chung, & Sisco, 2011; Cushing & Kennedy, 1997; Shukla et al., 1999). Given the current emphasis on documenting students' progress in relation to grade-level content standards, however, demonstrating that peer-mediated instruction interventions can actually enhance students' academic performance, as well as increase knowledge and skill acquisition, remains a critical need to be explored. Although these studies add to the small body of research that uses peer-mediated instruction to teach academic skills to students with MS/ID, there continues to be a need for further research. No studies to date have used systematic instruction in combination with SBI and graphic organizers delivered by peers to teach mathematical problem solving to students with MS/ID. If students with MS/ID are ever going to be transportable to an inclusive setting, there must be alternate modes to deliver instruction aside from the use of adults/teachers. The use of peers to deliver instruction can serve as a catalyst to move students with MS/ID towards inclusion. Investigating the specific strategies to deliver the instruction using peers (e.g., task analysis combined with LIPS) to teach chained tasks, specifically mathematical problem solving, to students with MS/ID remains a critical need to be investigated.

Summary of Review of the Literature

The overarching goal for all students is mathematical competence, including those with MS/ID. The Individuals with Disabilities Improvement Education Act (IDEA, 2004) is a momentous piece of federal legislation requires that students with disabilities are to be taught alongside their peers without disabilities to the greatest extent possible. Additionally, the No Child Left Behind Act (NCLB, 2006) set a precedent that established even higher expectations for all students, including those with disability. Schools are now required to annually test all students to monitor their academic progress and all students must meet the adequate yearly progress (AYP) standards. This has placed increased demands on teachers to meet these higher expectations in all academic areas. The NCTM standards and the CCSSM emphasize the importance of teaching mathematical problem solving to *all* students, as this is a pivotal skill that directly influences a student's ability to solve real-world mathematical problems. Mathematical problem solving is life skill that all students must have to be successful in life and can provide more opportunities to students with MS/ID. In addition to being an important life skill, mathematical problem solving is a foundational skill that can be applied across all standards of mathematics. Browder, Jimenez, and Trela (2012) found that by combining the use of mathematics story to provide students with an opportunity to solve real-world problems, systematic instruction of a task analysis of a mathematical problem, students could solve problems related to algebra, data analysis, measurement and geometry. With this in mind, mathematical content for students with MS/ID should be a priority skill as it addresses the need to teach academic content in a personally relevant context (Courtade, Lingo, Karp, & Whitney, 2013).

Research shows that students with MS/ID can learn mathematics, but more research is needed that links to the NCTM standards and the CCSSM (Browder et al., 2008). Systematic instruction with prompt fading procedures, such as constant time delay and least intrusive prompts have been identified as evidence-based practices for teaching mathematics to students with MS/ID (Browder et al., 2008). The majority of mathematical research for students with MS/ID has focused on functional mathematical skills, such as time and money, or on simple skills, like number identification. Few studies have touched on using higher level mathematical thinking, such as problem solving, for this population.

There have been several strategies used to teach problem solving to students with high incidence disabilities. One such strategy is SBI, which has a strong literature base (Gersten et al., 2009). Only one study to date has examined the effects of SBI on teaching problem solving to one student with moderate ID (Neef et al., 2003), and two additional studies have examined the effects of SBI on teaching mathematical problem solving to students with ASD (Root et al., 2015; Saunders, 2014). More high quality research is needed to demonstrate the effectiveness of systematic instruction and SBI with students with MS/ID, as well as generalizable modes of delivery, such as using peer-delivered instruction.

Research on using peer-mediated instruction spans nearly 50 years and clearly demonstrates that using peers to deliver instruction is an effective strategy (Cloward, 1967; Cohen et al., 1982; Jimenez et al., 2012; Scruggs et al., 2012). Research has been conducted that involved teaching peers to use CTD to instruct students with disabilities to identify sight word vocabulary (Miracle et al., 2001; Wolery et al., 1994); and to generalize the reading of cooking labels (Collins et al., 1995), and prepare food (Godsey et al., 2008). In 1994, Wolery et al. investigated the effect of a CTD procedure delivered by peers in an inclusive elementary school classroom. The CTD procedure was found to be effective in promoting positive learning outcomes for students with moderate ID. The success of peer-mediated instruction may be attributed to instructional components that include social interactions, frequent opportunities to respond, increased time on task, and regular and immediate feedback. Research has shown positive social effects for students with mild ID using peer-mediated instruction across subjects such as literacy or reading (Oddo, Barnett, Hawkins, & Musti-Rao, 2010), social studies (Lo & Cartledge, 2004), science (Bowman-Perrott, Greenwood, & Tapia, 2007), and mathematics (Allsopp, 1997; Calhoon & Fuchs, 2003; Hawkins, Musti-Rao, Hughes, Berry, & McGuire, 2009). Although this research base provides evidence that student outcomes are better with the use of peer-mediated instruction, only two recent studies included students with MS/ID with one in reading (Hudson et al., 2014), and one in science (Jimenez et al., 2012). Currently, there is no literature on the use of peer-mediated instruction to teach mathematical problem solving to students with MS/ID. If students with MS/ID are ever going to be transportable to an inclusive setting, there must be alternate modes to deliver instruction aside from the use of adults/teachers. The use of peers to deliver instruction can serve as a catalyst to move students with MS/ID towards inclusion.

The current study is believed to be the first to demonstrate how to successfully use evidence-based teaching methods (i.e., task analytic instruction, total task presentation, LIPS, peer-mediated instruction, and modified SBI instruction) to teach mathematical problem solving for students with MS/ID. Currently, the use of SBI for students with ASD and/or MS/ID to learn mathematical word problem solving is just emerging (Root et al., 2015; Saunders, 2014; Spooner, Saunders, et al., 2015). There currently are no studies that have investigated the use of peer-delivered SBI instruction to teach mathematical problem solving to students with MS/ID. For this reason, this investigation provided what is believed to be the first study to examine the use of peer-mediated instruction to teach mathematical problem solving to students with MS/ID. This study is significant in that it served to demonstrate that students with MS/ID have the capacity to learn mathematics within a general education context with peer-supports, when given the opportunity.

CHAPTER 3: METHODOLOGY

The purpose of this study was to investigate the effects of peer-mediated schema based instruction on the number of correct steps of a task analysis to solve the *change* problem type of mathematical word problems with middle school students with MS/ID during peer-tutor delivered instruction. An additional purpose of this study was to determine the effects of peer-mediated schema based instruction on the number of correct mathematical problems solved with MS/ID. This study also examined the peer-tutees ability to discriminate between addition and subtraction in word problems for the *change* problem type. Additionally, this study sought to determine if peer-tutees are able to generalize the learned mathematical skills to unfamiliar peers. Finally, this study investigated the effects of peer-mediated instruction on both tutor and tutees social attitudes and perceptions of one another before and after the study's completion.

Participants

Students with disabilities (peer tutees). Four students with moderate/severe disabilities were recruited to participate in this study. To participate, students met the following criteria: (a) identified as having a moderate/severe intellectual disability (IQ of 55 or below); (b) assigned to middle school (6^{th}-8^{th} grade); (c) received special education services with an active individualized education program (IEP); (d) maintained consistent attendance (i.e., absent no more than two times per month); (e) had a clear response mode; and (f) had the required prerequisite early numeracy skills, including identifying numerals 1-10 in random order, counting with one-to-one correspondence, creating sets up to 10 objects, and rote counting numbers up to 10.

The special education teacher nominated the students based on these criteria. The experimenter verified the student characteristics by reviewing school cumulative records for criteria (a) through (e).

After parental consent and student assent were obtained, student nominees were administered a prescreening measure. The prescreening measure assessed the participants' ability to (a) receptively and expressively identify numerals up to 10, (b) make sets of numbers 1 to 10, (c) count with one-to-one correspondence, (d) copy one- and two-word phrases, and (e) solve one-step word problems. The experimenter administered the prescreening measure in a one-on-one format. The experimenter presented materials to the participant, such as a graphic organizer with a single large oval and manipulatives (e.g., counting cubes). The experimenter modeled how to perform the behavior (e.g., "My turn. I am going to make a set of four. 1, 2, 3, 4") and then asked the participant to perform a similar behavior (e.g., "Your turn. Make a set of 3"). All skills were modeled first to ensure errors were due to skill deficits, rather than receptive language errors. The prescreening took approximately 5 min to administer per participant. A participant achieved satisfactory performance on prescreening measure to continue with participation if he or she completed items (a) to (d) with 100% accuracy and item (e) with no more than 25% accuracy. Characteristics of the peer tutees are listed in Table 1. The students' age, gender, grade, range of disability, and ethnicity are reported.

Table 1: Characteristics of peer tutees

Student (Tutee)*	Age	Gender	Grade	IQ	Disability	Ethnicity
(*All names are pseudo-names)				*Full Scale*		
Marcus	12	Male	6th	55 (WISC-IV)	Mod ID, ASD, ADHD	African American
Carrie	13	Female	7th	48 (WISC-IV)	Mod ID	Caucasian
James	13	Male	7th	51 (DAS-III)	Mod ID, Williams Syndrome	Caucasian
Maria	14	Female	6th	46 (UNIT)	Mod/Severe ID	Hispanic

WISC-IV = Wechsler Intelligence Scale for Children- Fourth Ed., DAS-III = Differential Ability Scales- Third Ed., UNIT = Universal Nonverbal Intelligence Scale.

Marcus. Marcus was a 12-year-old African American male in the sixth grade diagnosed with moderate ID, Autism Spectrum Disorder (ASD), and attention deficit hyperactivity disorder (ADHD). Marcus was diagnosed in the 2nd grade by clinicians while he resided in Ohio. According to his most recent evaluation data, Marcus had a full scale cognitive intellectual quotient of 55 on the Wechsler Intelligence Scale for Children- Fourth Edition (WISC-4; Wechsler, 2003). Marcus was given the Wechsler Individual Achievement Test-Third Edition (WIAT-III, Wechsler, 2009) as an educational evaluation and received a 54 (0.1%ile) in Mathematical Problem Solving, 40 (<0.1%ile) in Numerical Operations, 48 (<0.1%ile) in Mathematical Fluency-Addition, and a 67 (0.5%ile) in Word Reading with an overall academic function rated as significantly below the average range in all areas measured. His most recent Individual Education Program (IEP) stated that he is able to identify numbers 1-10 with 100% accuracy and had emerging basic addition skills. Marcus had an IEP goal of independently adding a set of single digit mathematical problems. Marcus received all of his academic instruction from a special education teacher in a self-contained classroom. He attended lunch, music, and physical education with the other students in the self-contained classroom and non-disabled peers. Marcus was provided the *Unique Learning System* curriculum (N2y, 2015) instruction curriculum for all academic areas, including mathematics. Marcus did not receive any related services.

Carrie. Carrie was a 13-year-old Caucasian female in the seventh grade diagnosed with moderate ID. No formal disability determination was reported for Carrie. According to her most recent evaluation data, Carrie had a full scale cognitive IQ of 48 on the WISC-4 (Wechsler, 2003). Carrie was given the Woodcock-Johnson Third Edition (WJIII; Woodcock, McGrew, & Mather, 2007) Tests of Academic Achievement as an educational evaluation and received a 35 in Broad Mathematics, and a 36 in Basic Reading Skills. Her IEP stated that in the areas of broad reading, broad mathematics, mathematical calculations skills, brief mathematics, and Carrie's scores were all in the very low range (grade equivalent between kindergarten and 1st grade) with no actual scores reported. Her most recent IEP stated that she is able to identify numbers 1-10 with 100% accuracy and had emerging basic addition skills. Carrie had an IEP goal of independently adding a set of single digit mathematical problems. Carrie received all of her academic instruction from a special education teacher in a self-contained classroom. She attended lunch, music, and physical education with the other students in the self-contained classroom and non-disabled peers. Carrie was provided the *Unique Learning System* curriculum (N2y, 2015) instruction curriculum for all academic areas, including mathematics. Carrie did not receive any related services.

James. James was a 13-year-old Caucasian male in the seventh grade diagnosed with Williams Syndrome and moderate ID. James' diagnosis of Williams Syndrome occurred at birth and the physicians report noted that James would have significant developmental delays throughout his life and those diagnosed with this syndrome have a cognitive ability (IQ) that has a range of 41-80. According to his most recent evaluation data, James had a full scale cognitive IQ of 51 (0.1%ile; very low range) on the Differential Ability Scales-Second Edition (DAS-II; Elliot, 2007). James was given the Woodcock-Johnson Third Edition (WJIII; Woodcock, McGrew, & Mather, 2007) Tests of Academic Achievement as an educational evaluation and received a 13 in Mathematical Calculation Skills, a 41 in Mathematical Reasoning, and a 32 in Basic Reading Skills. Broad Mathematics, and a 36 in Basic Reading Skills. It was noted that both his academic skills and his ability to apply those skills was within the very low range (pre-kindergarten to 1st grade) and no actual scores were reported. His most recent IEP stated that he was able to read some basic sight words and answer basic "wh" questions after having them read aloud to him. James was able to add single digit equations with the use of manipulatives, could match some coins and bills but was unable to demonstrate purchasing items using the next dollar method. James had IEP goals of independently subtracting a set of single digit mathematical problems, and to accurately use the next dollar method to make purchases. James received all of his academic instruction from a special education teacher in a self-contained classroom. He attended lunch, music, and physical education with the other students in the self-contained classroom and non-disabled peers. James was provided the *Unique Learning System* curriculum (N2y, 2015) instruction curriculum for all academic areas, including mathematics. James did not receive any related services.

Maria. Maria was a 14-year-old Hispanic female in the sixth grade diagnosed with moderate ID. No formal disability determination was reported for Maria. Her IEP showed she was born in Honduras and he mother noted that she had developmental delays since birth and no formal diagnosis was made by a physician. Her mother reported that Maria did not speak until she was 3-years old, and was not toilet trained until she was 4-years old. According to her most recent evaluation data, Maria was given the WISC-4 (Wechsler, 2003) and her full scale score for that assessment could not be calculated as scores of zero were given on many subtests. Maria was given the Universal Nonverbal Intelligence Scale (UNIT, McCallum, 2003) and received a full scale score of 46, very low range. Maria was given the given the Wechsler Individual Achievement Test-Third Edition (WIAT-III, Wechsler, 2009) as an educational evaluation and evaluators were unable to obtain a composite score for Maria in any academic area. Informal assessments were administered to assess her basic skills, and Maria was able to identify three letters of the alphabet and three colors. She had difficulty identifying numbers up to 10, but was able to identify basic body parts and one shape (square) and no standardized scores reported. Her most recent IEP stated that she was now able to identify numbers 1-10 with 100% accuracy and had emerging basic addition skills. Maria had an IEP goal of independently adding a set of single digit mathematical problems. Maria received all of her academic instruction from a special education teacher in a self-contained classroom. She attended lunch, music, and physical education with the other students in the self-contained classroom and non-disabled peers. Maria was provided the *Unique Learning System* curriculum (N2y, 2015) instruction curriculum for all academic areas, including mathematics. Maria received speech and occupational therapy services.

Students without disabilities (peer tutors). Five students without disabilities were selected to participate as peer tutors in this study. To participate in the study, students met the following criteria: (a) was a middle school student enrolled in a general education mathematics course without a diagnosed disability, (b) received grades at or above a B level in mathematics, (c) consistent attendance with absence no more than two times per month, (d) agreed to be trained and to serve as a peer tutor, and (e) meeting fidelity criteria in training, (f) attend the same middle school as the students with MS/ID, and (g) returned student assent and parental consent. The students were nominated by the Honors Program mathematics teacher. Once student assents and parental consents were obtained, the nominated students were given a prescreening measure by the experimenter that consisted of (a) an ability to read aloud and follow the task analysis for the change problem type, (b) ability to read aloud and follow a scripted lesson exactly as it is written, and (c) ability to solve 10 of 10 mathematical problems of the change problem type with 100% accuracy. The experimenter selected five peer tutors from the pool of students, based on highest scores on the prescreening measure, who met all inclusion criteria. Four peer tutors were selected to be assigned to the peer tutees with a fifth peer tutor serving as a substitute should the assigned peer be absent. The male peer tutors were assigned to the male peer tutees and the female tutors were assigned to the female tutees. The genders were reversed for the unfamiliar peer generalization measure. Characteristics of peer tutors are listed in Table 2. The students' age, gender, grade, GPA, honors courses, and ethnicity are reported.

Table 2: Characteristics of peer tutors

Student (Tutor)*	Age	Gender	Grade	GPA	Honors Courses	Ethnicity
(*All names are pseudo-names)						
Alex	12	Male	6th	3.84	Honors Mathematics	Caucasian
Juan	11	Male	6th	3.97	Honors Mathematics Honors ELA**	Hispanic
Janya	11	Female	6th	3.86	Honors Mathematics Honors ELA**	Asian Indian
Brittany	11	Female	6th	3.57	Honors Mathematics	African American
Amanda*	12	Female	6th	3.29	Honors Mathematics Honors ELA**	Hispanic

*Amanda served as the substitute peer. ** ELA = English Language Arts.

Setting

This study took place in a public middle school in an urban school district in the southeast United States. The school served 780 students in grades six to eight with a student population comprised of 38% African American, 28% White, 28% Hispanic, and 6% from other nationalities. Approximately 10% of the students were enrolled in at least one honors course, with many of those students being enrolled in a full honors program, which is more than double the state average. The school was categorized as economically disadvantaged, meaning the entire school qualifies for free/reduced lunch.

Each participant with disabilities received all of his or her academic instruction in core content areas from a special education teacher. Intervention sessions were conducted in the media room/teacher work room adjacent from the center-based classroom. Peer tutors attended and stayed in the room during the 45-min time frame for every session as this was their Academic and Enhancement (A&E) period, similar to a study-hall. The peer tutees would only stay during their intervention session. The media room/teacher work room had two long tables parallel to one another, and a teacher desk, white boards, projector and projector screen, and a variety of other technology and supplies in cabinets and on counters around the room. The peer tutors sat in male pairs at one table and female pairs at another table with the substitute peer tutor sitting at the teacher desk. The peer tutee would sit with his/her respective assigned peer tutor grouping for instruction. The experimenter conducted all peer tutor training in this room and all peer tutor/tutee sessions took place in this room. The experimenter served as the trainer and collected all data using the data collection instrument across all conditions.

Materials

Materials for this study included were developed by a research team at the University of North Carolina at Charlotte for The Solutions Project, IES Grant # R324A130001. The research team was comprised of Principal Investigator, Diane Browder, Ph.D., Co-PI, Fred Spooner, Ph.D., Co-PI, Ya-yu Lo, Ph.D., Research Associate/Project Coordinator, Alicia Saunders, Ph.D., and Graduate Research

Assistants, Jenny Root, M.Ed., and Luann Ley Davis, MA-SNC. This study addressed one of the goals of The Solutions Project, which was measuring the degree to which students can generalize learning word problem solving through the use of peer-mediated instruction. The scripted lessons were developed based on the SBI work done by Jitendra and colleagues (1996, 2002, 2008), Neef et al. (2003), and Rockwell and colleagues (2011, 2012), as well as the research on teaching mathematics to students with moderate/severe ID (Browder et al., 2008; Browder et al., 2013).

Materials used for this study included scripted lessons, graphic organizers, a problem solving mat, task analysis, manipulatives (e.g., counters), dry-erase markers, word problems for change addition and change subtraction, as well as procedural fidelity, interobserver agreement, and task analysis data collection sheets. A pre- and post-assessment instrument (KeyMath3 Numeracy subtest; Connolly, 2015) was used as a distal measure, as well as pre- and post-attitudes and perspectives surveys.

Mathematical word problem solving delivered through peer-mediated instruction for students with MS/ID consisted of several critical features, including task analytic instruction, read alouds, rules, graphic organizers, concrete manipulatives, and formulated mathematical word problems of the *change* problem type. First, the complex skill of arithmetic problem solving was taught through task analytic instruction; steps for solving a word problem were broken down into 10 sequential steps. These steps were taught through a forward chaining total task procedure. Table 3 describes each step of the task analysis and the expected student response.

Table 3: Steps in the task analystic instruction and expected student response

Step of Task Analysis	Expected Student Response
1. Read the problem	Peer tutee read problem aloud or requested peer tutor to read aloud.
2. Find the "what"	Tutee circled the two nouns with pictures over them.
3. Find the label in question	Tutee underlined the noun in the question and wrote label (generalization) in blank of number sentence.
4. Use my rule	Stated chant with hand gestures that corresponded to the *change* problem type.
5. Circle the numbers	Tutee circled numbers in word problem
6. Fill-in number sentence	Tutee filled-in numbers in boxes on number sentence
7. + or -	Tutee determined if problem was addition or subtraction and wrote symbol in circle on number sentence.
8. Make sets	Tutee used concrete manipulatives to make sets on graphic organizer.
9. Solve	Tutee solved problem by counting total/remaining manipulatives.
10. Write and say answer	Tutee wrote number into last box on number sentence and read entire numerical problem aloud to tutor.

Task analysis. Task analytic instruction was used in place of a heuristic, such as *RUNS* (Rockwell et al., 2011) or *FOPS* (Jitendra, 2008), which is traditionally found in SBI, as an evidence-based practice for teaching mathematics to students with learning disabilities. Memorizing a heuristic may overload the working memory of individuals with MS/ID, and students may not have enough literacy skills (e.g., semantic barriers) to relate the letters of the heuristic to the words for which each letter stands. As a result, the task analysis was presented in a self-monitoring checklist, referred to as the "student self-instruction sheet," and the participants followed the sheet and checked off each step as they completed each step during the instruction. Pictures were paired with each step to support emerging readers. Figure 2 presents a screen shot of the student self-instruction sheet with the 10-step task analysis.

1.			Read the problem
2.		horses	Circle the "what"
3.		How many ___?	Find label in question
4.			Use my rule
5.		3	Circle the numbers
6.			Fill-in number sentence
7.			+ or -
8.			Make Sets
9.			Solve
10.			Write and Say Answer

Figure 2: Student self-instruction checklist.

Read alouds. Read alouds were used to address reading deficits of the participants in this study. Peer tutees could ask the peer tutor to read aloud the entire word problem, and/or read aloud the steps of the student self-instruction checklist if needed.

Rules. Rules were developed to describe the key components of the problem structure in order to teach problem schema identification in a concrete manner. A chant was used to help each participant remember the rule, and hand motions representing the schema for each problem type were paired with the chant. The *change* problem type hand motion and chant was performed by holding up the left pointer finger and saying “one” and quickly flipping over left palm so it faced up and simultaneously saying “thing,” then pretending to pick up counters from upper right of left palm and placing on left palm with right hand while saying “add to it,” followed by pretending to remove counters from left palm and discard to lower right of left palm with right hand and saying “OR take away,” and finally moving left palm in a left to right motion and saying “change.” The accompanying hand motions could be performed directly over the graphic organizers to help the peer tutees relate the problem structure to the schema. The chant and hand motions were taught to the peer tutees by the peer tutors in a model-lead-test format at the start of Phase I.

Graphic organizers. Graphic organizers were developed to provide a visual organization of the mathematical problem. Figure 3 shows a screenshots of the graphic organizer used for this study. The change graphic organizer includes a space (starting amount) where peer tutees would place the number of manipulatives that corresponded with the number written in the intital position of the number sentence. Additional counters would be placed in the addition sign on the graphic organizer to provide a visual of *adding more* to the starting amount. To subtract, the peer tutee would pull manipulatives from the starting amount and move them to the visual of the trash can to represent *taking away*, or subtracting from the starting amount. The peer tutee would then move the remaining manipulatives into the final circle that represented a *change* from the starting amount.

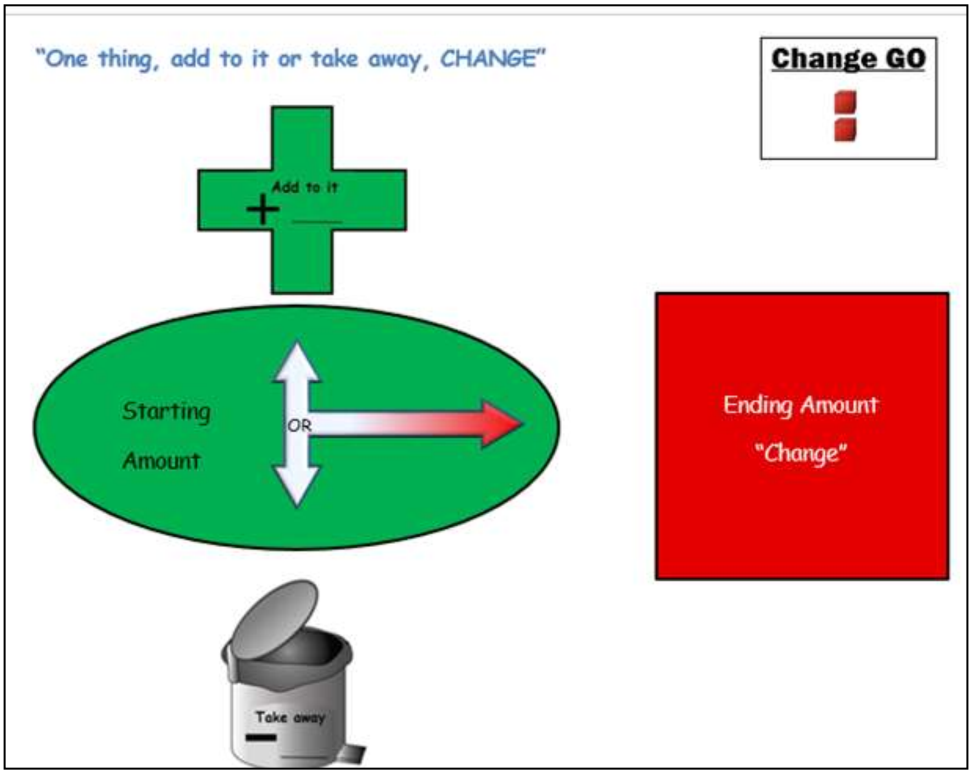

Figure 3: Graphic organizer for the *change* problem type

Story grammar instruction and story mapping. Steps 2-4 of the task analysis consisted of explicitly teaching story grammar instruction and story mapping, including "find the what," "find the label in the question," and "use my rule," in for the *change* problem type. Story grammar instruction and story mapping were used to teach peer tutees how to determine (discriminate) if the problem was addition or subtraction.

Figure 4 shows the screen shot of the problem solving mat that peer tutees used to organize their mathematical word problems, and graphic organizer. It includes a specific area with boxes for the peer tutees to write in the numbers, a circle for the operation (+/-), and a blank space where the peer tutees wrote the lable from the problem.

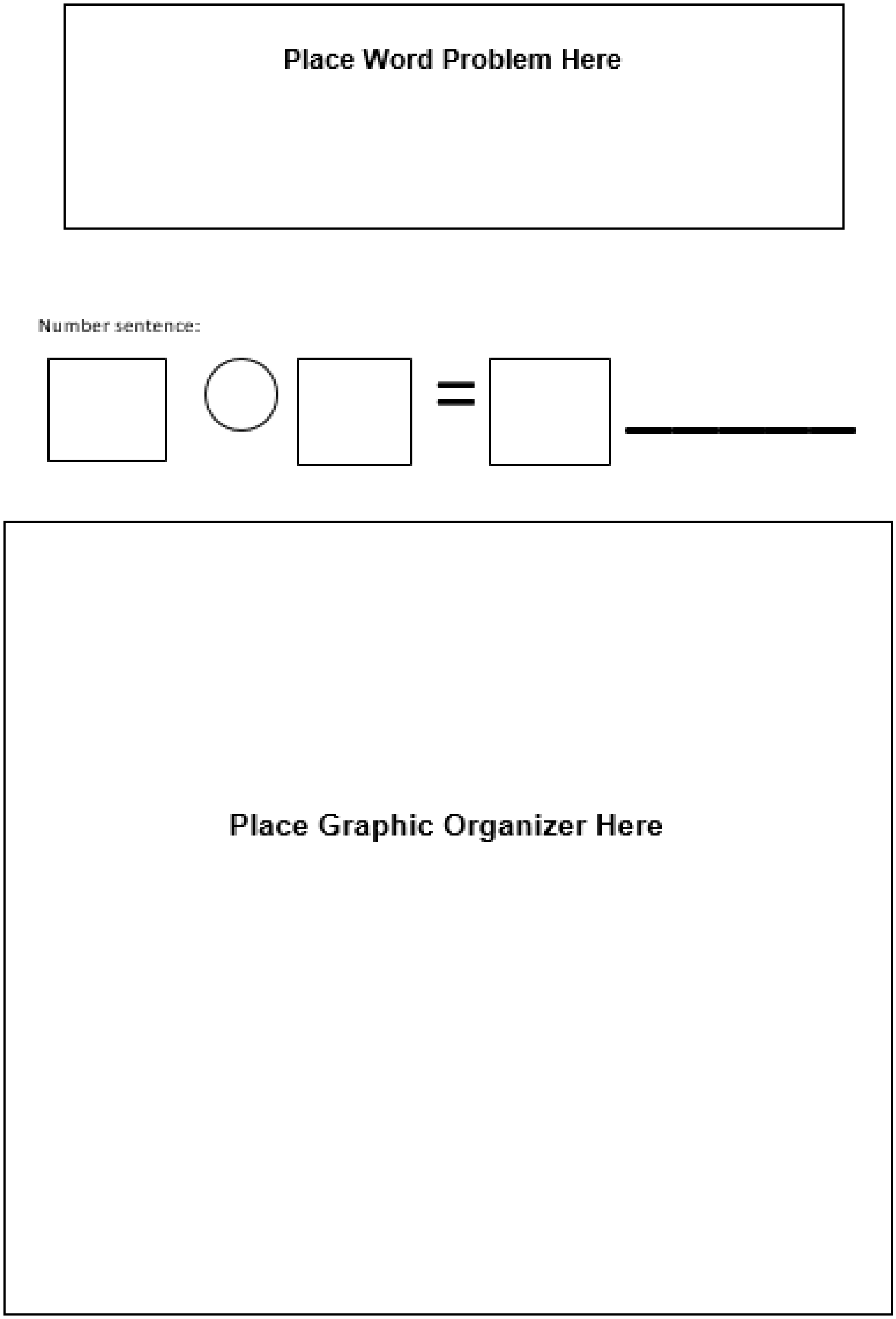

Figure 4: Problem solving mat

Content validity. Accuracy of the assessment and measurement materials (e.g., story based mathematical problems, task analysis, graphic organizer) were evaluated by a mathematical content expert to ensure the constructs included in this study are accurately assessing what the experimenter was measuring. Content validity of all materials (including the story based mathematical problems) have been previously verified and validated by a mathematical content expert with experience in both general and special education during the first year of the main Solutions Project study. The expert has evaluated and provided feedback on the scripted lessons, formulas for writing word problems, and graphic organizers. The mathematics expert also validated the scripted lessons and reviewed a sample change problem type lesson. In addition, the mathematics expert validated the accuracy of the formulas for writing word problems used to develop the word problems in this study.

Daily instruction. All students involved in the investigation received mathematical instruction in the special education classroom from the *Unique Learning System* curriculum (N2Y, 2014) for mathematics instruction. During all conditions, the special education teacher continued their mathematics lessons through teacher-made mathematics lessons and those downloaded from the Unique Learning System (N2Y, 2014) for mathematics, but did not teach any word problem solving throughout the duration of this study.

Experimenter and Interventionists

The experimenter is a doctoral student at a local university with a total of 16 years teaching experience working with students with MS/ID. The experimenter was the primary trainer and data collector. The peer tutors were trained to implement the intervention over a period of 2 consecutive days during their Academic and Exploration (A & E) time, which is similar to a study hall. The peer tutors served as the interventionists. The experimenter collected all data across all conditions and collected procedural fidelity on the peer tutors implementation procedures. The experimenter directed all sessions, managed all student sessions, collected all data, provided in-vivo feedback to peer tutors as they delivered instruction, and held post-session discussions after each session. A second doctoral student collected interobserver agreement for a minimum of 30% of all sessions across all conditions and phases.

Experimental Design

This study was a single-case, multiple probe design across four peer tutees (Gast & Ledford, 2014; R. D. Horner & Baer, 1978; Tawney & Gast, 1984). This design allows the experimenter to (a) analyze the effectiveness of the intervention based on the discrepancy between baseline and intervention data across participants, and (b) intermittently collect baseline data for verification purpose, thus minimizing participants' frustration and familiarity with materials prior to entering the intervention phase. The implementation of the design adhered to the criteria established by the What Works Clearinghouse (WWC, Kratochwill et al., 2010, 2013). The study consisted of three conditions: baseline, intervention, and maintenance. The intervention condition included three phases: Phase I, Change Addition (CA): Phase II, Change Subtraction (CS): and Phase III, Change Mixed (CM; randomly alternating equal number of CA and CS problems). Data were collected on the primary dependent variable of the total number of steps of the task analysis performed correctly each session. Additionally, the total number of problems solved correctly per session, and the total number of discriminations between addition and subtraction performed correctly during Phase III of the intervention condition and during maintenance were both graphed cumulatively. The effectiveness of the independent variable on the dependent variables was determined through visual analysis of the graph of the primary dependent variable and established through a functional relation (Cooper et al., 2007; Gast & Ledford, 2014; Johnston & Pennypacker, 1980, 2008). A minimum of five data points were collected in baseline with no problem solving instruction, prompting, or feedback. Once a stable or decreasing trend is demonstrated, the participant with the lowest baseline mean and the most stable baseline data path was the first to enter intervention, CA Phase I. The mastery criterion for each student to move from one condition to the next (e.g., baseline to intervention; intervention to maintenance) was the peer tutee correctly solving both of the problems independently for two consecutive sessions. Once mastery was reached in Phase III of the intervention condition, students moved into the maintenance condition. Data were collected following each peer tutees mastery of a phase within the intervention condition to determine the peer tutees ability to generalize his/her skills by solving two novel/unfamiliar mathematical word problems (one CA and one CS) presented by an unfamiliar peer (a peer tutor of the opposite gender). Generalization data were collected by the experimenter using the same data collection instrument used during the intervention and was graphed cumulatively.

Dependent Variables

The primary dependent variable in this study was the number of steps of a task analysis completed independently correct for solving mathematical word problems of the *change* problem type. The data collected from the primary dependent variable were used to make decisions for changing phases and conditions. There also were three additional variables that were graphed cumulatively: (a) the total number of mathematical word problems solved correctly each session, (c) the total number of correct discriminations each session between addition and subtraction during Phase III of the intervention and maintenance conditions, and (d) the total number of steps of a task analysis completed independently correct for solving mathematical word problems of the *change* problem type presented by an unfamiliar peer tutor (peer tutor of the opposite gender) as a generalization measure.

Primary dependent variable. The primary dependent variable was measured across all experimental conditions (e.g., baseline, intervention, maintenance) and was defined as each student's independent correct responses for items on the task analysis that comprise the steps to solve the change problem type mathematical word problems. The task analysis offered 20 opportunities for the peer tutee to respond (10 responses for two problems) and was adapted from a template used in Saunders (2014) study to teach mathematical word problems. This study served to build on the previous study on mathematical word problem solving and adapted them specifically for the change problem type. The task analysis included opportunities to: (a) read the problem (or ask the tutor to read the problem); (b) find the "what" in the word problem (circle the nouns); (c) find the label in the question (underline the label); (d) use the change problem type rule (state and act out the rule to solve change problems); (e) circle the numbers in the initial and change sets (circles the numbers in word problem); (f) fill-in the numbers in the number sentence (writes numeral in the number sentence); (g) decide if the problem is addition or subtraction and fill in the applicable sign (e.g., + or -); (h) make sets (use manipulatives on the graphic organizer to represent the numbers in the word problem); (i) solve (student pushes the ending amount of manipulatives into the final circle on the graphic organizer and counts them for a total), and (j) write the answer (student writes their final number and gestures to or states the number and label). The student was presented with all materials, given one of two mathematical problems at a time, and asked to solve the problem. A data collection sheet was used to collect observational data on student responses (see Appendix B). Students received a / for each independent correct response for each step of the task analysis. The total number of correct responses were circled and totaled at the bottom of the data collection sheet. An x was used to indicate correct discrimination between addition and subtraction with the total included at the bottom of the data collection sheet. The total number of independent correct responses for each session was graphed and analyzed visually. Mastery criteria for the primary dependent variable was set at the student correctly solving (e.g., student writes their final number and gestures to or states the correct number and label) for both problems for 2 consecutive days. Once mastery is reached in each phase of the intervention condition, the student received a generalization probe presented by an unfamiliar peer of the opposite gender and moved to the next phase in the intervention condition. Three additional variables were graphed cumulatively.

The first was total number of mathematical word problems solved correctly each session, with two possible per session. The experimenter totaled the number of mathematical word problems solved on the primary variable data collection sheet by counting the number of correct problems solved, and graph the daily total cumulatively (see Appendix B). There were a total of two possible correct problems the peer tutee could have solved each session. Data were collected and graphed cumulatively for each session for all conditions (e.g., baseline, intervention, maintenance) for each tutee.

Secondary dependent variables. A secondary dependent variable was the total number of correct discriminations between addition and subtraction each session starting at Phase III of the intervention condition and continued through maintenance conditions. Exhibiting the ability to discriminate between +/- demonstrates a conceptual understanding of the underlying composition of mathematical word problems (Siegler & Shrager, 1984). An x on the data collection sheet was used to indicate the number of correct discriminations between addition and subtraction with the total for each session included at the bottom of the data collection sheet (see Appendix B). The experimenter totaled the number of correct discriminations between addition and subtraction on the primary dependent variable data collection sheet by counting the number of correct discriminations, and graph the totals for each session cumulatively. There was a total of two possible correct discriminations that could be made each session during Phase III and maintenance. Data were collected and graphed cumulatively for each session for all conditions (e.g., baseline, intervention, maintenance) for each tutee.

A generalization measure was used to determine if tutees could generalize their mathematical problem solving skills to an unfamiliar peer tutor (e.g., a trained peer tutor that is *not* the tutees primary tutor, and was the opposite gender). Generalization probes were given one time following mastery of each condition and a minimum of one time during maintenance. During baseline, all peers were unfamiliar to the peer tutees during that condition, negating a need to probe generalization during baseline. The unfamiliar peer tutor presented the tutee with two mathematical problems and asked the tutee to solve the problems independently (without peer tutor support) to determine if tutees can generalize their mastered skills to being paired with an unfamiliar peer tutor. Tutees were presented with two mathematical problems of the change problem type (e.g., one CA and one CS in varied orders) and were presented one at a time. The format for presentation replicated the same exact procedures used for the primary dependent variable. The experimenter collected all data on the generalization to an unfamiliar peer on the data collection sheet where the total number of problems solved correctly were added together for each generalization probe and graphed cumulatively (see Appendix B).

Data Collection

The instruments included a task analysis of the steps to complete a mathematical word problem of the change problem type, a procedural fidelity (PF) checklist, and an interobserver agreement (IOA) data collection checklist. Using the data collection instruments, the experimenter collected all data across all phases and participants. The experimenter trained the peer tutors to deliver instruction using an explicit script. The experimenter recorded each step of the task analysis during each session as an independent correct or incorrect response (e.g., a / for correct, no mark for incorrect) and then totaled the sum (e.g., 15/20 steps completed independently correct). The data collected consists of the number of correct steps using tutor support that the tutee can independently follow on a task analysis (all sessions in all conditions), the number of correct discriminations between addition and subtraction (step 7 on the task analysis; intervention Phase III and maintenance condition only), and the number of correctly solved problems each session. There was a total of two mathematical problems to solve each session for a total of 20 possible points for the steps correct on the task analysis, two discriminations (for intervention phase III and maintenance conditions only), and two correctly solved problems. The experimenter collected all baseline data, the pre and post assessments, the distal measure, as well as the pre and post perception and attitude surveys. Procedural fidelity on the peer tutors accuracy while delivering instruction was taken by the experimenter. Interobserver agreement of student responses was collected by a second doctoral student and was calculated using a point-by-point method in which number of agreements were divided by the number of agreements plus disagreements and multiplied by 100. The peer tutors were administered the student/peer attitude survey by the experimenter during the peer training session, and the peer tutees were administered the student/peer attitude survey by the experimenter prior to the administration of the pre-distal measure.

Procedures

The intervention consisted three conditions (a) baseline, (b) intervention (which included three phases), and (c) maintenance. The three phases of intervention are: Phase I, Change Addition (CA): Phase II, Change Subtraction (CS): and Phase III, Change Mixed (CM; randomly alternating equal number of CA and CS problems). Maintenance probes were given following mastery of Phase III of the intervention condition. The intervention also included peer tutor training and a generalization measure. Peer tutor training took place prior to baseline data collection by the experimenter. Generalization probes were given following mastery of each of the phases during the intervention condition. Each session included two mathematical word problems of the *change* problem type.

Peer tutor training and baseline. During this condition, the peer tutors received training on how to introduce the problem type, the graphic organizer, and how to deliver instruction. This training took place prior to baseline data being collected. Peers were trained by the experimenter, a model, lead, test strategy was used to ensure peer tutor mastery of the instructional procedures. The experimenter collected procedural fidelity data on the tutor, and a second doctoral student collected IOA on the tutee and the experimenter to ensure that all peers have mastered delivering instruction with mastery criteria set at 100%. Due to the nature of single-case design using a multiple probe across participants, only one peer tutor group delivered instruction immediately following training/baseline. There was a delay in peer tutors entering intervention with his/her tutee, therefore, to ensure that all tutors retain their training and instructional fidelity, the remaining tutors were provided a booster training session by the experimenter immediately prior to them starting intervention.

During baseline, the experimenter collected a minimum of three data points and the peer tutors collected one baseline data point each, for a minimum of five data points total in baseline. During baseline the peer tutee was presented with four mathematical problems of the change problem type (e.g., two CA, two CS) and all instructional materials. The tutee received the prompt, "*Today we are going to solve some mathematical word problems.*" The instructor (experimenter or peer tutee) then held out the four mathematical word problems in front of the peer tutee and asked them to choose one to ensure randomization of problem selection. The peer tutee had all other materials (e.g., task analysis, graphic organizer, manipulatives, problem solving mat) and was given the cue "*Show me how to solve this problem.*" The experimenter recorded any steps on the data collection sheet the student responded to correctly with no specific praise or feedback. If the student responded incorrectly, the instructor (experimenter or tutor) provided no prompts or feedback, removed the first problem and asked the peer tutee to select the second problem, presented it to the peer tutee, and provided the cue "*Show me how to solve this problem.*" Again, the experimenter recorded any correct responses with no specific praise or feedback. Should the student not respond at all following presentation of the mathematical word problem during baseline, the instructor waited for 5s, the problem was removed, and a 'no response' on the data collection sheet was recorded with a (0) correct for that problem. This process was repeated for the remaining mathematical word problems. After all four mathematical word problems were presented, the baseline session concluded. The peer tutee who demonstrated the most need with the most stable baseline was selected to enter intervention first, and subsequent peer tutees entered intervention based on the same criteria following the first tutee reaching mastery of Phase I of the intervention condition. To ensure that the peer tutees responses were not correlated to the experimenter delivering the intervention, the peer tutors collected one baseline data point each by following the exact baseline procedures the experimenter conducted, resulting in a minimum of five data points total (e.g., three conducted by the experimenter, one by each of two tutors) in baseline for all four peer tutees. The experimenter collected a minimum of three baseline data points for each peer tutee, and each peer tutor collected one data point for a total of five baseline data points, with no less than one baseline data point collected every eight sessions for the remaining peer tutees.

Peer tutor training. Prior to baseline and intervention, five general education middle school peers were selected to participate in the intervention based on the eligibility criteria stated above. Prior to baseline, the peer tutors received training from the experimenter until all five peer tutors had 100% procedural fidelity. The tutors were trained to fidelity to (a) follow a task analysis for the change problem type, (b) provide instruction by using model-lead-test procedure, and (c) provide the least intrusive prompting system (LIPS) to remediate errors made by the tutee. The experimenter trained the peer tutors as a group in the media center/teacher work room using the scripted lessons, and all study materials. Using explicit instruction with a model-lead-test format, the experimenter provided explicit scripts for each peer tutor and modeled correct procedures in delivering instruction. Then, the peer tutors each practiced by delivering the intervention to the experimenter with explicit feedback (lead). The peer tutors then took turns delivering the intervention to one another while the experimenter observed, provided feedback, and collected procedural fidelity on each peer tutor. Any peer tutor who did not have 100% procedural fidelity was immediately retrained. The tutors who demonstrate the strongest delivery of instruction were assigned to their respective same-gender peer tutee. The fifth peer tutor served as an alternate/substitute and was used to deliver the intervention when the assigned peer tutor was absent. Each peer tutee was paired with two peer tutors of the same gender that alternated in delivering instruction. This allowed for one peer tutor to always be present should one be absent. Due to the nature of single-case design using a multiple probe across participants, only one peer tutor pair delivered instruction immediately following training/baseline. There was a delay in peer tutors entering intervention with his/her tutee, therefore, to ensure that all peer tutors retained their training and instructional fidelity, the remaining tutors were provided a booster training session by the experimenter immediately prior to them starting intervention. The experimenter was responsible for recording each step of the task analysis during each session as an independent correct or incorrect response, and then totaled the sum (e.g., 15/20 steps completed independently correct).

Introduction of change problem type. To introduce the change problem type, the peer tutor delivered the prompt "*Today we are going to learn about math word problems! The kind of problem we are going to learn about is called a change problem, can you say change" Student responds, "Change*!" Then the tutor said "*Change problems have a starting amount of something, then we change it somehow,* *and we get an ending amount. Change problems always talk about one thing, the same thing. Change problems can change in two ways, we either add to the starting amount to change it, or we take away from the starting amount to change it. Change problems can be addition or subtraction problems. We have a rule to help us remember what a change problem is. Are you ready*?" The rule for the change problem type is 'one thing, add to it, or take away, and change.' The peer tutor then performed the hand motions for change problem with the chant. The peer tutor held up his/her pointing finger as if signaling number one, quickly flipped his/her hand over and held up their left palm and said "*one thing*," then using their right hand and pretending as though s/he is putting things on their left palm using fingers they then said "*add to it*," followed by a reverse motion by pretending to remove things from left palm using right hand and said "*take away*," and finally would slide their left palm from left to right and said "*change*." The tutor then used model-lead-test to practice the change rule with the chant and gestures until the tutee was able to demonstrate the chant and gestures independently. If the tutee is nonverbal or has limited verbal skills, he/she was allowed to perform the hand motions while the tutor stated the chant.

Introduction of graphic organizer. The tutor pointed to the tutees change graphic organizer and said, "*Here is a graphic organizer to help us solve change word problems.*" Then the tutor described the change graphic organizer (e.g., starting amount circle, addition sign, subtraction trash can, ending *change* area) and make the connection to the hand gestures and chant by saying, "*Just like the rule says*- (tutor points to first oval) *the first oval is the starting amount for our one 'one thing*' (tutor holds up pointer finger to signal the number one and then flips their palm over above the beginning oval), *we either 'add to it*' (tutor uses right hand and pretends like s/he is picking up things from the storage box and placing them on their left palm), *or 'take away' from it* (tutor pretends to remove things from left palm using right hand and placing things in the trash can, then the tutor would move their hand across the arrow to the 'end' oval) *and change! Your turn. Show the rule using the graphic organizer.*" The tutor then waited for the tutee response and repeated as necessary until the tutee was able to independently perform the chant and hand motions with the change graphic organizer.

Baseline. During baseline, the experimenter collected a minimum of three data points and the assigned peer tutors collected one baseline data point each, for a minimum of five data points total in baseline. The experimenter presented the peer tutee with four mathematical problems of the change problem type (e.g., two CA, two CS) and all instructional materials. The tutee received the prompt, "*Today we are going to solve some mathematical word problems.*" The experimenter then held out the four mathematical word problems in front of the tutee and asked the tutee to choose a problem to ensure randomization of problem selection. The mathematical word problem was then laid in front of the tutee with all the other materials (e.g., task analysis, graphic organizer, manipulatives, problem solving mat) and provide the cue "*Show me how to solve this problem.*" The experimenter recorded any steps on the data collection sheet the student responded to correctly with no specific praise or feedback. If the tutee responded incorrectly the experimenter provided no prompts or feedback, removed the first problem, and asked the tutee to select another problem.

The tutee was provided the prompt “*Show me how to solve this problem.*” Again, the experimenter recorded any correct responses with no specific praise or feedback. This process continued until all four problems were presented to the tutee and the baseline session concluded. If the tutee did not respond at all following presentation of the mathematical word problem during baseline, the experimenter waited for 5-s, the problem was then removed, the student was asked to select another problem, and a ‘no response’ on the data collection sheet was recorded with a (0) correct for that problem.

To ensure that the tutees responses were not correlated to the experimenter delivering the prompts, the assigned peer tutors each collected a minimum of one baseline data point each by following the exact baseline procedures the experimenter conducted, resulting in a minimum of five data points total (e.g., three conducted by the experimenter, one by each of two tutors). The baseline procedure was replicated by the peer tutors when they delivered the baseline mathematical word problems. The peer tutor presented four mathematical word problems of the change problem type (e.g., two CA, two CS) and all instructional materials. The tutor then gave the tutee the prompt, “*Today we are going to solve some mathematical word problems.*” The tutor then held out the four mathematical word problems in front of the tutee and asked the tutee to choose a problem to ensure randomization of problem selection. The mathematical word problem was then laid in front of the tutee with all the other materials (e.g., task analysis, graphic organizer, manipulatives, problem solving mat) and provide the cue “*Show me how to solve this problem.*” The experimenter recorded any steps on the data collection sheet the student responded to correctly with no specific praise or feedback. If the student responded incorrectly the peer tutor provided no prompts or feedback, removed the first problem, and asked the tutee to select another problem. The tutee was given the prompt "*Show me how to solve this problem.*" Again, the experimenter recorded any correct responses with no specific praise or feedback. This process continued until all four problems were presented to the tutee by the tutor and the baseline session concluded. If the tutee did not respond at all following presentation of the mathematical word problem during baseline, the tutor waited for 5s, the problem was then removed, the tutee was asked to select another problem, and a 'no response' on the data collection sheet was recorded with a (0) correct for that problem by the experimenter.

The tutee demonstrating the most need with the most stable baseline entered intervention first, and subsequent tutees entered intervention based on the same criteria following the first tutee reaching mastery of Phase I of the intervention condition. The experimenter collected a minimum of three baseline data points for each tutee, and a minimum of two baseline points for each of the peer tutor delivered baseline sessions, with no less than one baseline data point collected every eight sessions for all remaining peer tutees. Data were graphed and visually analyzed following each session. Tutees were administered the student/peer attitude survey by the experimenter following baseline and prior to intervention.

Intervention Condition Phase I: Change addition. During this phase, tutors provided tutees instruction on mathematical problem solving of the change problem type. The same procedures described within this section were followed for all phases within the intervention condition. Tutees received story grammar instruction and story mapping through the use of their self-directed task analysis and graphic organizers. Steps 2-5 of the task analysis consisted of explicitly teaching story grammar instruction and story mapping, including “find the what,” “find the label in the question,” “use my rule,” and “find how many.” The peer tutee was taught to analyze the text, locate the structural features used, and determine if the problem was addition or subtraction. Fifteen themes with six corresponding word problems were developed for *change problem types* in order to align with the principles of contextual mathematics (Bottage & Hasselbring, 1993; Bottge, Rueda, Grant, Stephens, & Laroque, 2010; Saunders, 2014), to offer variation and maintain interest of students while repeatedly practicing the same skill (Browder et al., 2013), and to promote generalization through teaching sufficient examples (Cooper et al., 2007; Stokes & Baer, 1977). The procedures and mathematical word problems used for this study are adapted from The Solutions Project (funded by the U.S. Department of Education, Institute of Education Sciences [IES] #R324A130001) and Saunders (2014). The adaptations to Saunders (2014) include (a) middle school students with MS/ID, (b) the use of peers to deliver instruction, (c) modifying the task analysis student self-instruction sheet to include only steps critical to the present study (e.g., only of the change problem type), (d) modifications to the change problem type graphic organizer to include directive text written directly on the graphic organizer (e.g., “starting amount;” “one thing, add to it or take away, change” written on the colored circles as well as at the top of the page), an arrow that points in three directions with gradient coloring to indicate direction, the omission of the cabinet icon, and large plus and minus signs over the ‘add’ icon and the ‘subtract’ trash can icon, (e) the use of an unfamiliar peer to deliver instruction specific to the change problem type to evaluate generalization of acquired skills.

Change addition training. The first two sessions in Phase I consisted of the assigned peer tutors each taking a turn modeling how to solve a change addition problem. The tutor-tutee trio was seated beside each other with both the tutee and the two tutors having their own word problem solving mat, graphic organizer, student self-instruction checklist, change word problems, and dry erase markers set up in front of them. The first peer tutor introduced the *change* problem type by modeling the chant and hand gestures for the change problem type "*one thing, add to it or take away, change.*" The first peer tutor then modeled reading the student self-instruction checklist and how to perform each step. The first peer tutor read the first step, modeled how to perform the step using the materials, then asked the tutee to replicate the step using his/her own materials. To teach the tutee to use the self-instruction sheet, the tutor provided prompts the tutee if needed, *"What do we do when we're all done with a step? Place a check beside step '✓' on your checklist."* If the tutee performed the step correctly, the tutor moved to the second step and repeated this process with all remaining steps. If the peer tutee made an error, the tutor stopped the tutee as soon as possible and modeled the skill again and asked the tutee to replicate it. If the tutee performed the skill correctly, the tutor then moved to the second step and repeated the process with step two. If the tutee continued to make errors, the tutor reminded the tutee to wait for help before guessing. This process continued for all 10 steps of the task analysis (student self-instruction checklist). The next session, the second peer tutor then provided modeling for the tutee, and the two tutors each provided one modeling session for a total of two modeling sessions for each peer tutee. The tutors modeled a total of two change addition word problems for the first two sessions. These first two sessions comprised the ‘model’ and ‘lead’ strategy of ‘model-lead-test’ to train the tutee how to request tutor support and how to use the materials. No data were collected during these training sessions; however, the experimenter provided error correction for the peer tutors as needed.

Change addition intervention. Beginning the third session, the tutor-tutee trio began the session as described above, but during this condition, the experimenter collected data on tutees correct and incorrect steps as the peer tutee was given opportunity to complete each step independently. Steps 1-4 on the task analysis include conceptual knowledge and steps 5-10 procedural knowledge. The steps of the task analysis (student self-instruction checklist) are listed below (see *Table 1*). During the third session, the first assigned peer tutor provided the instructional cue, “*Let’s get started solving our change word problems! Solve this word problem and be sure to use your checklist, mat and graphic organizer to help you.*” The tutor then presented the tutee with two change addition mathematical word problems and asked the tutee to choose one to ensure randomization of problem selection, and then placed the mathematical word problem on the tutees problem solving mat. The tutee then started to solve the problem starting with step1, and continue through step 10. The experimenter collected data using a (/) for each correct step the tutee completes independently and a (0) for each step that was answered incorrectly. If the tutee did not respond, the peer tutor used pacing prompts that do not count as incorrect responses, such as “*how do we get our problem started*” (for the first step only), "*keep going!*" *and* "*what's next?*" The tutor did not read individual steps to the tutee unless the tutee pointed to the step and/or asked the tutor to read it aloud. If the tutee still did not respond within 5s, the tutee then received a (-) for that step and the tutor implemented the least intrusive prompting system (LIPS) by starting with a verbal prompt, then a specific verbal prompt, and then a model prompt. If the tutee responded incorrectly he/she received a (-) for that step and the peer tutor went directly to a model prompt for error correction. The tutors then reiterated to the tutee, "*remember, if you don't know the answer, don't guess, ask me for help.*" The tutor was provided a LIPS script that provided explicit instruction on what to say and do should the tutee did not respond or provided an incorrect response (Appendix H). This procedure continued until all 10 steps of the task analysis were completed and the problem was solved. The first peer tutor then presented the next change addition (CA) word problem and repeated the process until a total of two word problems were completed. The next session, second assigned peer tutor took a turn delivering instruction to the tutee and replicated the exact procedure described for the first peer tutor. The two assigned peer tutors continued alternating the delivery of instruction for two change addition word problems for each session. The experimenter collected data, and provided guidance and feedback as needed. When the tutee correctly solved both of the two CA word problems independently for two consecutive sessions, he/she was then given a generalization probe using an unfamiliar peer to deliver the instruction. All procedures remained exactly as described, with the exception of the delivery of instruction being provided by an unfamiliar peer of the opposite gender as the peer tutee. Following the generalization probe, the tutee then moved to Phase II.

Intervention Condition Phase II: Change subtraction. During this phase, the same instructional procedures were followed as in Phase I: Change addition; however, the assigned peer tutors provided tutees with instruction on how to *subtract*. Steps 1-6 on the task analysis remained the same and had been previously taught using explicit instruction. The content and instruction did not change for those steps, and step 7 was taught using LIP rather than repeating explicit instruction of previously mastered skills. The *'take away'* visual on the graphic organizer was depicted as a trash can and was used as a discrimination stimulus between addition and subtraction.

Change subtraction training. The first two sessions in Phase II of the intervention condition consisted of the assigned peer tutors modeling how to solve a *change subtraction* problem. The tutor-tutee trio was seated beside one another, with their own word problem solving mat, graphic organizer, student self-instruction checklist, change word problems, and dry erase markers set up in front of them. The first peer tutor introduced the *change* problem type by modeling the chant and hand gestures for the change problem type "*one thing, add to it or take away, change.*" The first peer tutor then modeled reading the student self-instruction checklist and how to perform each step. The first peer tutor read the first step, modeled how to perform the step using the materials, then asked the tutee to replicate the step using his/her own materials. To teach the tutee to use the self-instruction sheet, the tutor provided prompts the tutee if needed, *"What do we do when we're all done with a step? Place a check beside step '✓' on your checklist."* If the tutee performed the step correctly, the tutor moved to the second step and repeated this process with all remaining steps.

If the peer tutee made an error, the tutor stopped the tutee as soon as possible and modeled the skill again and asked the tutee to replicate it. If the tutee performed the skill correctly, the tutor then moved to the second step and repeated the process with step two. If the tutee continued to make errors, the tutor reminded the tutee to wait for help before guessing. This process continued for all 10 steps of the task analysis (student self-instruction checklist). The next session, the second peer tutor then provided modeling for the tutee, and the two tutors each provided one modeling session for a total of two modeling sessions for each peer tutee. The tutors modeled a total of two change addition word problems for the first two sessions. These first two sessions comprised the 'model' and 'lead' strategy of 'model-lead-test' to train the tutee how to request tutor support and how to use the materials. No data were collected during these training sessions; however, the experimenter provided error correction for the peer tutors as needed.

Discrimination training. To support the tutee in independently discriminating if the change word problem is addition or subtraction, the tutor provided explicit instruction to the tutee on step 7 of the task analysis following the two change subtraction training sessions. The peer tutor started by saying, "*We have to look for what happened in our word problem. This will help us figure out if we add or subtract. The second sentence with a number has clue words that tell us what happened* (tutor models pointing to second sentence with noun initially, and then faded support so tutee had to locate independently during later trials). *This sentence says*… (re-read sentence emphasizing the action/clue word, such as "more" or "left"). *We have to look for the change action and the change amount.*" The tutor then modeled locating the verb/key word in sentence initially by saying, "*The action/clue word in this sentence is* (state word: e.g., more, left, altogether, total) then rephrased the sentence by saying (e.g., "*She added 2 more apples,*" "*He put back 4 tennis balls*"). Then the tutor asked, "*Does our clue word describe adding or subtracting to solve our problem?*" and waited for the tutee to say "*add*" or "*subtract*." Then, the tutor provided specific feedback, and related the operation (+/-) to the clue word if possible by saying, "*That's right we (add/subtract) so write a (plus/minus) symbol in the circle on your number sentence!"* and modeled writing a (+) or (-) in the tutees problem solving mat number sentence. As with previous conditions, the tutor only prompted the tutee if needed, *"What do we do when we're all done with a step? Place a check beside step '✓' on your checklist."* During the next training session, the assigned peer tutors alternated and the second peer tutor then became the trainer and delivered instruction. No data were collected during these two change subtraction training sessions.

Change subtraction intervention. Beginning the third session, the tutor-tutee trio began the session as described above, but during this condition, the experimenter collected data on tutees correct and incorrect steps as the peer tutee was given opportunity to complete each step independently. Steps 1-4 on the task analysis include conceptual knowledge and steps 5-10 procedural knowledge. The steps of the task analysis (student self-instruction checklist) are listed below (see *Table 1*). During the third session, the first assigned peer tutor provided the instructional cue, "*Let's get started solving our change word problems! Solve this word problem and be sure to use your checklist, mat and graphic organizer to help you.*" The tutor then presented the tutee with two change subtraction mathematical word problems and asked the tutee to choose one to ensure randomization of problem selection, and then placed the mathematical word problem on the tutees problem solving mat. The tutee then started to solve the problem starting with step1, and continue through step 10. The experimenter collected data using a (/) for each correct step the tutee completes independently and a (0) for each step that was answered incorrectly. If the tutee did not respond, the peer tutor used pacing prompts that do not count as incorrect responses, such as "*how do we get our problem started*" (for the first step only), "*keep going!*" *and* "*what's next?*" The tutor did not read individual steps to the tutee unless the tutee points to the step and/or asks the tutor to read it aloud. If the tutee still did not respond within 5s, the tutee then received a (-) for that step and the tutor implemented the least intrusive prompting system (LIPS) by starting with a verbal prompt, then a specific verbal prompt, and then a model prompt. If the tutee responded incorrectly he/she received a (-) for that step and the peer tutor went directly to a model prompt for error correction. The tutors then reiterated to the tutee, "*remember, if you don't know the answer, don't guess, ask me for help.*" The tutor was provided a LIPS script that provided explicit instruction on what to say and do should the tutee did not respond or provided an incorrect response (*see Table 2*). This procedure continued until all 10 steps of the task analysis were completed and the problem was solved. The first peer tutor then presented the next change subtraction (CS) word problem and repeated the process until a total of two word problems were completed. The next session, second assigned peer tutor took a turn delivering instruction to the tutee and replicated the exact procedure described for the first peer tutor. The two assigned peer tutors continued alternating the delivery of instruction for two change subtraction word problems for each session. The experimenter collected data, and provided guidance and feedback as needed. When the tutee correctly solved both of the two CS word problems independently for two consecutive sessions, he/she was then given a generalization probe using an unfamiliar peer to deliver the instruction. All procedures remained exactly as described, with the exception of the delivery of instruction being provided by an unfamiliar peer of the opposite gender as the peer tutee. Following the generalization probe, the tutee then moved to Phase III.

Intervention Condition Phase III: Change mixed. Answering the research question regarding if students with moderate/severe ID can correctly discriminate between addition and subtraction was addressed during this phase. Once a tutee has met mastery criteria for change addition and change subtraction, determining his/her ability to correctly discriminate between addition and subtraction, reinforced that word problem solving concepts have been mastered.

Change mixed training. During the change mixed phase, the first assigned tutor presented the tutee with two change word problems that consisted of one CA and one CS and to ensure randomization, the tutee was asked to choose one from the tutors' hand. During the training phase, the first two sessions consisted of the first assigned peer tutor modeling how to solve one CA and one CS with an emphasis on step 7 of the task analysis to identify if it was a CA or a CS problem. The tutor-tutee trio were seated beside one other with each one having their own word problem solving mat, graphic organizer, student self-instruction checklist, change word problems, and dry erase markers set up in front of them. If the tutee still needed it, the tutor would model reading the student self-instruction checklist and how to perform each step as described above for phases II and III. If the tutee was able to independently respond to the steps on the task analysis, the tutor faded support to only providing LIPS and error correction when an error was made or the tutee did not respond within 5s. During the Phase III training phase, if the tutee responded incorrectly to step 7, the tutor went directly to an error correction by stopping and re-teaching the tutee using the procedure described above for discrimination training. During the next training session, the assigned peer tutors alternated and the second peer tutor then became the trainer and delivered instruction. No data were collected during these two change mixed (CM) training sessions.

Change mixed intervention. Beginning the third session, the tutor-tutee trio began as described above, with the experimenter collecting data on tutee's correct and incorrect steps as the tutee was given opportunity to complete each step independently. Steps 1-4 on the task analysis include conceptual knowledge and steps 5-10 procedural knowledge. The steps of the task analysis (student self-instruction checklist) are listed below (see *Table 3*). As with both Phase I and Phase II, Phase III following the same procedures. During the third session, the first assigned peer tutor provided the instructional cue, "*Let's get started solving our change word problems! Solve this word problem and be sure to use your checklist, mat and graphic organizer to help you.*" The tutor then presented the tutee with two mathematical word problems (one CA; one CS) and asked the tutee to choose one to ensure randomization, and then placed the mathematical word problem on the tutees problem solving mat. The tutee then started to solve the problem starting with step 1, and continue through step 10. The experimenter collected data using a (/) for each correct step the tutee completes independently and a (0) for each step that was answered incorrectly. If the tutee did not respond, the peer tutor used pacing prompts that do not count as incorrect responses, such as "*how do we get our problem started*" (for the first step only), "*keep going!*" *and* "*what's next?*" The tutor did not read individual steps to the tutee unless the tutee points to the step and/or asks the tutor to read it aloud. If the tutee still did not respond within 5s, the tutee then received a (-) for that step and the tutor implemented the least intrusive prompting system (LIPS) by starting with a verbal prompt, then a specific verbal prompt, and then a model prompt. If the tutee responded incorrectly he/she received a (-) for that step and the peer tutor went directly to a model prompt for error correction. The tutors then reiterated to the tutee, "*remember, if you don't know the answer, don't guess, ask me for help.*" The tutor was provided a LIPS script that provided explicit instruction on what to say and do should the tutee did not respond or provided an incorrect response (Appendix H). This procedure continued until all 10 steps of the task analysis were completed and the problem was solved. The first peer tutor then presented the next mathematical word problem and repeated the process until a total of two word problems were completed. The students were only given two problems (one CA and one CS) to prevent satiation and testing fatigue. The next session, second assigned peer tutor took a turn delivering instruction to the tutee and replicated the exact procedure described for the first peer tutor. The two assigned peer tutors continued alternating the delivery of instruction for two mathematical word problems (one CA; one CS) for each session. The experimenter collected data, and provided guidance and feedback as needed. When the tutee correctly solved both of the mathematical word problems independently for two consecutive sessions, he/she was then given a generalization probe using an unfamiliar peer to deliver the instruction. All procedures remained exactly as described for Phase III of the intervention condition, with the exception of the delivery of instruction being provided by an unfamiliar peer of the opposite gender as the peer tutee. Following the generalization probe, the tutee then moved to the maintenance condition.

Maintenance. When a tutee met the mastery criteria of correctly answering both the problems correct for 2 consecutive days, s/he entered the maintenance phase. Maintenance probes consisted of two CM probe mathematical problems (one CA and one CS problem) that were presented to the tutee in varied order and had no instruction, modeling, or feedback provided during the probe. The students were given only two problems (one CA and one CS) to ensure satiation and fatigue did not occur. The experimenter collected data on tutees correct and incorrect steps as the tutee was given opportunity to independently complete each step. Maintenance procedures replicated baseline conditions (i.e., no feedback or praise given during the probe) with alternations between assigned and unfamiliar peers delivering the mathematical word problem. Maintenance probes were conducted following the tutee mastering Phase III of the intervention condition and continued intermittently throughout the remainder of the study until the final tutee received a minimum of 1 maintenance probe, which brought the study to conclusion.

Generalization of intervention to an unfamiliar peer. For this strategy to be sustainable, an unfamiliar trained peer-tutor (other than the assigned peer-tutor) delivered instruction to determine if the tutee is able to generalize the skills they have learned to an unfamiliar peer-tutor. A generalization probe consisting of using an alternate, unfamiliar peer-tutor, to deliver instruction through the same exact procedures used for all phases of the intervention condition was conducted for all participants at least one time during baseline, once during each of the phases of the intervention condition, and at least once during maintenance for all participants. All procedures were identical to those used during the intervention condition, with the only change being the individual delivering the instruction (e.g., non-assigned peer-tutor). To create a realistic situation and create a potentially uncomfortable situation, a peer of the opposite gender was used as the unfamiliar peer every time. Data collection was identical to that of the intervention condition and the total number of correct responses during the generalization probes were compiled and presented in the form of a cumulative graph.

Data Analysis

Visual analysis was used to analyze and interpret the data on the primary dependent variable and additional variables. Results from each of the variables are displayed graphically. The primary dependent variable was graphed using a single-case multiple probe design. The additional variables were graphed cumulatively. The graphs allow for the data to be presented accurately, completely, and clearly which allows the viewer to readily understand the data (Cooper et al., 2007; Johnston & Pennypacker, 1980, 2008). As recommended by Cooper et al. (2007) two questions were answered during the visual analysis: (a) Did the behavior change in a meaningful way; and (b) if so, what extent can that change in behavior be directly attributed to the manipulation of the independent variable. Answering these questions was derived from an analysis of the extent and type of variability in the data, level and trends of the data, immediacy of effect, overlap, and consistency of data pattern across similar phases (Kratochwill et al., 2010, 2013). A visual analysis was used to determine the presence or absence of a functional relation, which indicates that the occurrence of the phenomena under study is a function of the operation of one or more specified and controlled variables in the experiments, demonstrated by a specific change in the dependent variables produced by manipulating the independent variable and that the change in the dependent variable was unlikely the result of any other factors (Cooper et al., 2007). The cumulative graphs for the additional variables were constructed to visually represent the total problems solved, total discriminations made, and ability to generalize to an unfamiliar peer-tutor for each peer-tutee. The slope of responses in baseline and intervention for each participant was calculated, as well as the difference between the two with the understanding that steep slopes indicate higher response rates. Finally, the results from the social validity questionnaires and student surveys were analyzed qualitatively. The results were interpreted based on themes from the responses regarding the impact and practicality of the intervention. Student pre-post attitude and perception surveys were compared and contrasted to glean additional information to the benefits for students of using peer-mediated instructional practices.

Potential Threats to Validity

Based on the recommendations of R. D. Horner and Baer (1978) and Cooper et al. (2007) this study demonstrated experimental control by the visual inspection of change occurring where the intervention is applied, not where there is no intervention. Demonstrating experimental control began by collecting baseline data for each participant simultaneously across a minimum of five sessions. Then, each participant (tutor-tutee pair) was introduced to the intervention in a staggered fashion, only after the previously introduced participant (tutor-tutee pair) had demonstrated a positive change in level and trend. It was foreseeable that there would be an immediate change in the dependent variable (mathematical word problem solving) upon entering the intervention. In addition, it was projected that this change would not be observed while participants were in the baseline condition. Staggering the introduction of the intervention across tiers and reducing the number of problems presented in baseline from four mathematical word problems to two during Phase III of the intervention condition and the maintenance condition, controlled for potential threats to internal validity that may be due to history, maturation, satiation, and testing fatigue. Threats due to instrumentation were controlled for by interobserver agreement and procedural fidelity data. Gathering baseline data on four participants (tutor-tutee pairs) assisted in controlling for a threat to attrition to ensure that there was a minimum of three demonstrations of effect at three different points in time. Threats due to testing were controlled for by: (a) only the minimum number of baseline session required to meet design standards being conducted with each participant (Kratochwill et al., 2010, 2013); (b) mathematical word problems administered during each of the sessions within all conditions followed the same format, however they varied by theme and numbers used for solving; and (c) no mathematical word problems were given more than one time to each participant across all intervention conditions. Due to the nature of the intervention, there may have been a threat of multiple treatment interference in the proposed study.

To control for threats to external validity, the setting for the proposed study was in an environment that was familiar to the participants (tutor-tutee pairs). Although the peer tutors served as the interventionists, and not the participants' classroom teacher, it remains feasible to consider this a natural instructional intervention. A foreseen limitation of single-case design research is the small sample size. This limits its generalization of effects and is listed as a delimitation of the current study. Future replications of the proposed study are needed to control for this limitation. The experimenter made efforts to recruit participants that represent the diversity of the school population to assist with generalization to other students with MS/ID and made efforts to include participants that are culturally and linguistically diverse to represent the larger population. The participants in the proposed study met a defined set of pre-requisite mathematical skills to be included. Although the presence of these skills limits generalization to all middle school students with MS/ID, the explicit information provided on these prerequisite skills assists in generalizing to other students with MS/ID with similar skill sets.

Procedural Fidelity

To ensure the tutors are accurately following the prescribed procedures, a procedural fidelity checklist was used (Billingsley, White, & Munson, 1980). Data also were collected on the experimenter's ability to provide consistent training by having a second doctoral student view a video recording of the sessions and score the experimenter's training implementation. Fidelity was collected for a minimum of 30% across all conditions and all participants with a criterion of 90% or above. If a peer tutors procedural fidelity dropped below 90%, he/she would immediately receive a booster training session to 100% and the second tutor would deliver instruction for the following session. After fidelity was restored, the peer tutors would resume alternating instructional delivery. Procedural fidelity was calculated by dividing the number of items correctly implemented by the interventionist by the total number possible of items and multiplying by 100.

Social Validity

A pre-post survey was given to the special education teacher and any teacher assistants that included the components of practicality, cost effectiveness, social importance, and magnitude of change (Wolf, 1978). Additionally, both the tutors and tutees were given pre-post questionnaires addressing perceptions and attitudes towards one another. This questionnaire was used to determine if using peer-mediated instruction had a positive, neutral or negative effect on the perceptions and attitudes of adolescents towards one another.

Interobserver Agreement

All tutor training, and pre-post assessments were implemented by the experimenter and videotaped. All baseline, intervention, and maintenance data collection procedures were implemented by the experimenter and the trained tutors. Video recording of the sessions were used to score and collect data for the interobserver agreement across 30% of all sessions, across all participants, across every condition of the study. Interobserver agreement was calculated by dividing the number of agreements between the interventionist and the interobserver by the total of agreements plus disagreements, and then multiplied by 100 (Cooper et al., 2007) for the primary dependent variable and all additional variables being examined. A second doctoral student not participating in the study collected all interobserver agreement data by watching the recorded videos.

CHAPTER 4: RESULTS

Procedural Fidelity and Interobserver Agreement

In this section, the results of procedural fidelity and interobserver agreement will be provided across peer tutors, peer tutees, and intervention conditions. Procedural fidelity (PF) was monitored by the experimenter using the PF data collection instrument on the least intrusive prompting procedure used by the peer tutors (Appendix A). Interobserver agreement (IOA) was collected by a second observer using permanent product (video) observations and data collected using the same data collection instrument as the experimenter (Appendix B).

Peer-tutor procedural fidelity. Using a detailed PF checklist (Appendix A), the experimenter collected PF data on the peer-mediated implementation of the least intrusive prompting procedure during mathematical world problem solving lessons. The peer tutee responses were part of the 10 step detailed task analysis checklist. Table 4 reports the percentage of sessions procedural fidelity was recorded for each peer, as well as the peer procedural fidelity range and mean across all conditions. All peer tutors were monitored for 100% of all sessions with PF taken for 30% or more across all intervention conditions and phases. The range for fidelity was set at 90-100% with immediate in-vivo feedback given to the peer tutors during each session, as needed. No retraining of any of the peer tutors was conducted, as none of the peer tutors PF fell below the established range. The experimenter assessed procedural fidelity in order to verify the degree to which the least intrusive prompting procedure was implemented consistently as designed and trained and, was collected for a minimum of 30% of the sessions of each phase for each peer tutor. To calculate procedural fidelity, the number of elements correctly implemented were divided by the total number of procedural elements, then multiplied by 100 (Billingsley, White, & Munson, 1980).

The experimenter collected procedural fidelity data a minimum of 30% across all conditions for all five peer tutors. Procedural fidelity for Alex was 99% with a range of 92.3-100 from 36% of all sessions (8 out of 22 sessions). Procedural fidelity for Juan was 94.2% with a range of 85-100 from 36% of all sessions (8 out of 25 sessions). During one session, Juan prompted the peer tutee prior to waiting 5s resulting in the peer tutee not having opportunity to respond independently and Juan receiving an 85% (11/13) on the PF data sheet for that session. He was given immediate feedback from the experimenter reminding him to count to 5 or tap his foot 5 times (e.g., to adhere to the 5s wait time) prior to providing a prompt. Juan was able to bring his PF within the set range by the following session. Procedural fidelity for Janya was 99% with a range of 92.3-100 from 40% of all sessions (8 out of 20 sessions). Procedural fidelity for Brittany was 99.3% with a range of 92.3-100 from 32% of all sessions (10 out of 26 sessions). Procedural fidelity for Amanda (substitute peer tutor) was 93.5% with a range of 75-100 from 62.5% of all sessions (5 out of 8 sessions). Amanda received a procedural fidelity probe of 75% during a baseline probe that she substituted for an assigned peer and had incorrectly read the problem for the student (step 1) without allowing the peer tutee opportunity to read it independently or ask for it to be read resulting in only receiving 2/3 (75%) on the PF data sheet for that baseline probe. Amanda immediately received feedback from the experimenter and was able to increase her fidelity to the set range within the next session she substituted.

Table 4: Peer tutor procedural fidelity

Peer Tutor	% of Sessions	Fidelity Range %	Mean
2 male, 3 female	*% from total*	*Set at 90-100*	*M*
Peer 1: Alex	35	92.3-100	99
Peer 2: Juan	30	85-100	94.2
Peer 3: Janya	35	92.3-100	99
Peer 4: Brittany	35	92.3-100	99.3
Peer 5: Amanda	50	75-100	93.5
Overall Means	**33**	**95-100**	**97%**

Interobserver agreement. Interobserver agreement (IOA) on word problem solving, generalization of word problem solving to an unfamiliar peer, total problems solved, and discrimination between addition and subtraction for the *change* problem type was collected for a minimum of 30% of the sessions in each condition and within all three phases of the intervention condition for each participant. The second observer collected IOA data during baseline for 40% of baseline sessions for Marcus (2 out of 5 sessions), 33% of baseline sessions for Carrie (2 out of 6 sessions), 43% of baseline sessions for James (3 out of 7 sessions), and 38% of baseline for Maria (3 out of 8 sessions). The agreement was 100% for all four participants during baseline.

Marcus. The second observer collected IOA during intervention for 43% of intervention sessions for Marcus (9 out of 21 sessions) with 2 of 6 for Phase I (CA) for 33%; 2 of 4 for Phase II (CS) for 50%; 4 of 11 for Phase III (CM) for 36%; and 2 of 4 maintenance sessions for 50% IOA. The mean agreement was 100% for the steps of the task analysis, 100% for total number of mathematical word problems solved, and 100% for total number of discriminations between addition and subtraction.

Carrie. IOA was collected by the second observer during intervention for 43% of intervention sessions for Carrie (8 out of 19 sessions) with 3 of 8 for Phase I (CA) for 37.5%; 2 of 4 for Phase II (CS) for 50%; 3 of 7 for Phase III (CM) for 43%; and 2 of 4 maintenance sessions for 50% IOA. The mean agreement was 100% for the steps of the task analysis, 100% for total number of mathematical word problems solved, and 100% for total number of discriminations between addition and subtraction.

James. The second observer collected IOA during intervention for 42% of intervention sessions for James (8 out of 19 sessions) with 3 of 8 for Phase I (CA) for 37.5%; 2 of 5 for Phase II (CS) for 40%; 2 of 6 for Phase III (CM) for 33%; and 1 of 3 maintenance sessions for 33% IOA. The mean agreement was 100% for the steps of the task analysis, 100% for total number of mathematical word problems solved, and 100% for total number of discriminations between addition and subtraction.

Maria. IOA was collected by the second observer during intervention for 53% of intervention sessions for Maria (10 out of 19 sessions) with 3 of 10 for Phase I (CA) for 33%; 3 of 7 for Phase II (CS) for 43%; 3 of 4 for Phase III (CM) for 50%; and 1 of 2 maintenance sessions for 50% IOA. The mean agreement was 93.75% for the steps of the task analysis, 100% (range 86 to 100) for total number of mathematical word problems solved, and 100% for total number of discriminations between addition and subtraction.

Results for Question 1: What are the effects of peer-mediated, schema-based instruction on the number of steps of a task analysis completed independently correct by students with MS/ID?

Figure 5 shows the effects of peer-mediated, schema-based instruction on the number of steps of a task analysis completed independently correct by students with

MS/ID. The graph shows the number of correct steps of the task analysis completed independently by each participant. During baseline all participants had a stable baseline. During intervention all four participants demonstrated a change in level or an increasing trend, with no overlapping data with baseline performance. Visual analysis of the graph indicated a functional relation between peer-mediated, schema-based instruction on the number of steps of a task analysis completed independently correct by students with MS/ID.

Marcus. During baseline condition, Marcus received three baseline probes delivered by the experimenter and two baseline probes delivered by his assigned peers. Marcus was able to read the problem or ask to have the problem read to him (step 1), and received one point for each of two change addition and one point for each of two change subtraction consistently during baseline. During the third baseline probe, Marcus did not read the problem or ask to have it read for one of the change subtract problems, resulting in only one point being given for change subtract during that session. His average rate of correct responding during baseline for CA was $m = 2$ (range 2-2) and for CS was $m = 1.8$ (range 1-2). During change addition (CA; Phase I) of the intervention condition, Marcus demonstrated a jump in level and trend, and reached mastery by his fifth session. Marcus was able to maintain 100% accuracy when given a generalization probe using unfamiliar peers of the opposite gender for a total of six sessions during Phase I. His average rate of correct responding during Phase I was $m = 18.33$ (range 13-20). During change subtraction (CS; Phase II) Marcus reached mastery by his third session and was able to maintain 100% accuracy when given a generalization probe using unfamiliar peers of the opposite gender for a total of four sessions during Phase II. His average rate of correct responding during Phase II was *m* = 19.75 (range 19-20). During the final phase of the intervention condition, change mixed (CM; Phase III), Marcus reached mastery on the tenth session and was able to maintain 100% accuracy when given a generalization probe using unfamiliar peers of the opposite gender for a total of eleven sessions during Phase III. His average rate of correct responding during Phase III was *m* = 18.33 (range 17-20). During the first four sessions of Phase III, Marcus received incorrect responses for step 7 (selecting + /-), and appeared to not be attending to the verbs within the word problems when he read them or when his assigned peers read them to him. Feedback was provided to his assigned peers to direct Marcus to attend to the verbs within the word problem when they were read following an incorrect selection of +/-, (e.g., "*Be sure to listen if the problem says s/he gets 'more' or if they lose something, pay attention to what they problem is saying happened.*"). During the sixth and eighth session of Phase III, Marcus hurried through step 9 (solve) and counted the manipulative cubes incorrectly, was prompted to recount them, and received an incorrect response for that step. During the maintenance phase, Marcus was given one probe by his assigned same gender peers, and two from unfamiliar, opposite gender peers. He was able to demonstrate 100% accuracy during all four maintenance probes, both with assigned and unfamiliar peers. The final maintenance probe consisted of unfamiliar peers delivering four mathematical word problems in randomized order by peer tutee choice (two CA; two CS). His average rate of correct responding during maintenance was *m* = 20 (range 20-20).

Carrie. During baseline condition, Carrie received four baseline probes delivered by the experimenter and two baseline probes delivered by her assigned peers. Carrie was not able to read the problem or ask to have the problem read to her (step 1), and did not engage with the mathematical word problem or any of the materials after she was given the scripted prompt *"Show me how to solve this problem."* Carrie received no points for each of two change addition and no points for each of two change subtraction for all six baseline probes. His average rate of correct responding during baseline for CA was *m* = 0 (range 0-0) and for CS was *m* = 0 (range 0-0). During change addition (CA; Phase I) of the intervention condition, Carrie demonstrated a jump in level and trend, and reached mastery by her seventh session. Carrie was able to maintain 100% accuracy when given a generalization probe using unfamiliar peers of the opposite gender for a total of eight sessions during Phase I. Her average rate of correct responding during Phase I was *m* = 18 (range 17-20). During her fourth session, Carrie was able to correctly solve 20/20 steps, but during the fifth session she forgot step 4 (use my rule) and incorrectly counted the manipulatives for step 9 (solve) and received incorrect responses for that session resulting in her having two more sessions with correctly answering 20/20 steps each to be given a generalization probe, and moving to the next phase. During change subtraction (CS; Phase II) Carrie reached mastery by his third session and was able to maintain 100% accuracy when given a generalization probe using unfamiliar peers of the opposite gender for a total of four sessions during Phase II. Her average rate of correct responding during Phase II was *m* = 19.75 (range 19-20). During the final phase of the intervention condition, change mixed (CM; Phase III), Carrie reached mastery on the sixth session and was able to maintain 100% accuracy when given a generalization probe using unfamiliar peers of the opposite gender for a total of seven sessions during Phase III. Her average rate of correct responding during Phase III was *m* = 19 (range 18-20). During the first three sessions of Phase III, Carrie received incorrect responses for step 7 (selecting + /-), and appeared to not be attending to the verbs within the word problems when her assigned peers read them to her. Feedback was provided to her assigned peers to direct Carrie to attend to the verbs within the word problem when they were read following an incorrect selection of +/-, (e.g., "*Be sure to listen if the problem says s/he gets 'more' or if they lose something, pay attention to what they problem is saying happened.*"). During the fourth session of Phase III, Carrie incorrectly counted her manipulative cubes for step 9 (solve), was prompted to recount them, and received an incorrect response for that step. During the maintenance phase, Carrie was given two probes by her assigned same gender peers, and one from unfamiliar, opposite gender peers. She was able to demonstrate 100% accuracy during all four maintenance probes, both with assigned and unfamiliar peers. The final maintenance probe consisted of unfamiliar peers delivering four mathematical word problems in randomized order by peer tutee choice (two CA; two CS). Her average rate of correct responding during maintenance was *m* = 20 (range 20-20).

James. During baseline condition, James received four baseline probes delivered by the experimenter and three baseline probes delivered by assigned peers. James was able to read the problem or ask to have the problem read to him (step 1), and received one point for each of two change addition and one point for each of two change subtraction consistently during baseline. During the second baseline probe, James did not read the problem or ask to have it read for one of the change subtract problems, resulting in only one point being given for change subtract during that session. His average rate of correct responding during baseline for CA was *m* = 2 (no variation) and for CS was *m* = 1.8 (range 1-2). During change addition (CA; Phase I) of the intervention condition, James demonstrated a jump in level and trend, and reached mastery by his seventh session. Marcus was able to maintain 100% accuracy when given a generalization probe using unfamiliar peers of the opposite gender for a total of eight sessions during Phase I. His average rate of correct responding during Phase I was m = 19.125 (range 17-20). During his fourth session, James received 20/20 steps correct, but during his fifth session he responded incorrectly to step 9 (solve). James counted the manipulative cubes incorrectly, was prompted to re-count them, and received an incorrect response for that step resulting in James having two more sessions to reach mastery. During change subtraction (CS; Phase II) James reached mastery by his fourth session and was able to maintain 100% accuracy when given a generalization probe using unfamiliar peers of the opposite gender for a total of five sessions during Phase II. His average rate of correct responding during Phase II was m = 18.8 (range 16-20). During his first session in Phase II, James incorrectly responded to steps 8 and 9 (make sets; solve) for both CS problems. It appeared that James was unsure how to correctly use the manipulatives to demonstrate a subtraction action, so his assigned peers were given in-vivo feedback to model how to correctly use the manipulatives and count the final amount, then ask James to replicate their actions immediately following his incorrect responses, then move to the next step. The second session, James correctly responded to step 8 (make sets) but incorrectly counted the manipulatives in the final set resulting in incorrect responses for step 9 (solve). Both times, the assigned peers provided an immediate model, lead, test strategy following the error and James was able to reach mastery during the next two sessions. During the final phase of the intervention condition, change mixed (CM; Phase III), James reached mastery on the fifth session and was able to maintain 100% accuracy when given a generalization probe using unfamiliar peers of the opposite gender for a total of six sessions during Phase III. His average rate of correct responding during Phase III was *m* = 19 (range 17-20). During the first three sessions of Phase III, James received incorrect responses for step 8 (making sets), and appeared to not be attending to the operation as he incorrectly added more cubes during a CS problem, or took cubes away during a CA problem. His assigned peers immediately used a model, lead, test strategy to error correct and James was then able to reach mastery. During the maintenance phase, James was given one probe by his assigned same gender peers, and one from unfamiliar, opposite gender peers. He was able to demonstrate 100% accuracy during all three maintenance probes, both with assigned and unfamiliar peers. The final maintenance probe consisted of unfamiliar peers delivering four mathematical word problems in randomized order by peer tutee choice (two CA; two CS). His average rate of correct responding during maintenance was *m* = 20 (range 20-20).

Maria. During baseline condition, Maria received four baseline probes delivered by the experimenter and four baseline probes delivered by an assigned peer for a total of eight baseline probes. Maria did not attempt to read the problem or ask to have the problem read to her (step 1), and did not engage with the mathematical word problem or any of the materials after she was given the scripted prompt *"Show me how to solve this problem."* Maria received no points for each of two change addition and no points for each of two change subtraction for seven of the eight baseline probes. During her seventh baseline probe, Maria wrote the numbers into the number sentence (step 6; fill in the number sentence) for both of the CA baseline probes, and for one of the CS probes and received correct independent responses for those during that session. During the two baseline sessions following, Maria again demonstrated no responses or engagement with the mathematical word problems or the materials, resulting in zero scores given. Her average rate of correct responding during baseline for CA was *m* = 0.25 (range 0-2) and for CS was *m* = 0.125 (range 0-1). During change addition (CA; Phase I) of the intervention condition, Maria demonstrated a jump in level and trend, and reached mastery by her ninth session. Maria was able to solve 19/20 with 95% accuracy when given a generalization probe using unfamiliar peers of the opposite gender for a total of ten sessions during Phase I. Her average rate of correct responding during Phase I was *m* = 18.5 (range 17-20). Maria was absent for two consecutive sessions during Phase I. The first four sessions of Phase I, Maria consistently missed step 4 (use my rule). Following each sessions completion, Maria received a booster session where the assign peers focused exclusively on re-training step 4 using a model, lead, test strategy. Maria appeared to have difficulty recalling the chant and motor challenges to concurrently make the hand gestures associated with the chant. She mastered step 4 (use my rule) by the fifth session and missed step 9 (solve) as she miscounted the manipulative cubes, was given the prompt by her assigned peers to re-count the cubes, and received an incorrect response for that step. After reaching mastery during session her ninth session of Phase I and receiving a generalization probe, Maria moved into Phase II, CS. During change subtraction (CS; Phase II) Maria reached mastery by her sixth session and was able to maintain 100% accuracy when given a generalization probe using unfamiliar peers of the opposite gender for a total of seven sessions during Phase II. Her average rate of correct responding during Phase II was *m* = 18.625 (range 16-20). During the first three sessions during Phase II, Maria received incorrect responses on varied steps, including step 6 (fill in the number sentence) as she would reverse the first and second numbers when writing them into the number sentence (e.g., writing the second number in the first box of the problem solving mat) and/or incorrectly counting the manipulative cubes for step 9 (solve). Maria's assigned peer tutors used the LIPS strategy to guide Maria to identifying her error for step 6 (fill in the number sentence) by first using a gestural prompt (e.g., pointing to the first number in the mathematical word problem, then using a verbal prompt (e.g., "step 6 says fill in the number sentence") and Maria would then correct the reversal of the first and second numbers written in the number sentence. As with the other participants, when Maria incorrectly counted the manipulative cubes, her assigned peer tutors would immediately error correct, conduct a model, lead, test strategy, and Maria received an incorrect response recorded on the data sheet. During the final phase of the intervention condition, change mixed (CM; Phase III), Maria quickly reached mastery on the third session and was able to maintain 100% accuracy when given a generalization probe using unfamiliar peers of the opposite gender for a total of four sessions during Phase III. Her average rate of correct responding during Phase III was m = 19.75 (range 19-20). During the first sessions of Phase III, Maria's only incorrect response was for step 7 (selecting + /-), and when her assigned peer tutors started to implement the LIPS strategy, Maria immediately erased the incorrect operation, wrote in the correct operation, received an incorrect response for that step, and continued with the remaining steps. During the maintenance phase, Maria was given one probe by her assigned same gender peers, and one from unfamiliar, opposite gender peers. She was able to demonstrate 100% accuracy during both maintenance probes, both with assigned and unfamiliar peers. The final maintenance probe consisted of unfamiliar peers delivering four mathematical word problems in randomized order by peer tutee choice (two CA; two CS). Her average rate of correct responding during maintenance was *m* = 20 (range 20-20).

Visual analysis of the graph indicated a functional relation between peer-mediated, schema-based instruction on the number of steps of a task analysis completed independently correct by students with MS/ID.

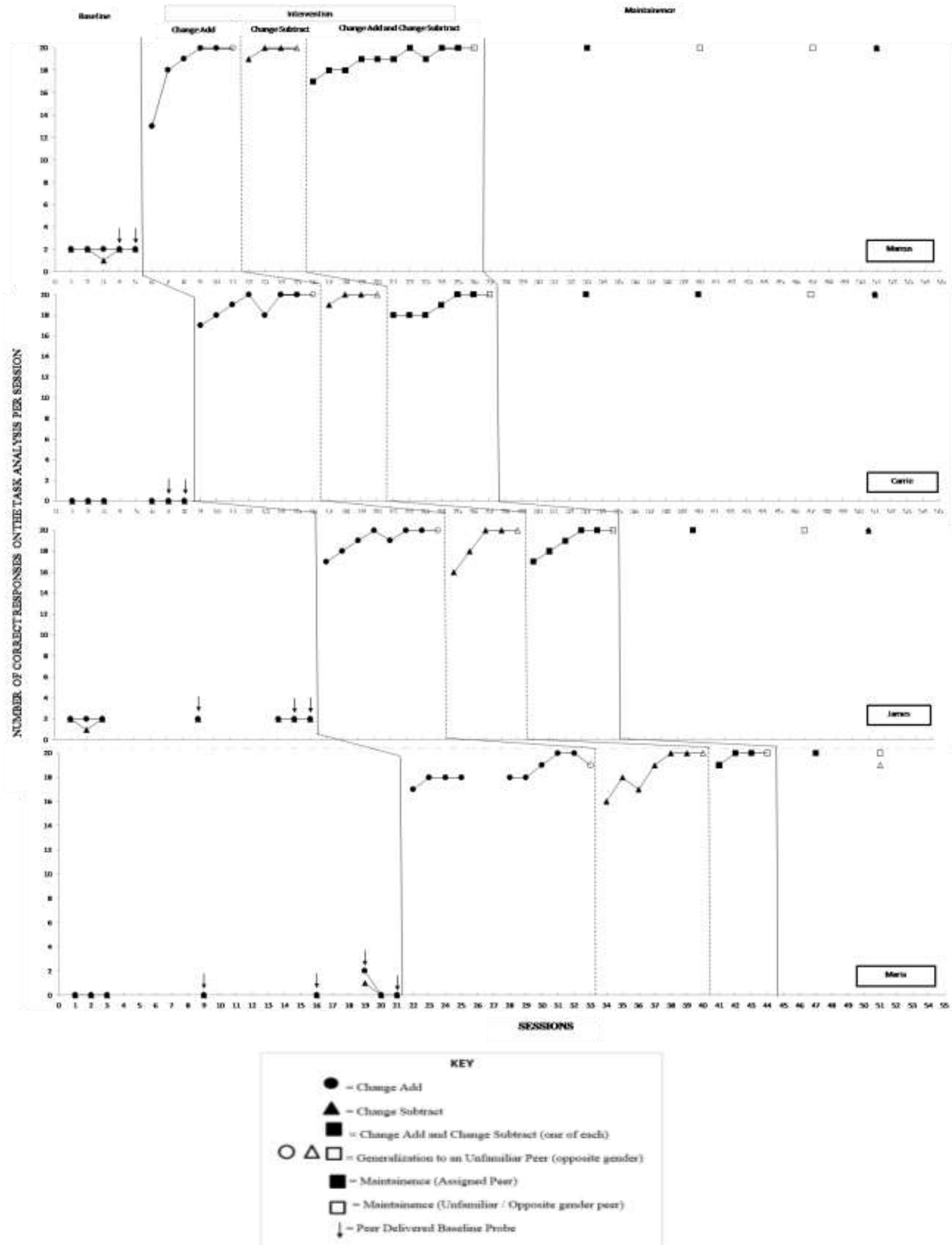
Baseline
Intervention
Maintainence
Change Add
Change Subtract
Change Add and Change Subtract
Marcus
Carrie
James
Maria
NUMBER OF CORRECT RESPONSES ON THE TASK ANALYSIS PER SESSION
SESSIONS
KEY
= Change Add
= Change Subtract
= Change Add and Change Subtract (one of each)
= Generalization to an Unfamiliar Peer (opposite gender)
= Maintainence (Assigned Peer)
= Maintainence (Unfamiliar / Opposite gender peer)
= Peer Delivered Baseline Probe

Figure 5: Number of correct responses on the task analysis across four participants for baseline, change addition (closed circles), and change subtraction (closed triangles). The arrows within the baseline condition indicate sessions that assigned peers delivered probes. Intervention condition: change addition (CA; closed circles), change subtraction (CS; closed triangles), change mixed (CM; closed squares), and maintenance (M; squares) phases. Open circles, triangles, and squares indicate a probe session where an unfamiliar peer of the opposite gender delivered a generalization probe or a maintenance probe.

Results for Question 2: What are the effects of peer-mediated, schema-based instruction on the number of correct mathematical problems solved by students with MS/ID?

Figure 6 shows the effects of peer-mediated, schema-based instruction on the number of correct mathematical problems solved by students with MS/ID. The graph shows the number mathematical word problems solved correctly across all conditions. This measure was derived from the number of problems in which the participant completed all steps of the task analysis 100% correctly resulting in a correct answer to the posed mathematical word problem. The graph shows the cumulative number of independent correctly solved mathematical word problems each participant performed in order to see the rate of change over time (Cooper et al., 2007; Ferster & Skinner, 1957). An overall response rate (ORR) was calculated for the intervention and maintenance conditions of the peer-mediated mathematical instruction (PMMI) by dividing the total number of independent correctly solved problems recorded during each of these conditions by the number of collection sessions during those conditions (Cooper et al., 2007). The higher the overall response rate, the greater the effect with a range of (0-2). In addition, the slope (i.e., rate of change) was calculated for baseline and intervention by dividing the vertical change (y2-y1) by the horizontal change (x2-x1) on a connected line. Slope provides information that considers both vertical change (i.e., change in responses) and horizontal change (i.e., change in time) on a graph. Table 5 shows both the overall response rate for intervention and maintenance, and slope for all conditions for each participant.

During baseline, the participants received two CA and two CS mathematical word problems. During intervention and maintenance each participant received two word problems (two mathematical word problems per session for a total of two possible for each session). During baseline all participants had a stable pattern of responding with no participant getting any mathematical word problems correct. All four participants had an ORR and slope of 0 during baseline, representing no problems solved. All four participants had an increase in ORR and slope during intervention, demonstrating their ability to correctly solve the word problems. Visual analysis of the graph indicated a functional relation between peer-mediated, schema-based instruction on the number of correct mathematical problems solved by students with MS/ID.

Marcus. Marcus did not solve any word problems correct during baseline condition. In his first intervention session he did not solve either of the two mathematical problems presented independently correct. During his second intervention session, he was able to correctly solve one problem, and quickly began to increase the number of problems he solved correctly. Marcus solved a total of 34 problems independently correct across the 24 intervention and maintenance conditions he was given. The ORR was 1.42 and the slope for all conditions from baseline to maintenance was 0.95 (0-1).

Carrie. Carrie did not solve any word problems correct during baseline condition. In her first intervention sessions she was able to correctly solve one problem, and quickly began to increase the number of problems she solved correctly. Carrie solved a total of 32 problems across the 22 intervention and maintenance sessions. The ORR in intervention was 1.44 and slope for all conditions from baseline to maintenance was 0.92 (0-1).

James. Stephanie did not solve any word problems correct during baseline condition. In his first intervention sessions he was able to correctly solve one problem, and quickly began to increase the number of problems he solved correctly. James solved a total of 29 problems independently correct across the 20 intervention and maintenance conditions he was given. The ORR was 1.45 and slope for all conditions from baseline to maintenance was 0.80 (0-1).

Maria. Maria did not solve any word problems correct during baseline condition. In her first four intervention sessions she did not solve either of the two mathematical problems presented independently correct. During her fifth intervention session, she was able to correctly solve one problem, and began to increase the number of problems she solved correctly throughout the remaining intervention and maintenance conditions. Maria solved a total of 23 problems independently correct across the 22 intervention and maintenance conditions she was given. The ORR was 1.05 and slope for all conditions from baseline to maintenance was 0.43 (0-1).

Table 5: Overall response rate and slope per phase for each participant for **number of problems solved**

	Marcus		Carrie		James		Maria	
Condition / Phase	ORR	Slope	ORR	Slope	ORR	Slope	ORR	Slope
Baseline	0	0	0	0	0	0	0	0
PMMI	1.44	1.44	1.48	1.43	1.47	1.43	1.04	1.04

Note. ORR = Overall response rate (i.e., average rate of response over a given time period), calculated by dividing the total number of independent correct mathematical problems solved responses recorded during a period by the number of observation periods; Slope (i.e., rate of change), calculated by dividing the vertical change (y2-y1) by the horizontal change (x2-x1) on a connected line. PMMI = Peer-Mediated Mathematical Intervention.

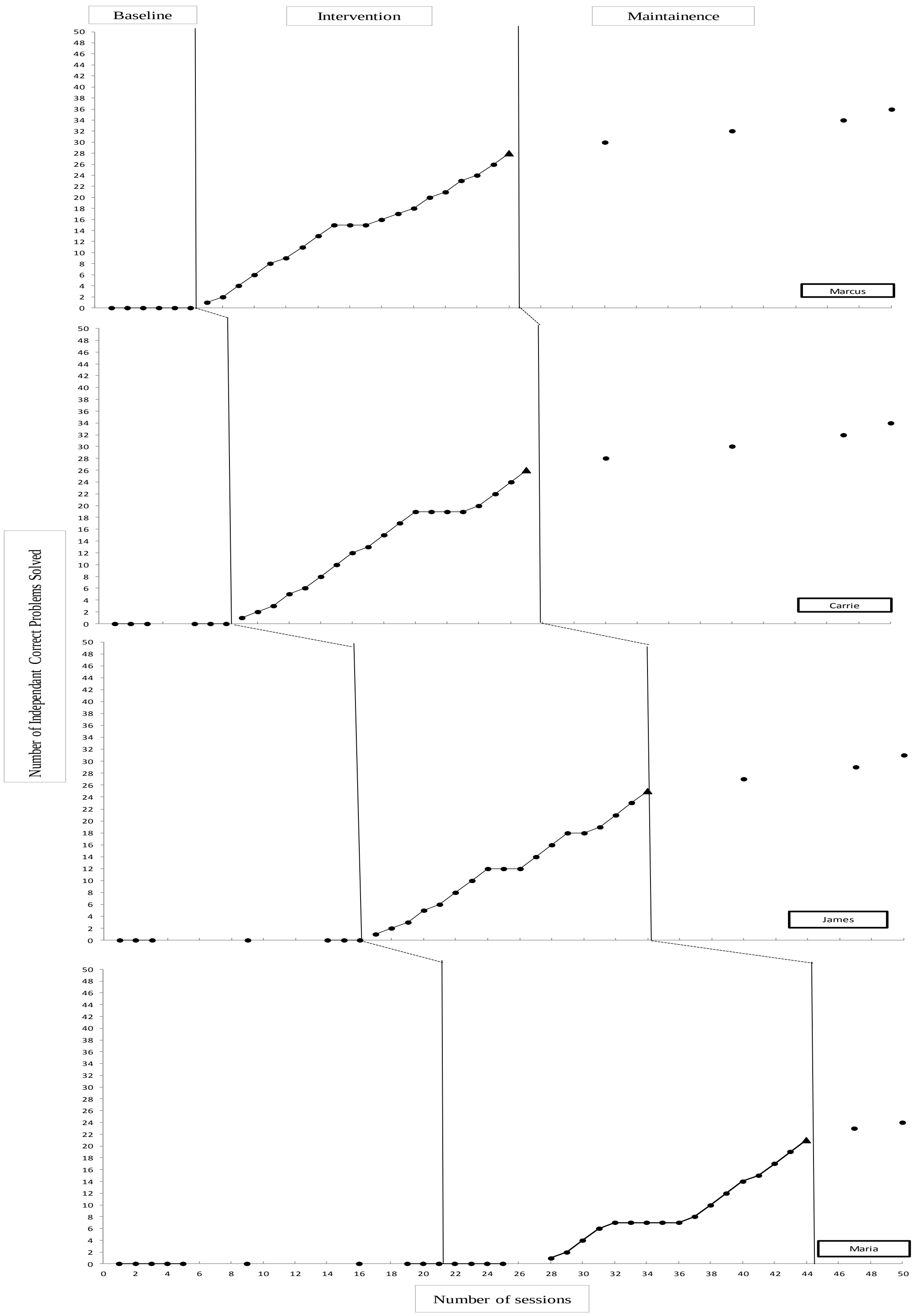

Figure 6: Cumulative number of independent correctly solved mathematical word problems. Triangle indicates when mastery was demonstrated prior to entering maintenance.

Results for Question 3: What are the effects of peer-mediated, schema-based instruction on students' ability to discriminate between addition and subtraction in word problems for the change problem type for students with MS/ID?

Figure 7 shows the effects of peer-mediated, schema-based instruction on students' ability to discriminate between addition and subtraction (discriminations) in word problems for the change problem type for students with MS/ID. The graph shows the number of independent correct discriminations made across all conditions. This measure was derived from the number of correct discriminations between addition and subtraction from Phase III (e.g., change mixed; one CA, one CS) of the intervention and maintenance conditions. The total number of discriminations between +/- were calculated by adding independent correct responses to step 7 (+/-) from the task analysis. Each participant was given two opportunities to respond correctly to step 7 (+/-) during each session beginning with Phase III of the intervention condition and continuing through the maintenance condition. The graph shows the cumulative number of independent correct responses to step 7 (+/-) for each participant in order to see the rate of change over time (Cooper et al., 2007; Ferster & Skinner, 1957).

An overall response rate (ORR) was calculated for Phase III of the intervention and maintenance conditions of the peer-mediated mathematical instruction (PMMI) by dividing the total number of independent correctly solved problems recorded during each of these conditions by the number of collection sessions during those conditions (Cooper et al., 2007). The higher the overall response rate, the greater the effect with a range of (0-2). In addition, the slope (i.e., rate of change) was calculated for baseline and intervention by dividing the vertical change (y2-y1) by the horizontal change (x2-x1) on a connected line. Slope provides information that considers both vertical change (i.e., change in responses) and horizontal change (i.e., change in time) on a graph. Table 6 shows both the overall response rate for intervention and maintenance, and slope for all conditions for each participant.

Table 6: Overall response rate and slope per phase for each participant for **number of correct discriminations.**

	Marcus		Carrie		James		Maria	
Condition/ Phase	ORR	Slope	ORR	Slope	ORR	Slope	ORR	Slope
Baseline	0	0	0	0	0	0	0	0
PMMI	1.38	1.38	1.36	1.36	1.44	1.44	1.66	1.83

Note. ORR = Overall response rate (i.e., average rate of response over a given time period), calculated by dividing the total number of independent correct mathematical problems solved responses recorded during a period by the number of observation periods; Slope (i.e., rate of change), calculated by dividing the vertical change (y2-y1) by the horizontal change (x2-x1) on a connected line. PMMI = Peer-Mediated Mathematical Intervention.

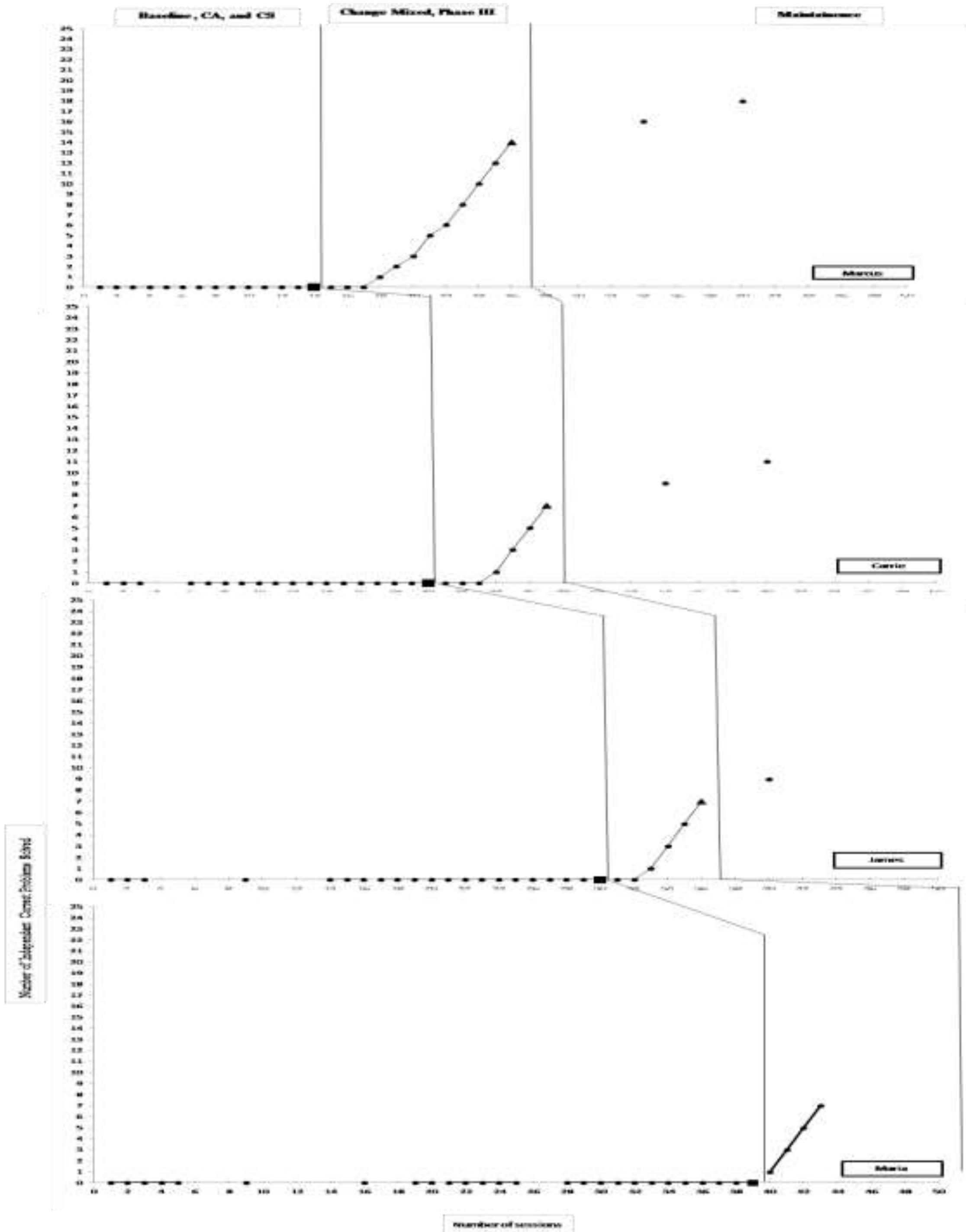

Figure 7: Cumulative number of independent correct discriminations between addition and subtraction for mathematical word problems. Triangle indicates when mastery was demonstrated prior to entering maintenance.

Starting at Phase III, participants received one CA and one CS mathematical word problem for a total of two possible discriminations between +/- for each session. During baseline all participants had a stable pattern of responding with no participant independently discriminating between +/- correctly. All four participants had an ORR and slope of 0 during baseline, representing no correct discriminations between +/- made. All four participants had an increase in ORR and slope during Phase III of the intervention condition that continued through maintenance. This demonstrated their ability to correctly discriminate between +/- when presented with a mathematical word problem of the *change* problem type. Visual analysis of the graph indicated a functional relation between peer-mediated, schema-based instruction on the number of correct discriminations made between +/- by students with MS/ID.

Marcus. Marcus did not correctly discriminate between +/- for the first three sessions of Phase III. Marcus received incorrect responses for step 7 (selecting + /-), and appeared to not be attending to the verbs within the word problems when he read them or when his assigned peers read them to him. Feedback was provided to his assigned peers to direct Marcus to attend to the verbs within the word problem when they were read following an incorrect selection of +/-, (e.g., "*Be sure to listen if the problem says s/he gets 'more' or if they lose something, pay attention to what they problem is saying happened.*"). During his fourth intervention session, he was able to correctly discriminate one problem, and quickly began to increase the number of discriminations between +/- throughout the remaining sessions. Marcus discriminated a total of 22 problems independently correct across the 16 sessions in Phase III (change mixed) of the intervention and maintenance conditions he was given. The ORR was 1.38 and the slope for Phase III to maintenance was 1.38 (0-2).

Carrie. Carrie did not correctly discriminate between +/- for the first three sessions of Phase III. Carrie received incorrect responses for step 7 (selecting + /-), and appeared to not be attending to the verbs within the word problems when she read them or when her assigned peers read them to her. Feedback was provided to her assigned peers to direct Carrie to attend to the verbs within the word problem when they were read following an incorrect selection of +/-, (e.g., "*Be sure to listen if the problem says s/he gets 'more' or if they lose something, pay attention to what they problem is saying happened.*"). During his fourth intervention session, she was able to correctly discriminate one problem, and quickly began to increase the number of discriminations between +/- throughout the remaining sessions. Carrie discriminated a total of 15 problems independently correct across the 11 sessions in Phase III (change mixed) of the intervention and maintenance conditions she was given. The ORR was 1.36 and the slope for Phase III to maintenance was 1.36 (0-2).

James. James did not correctly discriminate between +/- for the first two sessions of Phase III. James received incorrect responses for step 7 (selecting + /-), and appeared to not be attending to the verbs within the word problems when he read them or when his assigned peers read them to him. Feedback was provided to his assigned peers to direct James to attend to the verbs within the word problem when they were read following an incorrect selection of +/-, (e.g., "*Be sure to listen if the problem says s/he gets 'more' or if they lose something, pay attention to what they problem is saying happened.*"). During his third intervention session, he was able to correctly discriminate one problem, and quickly began to increase the number of discriminations between +/- throughout the remaining sessions. James discriminated a total of 13 problems independently correct across the 9 sessions in Phase III (change mixed) of the intervention and maintenance conditions he was given. The ORR was 1.44 and the slope for Phase III to maintenance was 1.44 (0-2).

Maria. Maria was able to correctly discriminate between +/- for one problem during the first session of Phase III. During her second Phase III intervention session, she was able to correctly discriminate both problems, and quickly began to increase the number of discriminations between +/- throughout the remaining sessions. Maria discriminated a total of 11 problems independently correct across the 6 sessions in Phase III (change mixed) of the intervention and maintenance conditions she was given. The ORR was 1.83 and the slope for Phase III to maintenance was 1.66 (0-2).

Results for Question 4: What are the effects of peer-mediated, schema-based instruction on the generalization of the learned mathematical skills to an unfamiliar peer on mathematical problems for students with MS/ID?

Figure 5 and Table 7 demonstrate the generalization performance of each participant. Each participant was given one generalization probe following mastery of each phase of the intervention conditions and a minimum of one generalization probe during maintenance. During baseline, all peers were unfamiliar to the peer tutees during that condition and no participant correctly solved any mathematical word problems either with the experimenter or the peer tutors. Because there was no continuous data collection on the generalization probes, ORR and slope were not calculated.

Table 7: Number of points and percentage of problems solved correctly in **generalization probes**

	Baseline Generalization		**Intervention Generalization**		**Maintenance Generalization**	
	Points Received / Points Possible	Percentage Correct	Points Received / Points Possible	Percentage Correct	Points Received / Points Possible	Percentage Correct
Marcus	0/40	0.00%	60/60	100%	40/40	100%
Carrie	0/40	0.00%	60/60	100%	20/20	100%
James	0/60	0.00%	60/60	100%	20/20	100%
Maria	0/80	0.00%	59/60	98.3%	19/20	95%

During the baseline generalization probes, no peer tutee's correctly solved any of the mathematical word problems presented to them by the experimenter or the peer tutors. All peer tutors were unfamiliar peers during baseline condition. Following introduction of the intervention, all four peer tutees were able to correctly solve the mathematical word problems that were presented by an unfamiliar peer of the opposite gender.

Marcus. Marcus was given two baseline probes by peer tutors for a total of 40 possible points on the task analysis (e.g., 20 points x 2 probes = 40 possible points). He received 0 points and did not solve either problem presented by a peer tutor during baseline. Marcus received one generalization probe following mastery of each phase during the intervention condition for a total of three generalization probes, or 60 points possible (e.g., 20 points x 3 probes = 60 possible points). He received 60/60 points, or 100% independently correct solving the mathematical word problems with unfamiliar peers. During maintenance, Marcus had 2 probes delivered by unfamiliar peers and scored 20/20 on the task analysis for both, or 100%.

Carrie. Carrie was given two baseline probes by peer tutors for a total of 40 possible points on the task analysis (e.g., 20 points x 2 probes = 40 possible points). She received 0 points and did not solve either problem presented by a peer tutor during baseline. Carrie received one generalization probe following mastery of each phase during the intervention condition for a total of three generalization probes, or 60 points possible (e.g., 20 points x 3 probes = 60 possible points). She received 60/60 points, or 100% independently correct solving the mathematical word problems with unfamiliar peers. During maintenance, Carrie was given one probe delivered by unfamiliar peers and scored 20/20 on the task analysis, or 100%.

James. James was given three baseline probes by peer tutors for a total of 60 possible points on the task analysis (e.g., 20 points x 3 probes = 60 possible points). He received 0 points and did not solve the problems presented by a peer tutor during baseline. James received one generalization probe following mastery of each phase during the intervention condition for a total of three generalization probes, or 60 points possible (e.g., 20 points x 3 probes = 60 possible points). He received 60/60 points, or 100% independently correct solving the mathematical word problems with unfamiliar peers. During maintenance, James was given one probe delivered by unfamiliar peers and scored 20/20 on the task analysis, or 100%.

Maria. Maria was given four baseline probes by peer tutors for a total of 80 possible points on the task analysis (e.g., 20 points x 4 probes = 80 possible points). She received 0 points and did not correctly solve any problem presented by a peer tutor during baseline. Maria received one generalization probe following mastery of each phase during the intervention condition for a total of three generalization probes, or 60 points possible (e.g., 20 points x 3 probes = 60 possible points). She received 59/60 points, or 98.3% independently correct solving the mathematical word problems with unfamiliar peers. During maintenance, Maria was given one probe delivered by unfamiliar peers and scored 19/20 on the task analysis, or 95%.

Results for Question 5: What are the effects of peer-mediated, schema-based instruction on both peer-tutors and peer-tutees social attitudes and perceptions of one another?

The results of participant social validity surveys can be seen in Table 8 and Table 9. Each participant completed the same social validity survey and questionnaire pre and post intervention. Participants were given a Likert Scale to rate their perceptions where 5= Strongly Agree and 1 = Strongly Disagree. All Likert Scale statements were followed by open-ended questions that allowed opportunity for participants to elaborate, if they chose. Overall, all nine participants responded positively.

Peer tutees. Table 8 shows the pre and post intervention responses from the peer tutees. It was noted that their feelings of anxiousness and nervousness to be alone with a peer tutor (work with individually) decreased following the study. They also reported decreases in their feelings of nervousness or anxiety to attend a general education class with a peer following this study. None of the peer tutees reported that they had ever worked in class or outside of class with a peer tutor prior to this study. All peer tutees felt that peer tutors were a lot like them, and all felt that learning mathematical word problems would help them later in life. Reported rates of spending time or working with a peer tutor outside of this study/class did not change from pre to post intervention; however, all peer tutees reported they would like to remain working with their peer tutors after this study.

Table 8: Results from **Peer Tutee** perception of peer-mediated word problem solving pre and post survey/questionnaire.

Statement:	Marcus		Carrie		James		Maria	
5 = Strongly Agree to 1 = Strongly Disagree	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1. I feel anxious/nervous when I have to be alone with a peer-tutor	4	2	5	3	2	1	4	3
2. I enjoy spending time alone with a peer-tutor	5	5	3	5	5	5	5	5
3. I would like to have a peer-tutor to be in more regular ed classes with me	5	5	3	5	5	5	5	5
4. I have partnered with a peer-tutor in class before	1	5	1	5	1	5	1	5
5. I have partnered with a peer-tutor outside of class	1	1	1	1	1	5	1	1
6. Being in a regular ed class makes me feel nervous/anxious	3	1	4	2	4	3	5	1
7. Learning to solve mathematical word problems can help me later in life	5	5	5	5	5	5	5	5
8. Peers-tutors are a lot like me	5	5	5	5	5	5	5	5
9. I enjoy being with a peer-tutor	5	5	5	5	5	5	5	5
10. I will ask to have a peer-tutor again after this study is over	5	5	3	5	5	5	3	5

Peer tutors. Table 9 shows the pre and post intervention responses from the Peer Tutors. It was noted that feelings of anxiousness and nervousness for two of the peer tutors decreased following the study. Two also reported increases in their feelings about wanting peers with disability to be in their regular education classes more often. Two peer tutors (Janya and Brittany) reported that they had family members with disability that they had spent time with prior to this study; however, none reported having peers with disability in any classes or tutoring them prior to this study. All peer tutors felt that peer tutees were a lot like them, and all felt that learning mathematical word problems would help them later in life. There was a decrease in the perception that peers with disability make learning in class harder. Reported rates of spending time or working with a peer tutee outside of this study/class increased from pre to post intervention, and all peer tutees reported they would like to remain working with their peer tutors after this study.

Table 9: Results from **Peer Tutor** perception of peer-mediated word problem solving pre and post survey/questionnaire.

Statement:	Alex		Juan		Jayna		Brittany		Amanda	
5 = Strongly Agree to 1 = Strongly Disagree	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1. I feel anxious/ nervous when I have to be alone with a peer with a disability	3	1	1	1	2	1	1	1	1	1
2. I enjoy spending time alone with a peer with disability	5	5	3	5	5	5	5	5	5	5
3. I would like peers with disability to be in my regular ed classes more often	2	5	3	5	4	4	5	5	5	5
4. I have partnered with a peer with disability in class before	1	5	1	5	5	5	5	5	1	5
5. I have partnered with a peer with disability outside of class	1	5	3	5	4	5	5	5	1	5
6. Peers with disability make learning in class harder than when they are not there	3	2	4	1	4	3	1	1	2	1
7. Learning to solve mathematical word problems can help peers with disability later in life	5	5	5	5	5	5	5	5	5	5
8. Peers with disability are a lot like me	4	4	5	5	5	4	5	5	5	5
9 I enjoy being a peer-tutor to a peer with disability	5	5	5	5	5	5	5	5	5	5
10. I will ask to be a peer-tutor again after this study is over	5	5	5	5	5	5	5	5	5	5

Social validity. Social validity data were collected from two classroom Exceptional Children (EC) teachers who shared in the daily classroom teaching of the peer tutees participating in the study. Although both teachers shared core content instruction, one EC teacher focused on mathematics and the other EC teacher focused on English language arts (ELA) and they would switch mid-year. Data from two paraprofessionals who worked in both classrooms was also collected. The social validity data came from a form of a questionnaire pertaining to importance, feasibility, generalization, social benefits, and cost effectiveness of the study. The social validity questionnaire (Appendix D) was used to measure the perceptions of the EC teachers and Para's on the effectiveness and feasibility of using PMMI to deliver problem solving instruction.

The results of the EC teachers and paraprofessionals social validity survey can be seen in Table 10. Overall, the teachers' perceptions changed moderately pre to post intervention for most items. The two EC teachers' scores indicated a change in their perception of using peers to deliver instruction as being practical in reducing teacher time spent teaching mathematics one-on-one. The EC teacher who focused on mathematics reported more agreement that mathematical concept skills for students with MS/ID were generalized to their daily mathematics. All participants in the social validity questionnaire strongly agreed that students with MS/ID benefitted socially from this study, and both EC teachers agreed that it was feasible and cost effective on the post-survey after initially reporting some disagreement on the pre intervention survey. Scores reported for the importance for students with MS/ID to learn mathematical word problem solving varied. Overall, all four participants in the survey responded positively.

Table 10: Results from teacher social validity word problem solving pre and post survey.

Statement:	EC/ ELA Teacher		EC/Math Teacher		Para 1		Para 2	
5 = Strongly Agree to 1 = Strongly Disagree	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1. It is important for students with moderate/severe intellectual disability to learn mathematical word problem solving	3	4	5	5	5	5	4	4
2. Using peers to deliver instruction was effective in teaching mathematical word problem solving (magnitude of change was significant)	3	5	3	5	5	5	5	5
3. Using peers to deliver instruction was practical in reducing teacher time spent teaching mathematics one-on-one	2	5	3	5	5	5	5	5
4. The mathematical concept skills the students with MS/ID learned generalized to their daily mathematics	3	4	2	5	5	5	5	5
5. Students with MS/ID benefitted socially from having a peer deliver instruction	3	5	3	5	5	5	5	5
6. Having peers deliver instruction was cost effective	3	5	5	5	4	4	5	5

Results from the distal measure (KeyMath-3 Diagnostic Assessment; Connolly, 2007) prior to implementation of the study compared to completion of the study.

The KeyMath-3 DA includes two main types of normative scores that can be used to describe math performance: relative standing and developmental. Scale scores, standard scores, and percentile ranks are relative-standing scores as they indicate the position of the students' raw score in relation to the distribution of scores in a specific grade level or age group. Grade equivalents, age equivalents, and growth scale values (GSVs) are considered to be developmental scores as they locate a student's raw score on a developmental continuum that spans the full range of grade levels and age groups. Since this study used only the Numeration subtest, a 68% confidence-interval value was used to provide a range for each peer tutees GSV on the pre and post raw scores. Table 11 depicts each participant's pre and post raw scores, and their GSV.

Table 11: Results of KeyMath-3 DA pre and posttest raw scores for Numeration subtest, Confidence Interval (CI), and Growth Scale Value (GSV)

Student:	RAW Score		68% Confidence Interval (.90)		GSV	
	Pre	Post	Pre	Post	Pre	Post
Marcus	6	7	5.1-6.9	6.1-7.9	1st-2nd	2nd
Carrie	7	6	6.1-7.9	5.1-6.9	2nd	1st-2nd
James	4	8	3.1-4.9	7.1-8.9	1st	3rd
Maria	4	6	3.1-4.9	5.1-6.9	1st	1st-2nd

Marcus. The raw score for Marcus increased by one point from pre to post intervention with a confidence interval of 6.1-7.9 and a GSV of 2nd grade. There was no significant change in his scores for the Numeration subtest from pre to post intervention.

Carrie. The raw score for Carrie decreased by one point from pre to post intervention with a confidence interval of 5.1-6.9 and a GSV of 1st - 2nd grade. Although

Carrie dropped one point, there was no significant change in her scores for the Numeration subtest from pre to post intervention.

James. The raw score for James increased by four points from pre to post intervention with a confidence interval of 7.1-8.9, and a GSV moving from 1^{st} grade to 3^{rd} grade. Although this increase is dramatic, no causality can be determined pertaining to the intervention on James' scores for the Numeration subtest from pre to post intervention.

Maria. The raw score for Maria increased by two points from pre to post intervention with a confidence interval of 5.1-6.9 and a GSV of 1^{st} - 2^{nd} grade. Although Maria increased two points, there was no significant change in her scores for the Numeration subtest from pre to post intervention.

CHAPTER 5: DISCUSSION

The purpose of this study was to investigate the effects of peer-mediated embedded schema-based instruction on the acquisition and generalization of mathematical problem solving skills for middle school students who have been identified as having MS/ID. There is limited research addressing mathematical instruction to students with moderate/severe disability through the use of peers. Students with MS/ID need to be explicitly taught how to successfully solve mathematical word problems. This study sought to extend the work of The Solutions Project (funded by the U.S. Department of Education, Institute of Education Sciences [IES] #R324A130001) to expand support for inclusionary practices and broaden generalization skills for students with MS/ID. In order to demonstrate using peer supports to alleviate the need for constant adult support, this study used a multiple probe across four peer tutees with between participant replications for four students who received the peer-mediated embedded instruction (tutees) design (R. D. Horner & Baer, 1978; Gast & Ledford, 2014; Tawney & Gast, 1984).

This investigation consisted of three conditions (baseline, intervention, maintenance) with three phases within the intervention condition (Phase I, Change Addition (CA): Phase II, Change Subtraction (CS): Phase III, Change Mixed (CM)). During the final phase of the intervention condition and the maintenance condition, peer tutees received randomly alternated equal numbers of CA and CS. Peer-tutor training took place prior to the study beginning and peer tutors were assigned to peer tutees by gender. Generalization probes were given following mastery criteria being met for each of the three phases in the intervention condition and a minimum of one time during maintenance. Generalization was investigated to determine if peer tutees could continue to independently correctly solve mathematical word problems when they were delivered by an unfamiliar peer of the opposite gender. The experimenter collected data on the number of steps performed correctly using a task analysis, the number of problems solved correctly, and the number of discriminations between addition and subtraction performed correctly during Phase III and the maintenance condition. The effectiveness of the independent variable on the dependent variables was established through a functional relation and determined through visual analysis of the graph (Cooper et al., 2007; Gast & Ledford, 2014; Johnston & Pennypacker, 1980, 2008).

The use of peer instruction to teach academics is promising. Although studies have been successful in teaching mathematic problem solving to students with mathematical disabilities (mild disability) using model based word story grammar (Xin, Wiles, & Lin, 2008) and using peer-mediated instruction to teach discrete science skills to students with MS/ID in a general context (Jimenez et al., 2012), the lack of studies that use peer-mediated instruction to teach chained skills for mathematical problem solving with generalization to the general education context is sparse (Browder et al., 2008). Research reveals that the academic accomplishments of students with MS/ID increase through interaction with typically developing peers in an integrated environment, and increases their ability to meet the goals of their individual education programs (IEPs, Brinker & Thorpe, 1984; Westling & Fox, 2009). Moving students with MS/ID towards inclusive education remains the ultimate goal, and serves as a viable strategy to assist general and special educators in providing meaningful and effective content instruction to students with MS/ID. If students with MS/ID are ever going to be transportable to an inclusive setting, there must be alternate modes to deliver instruction aside from the use of adults/teachers. The use of peers to deliver instruction can serve as a catalyst to move students with MS/ID towards inclusion.

The current study is thought to be the first of its kind demonstrating how to successfully use evidence-based teaching methods (i.e., task analytic instruction, total task presentation, LIPS, peer-mediated instruction, and modified schema-based instruction) to teach mathematical problem solving specifically to students with MS/ID. Currently, the use of schema-based instruction (SBI) for students with ASD and/or MS/ID to learn mathematical word problem solving is just emerging (Root et al., 2015; Saunders, 2014; Spooner, Saunders, et al., 2015). There currently are no studies that have investigated the use of peer-delivered SBI instruction to teach mathematical problem solving to students with MS/ID. For this reason, this investigation provides what is believed to be the first study to examine the use of peer-mediated instruction to teach mathematical problem solving to students with MS/ID.

In this chapter, outcomes are presented by research question. This chapter also will discuss the outcomes by research question and include contributions to the field. Limitations of the study, directions for future research, implications for practice, and the themes that emerged from the outcomes of the intervention will be explored in relation to the conceptual underpinnings of the components of the intervention.

Outcomes of the Study by Research Question

Outcomes. Overall outcomes for each of the research questions were detailed within the results section of this study. The following **outcomes** were found and are briefly reviewed for the research questions that guided this investigation:

(1) What are the effects of peer-mediated, schema-based instruction on the number of steps of a task analysis completed independently correct by students with MS/ID? Based on the finding of this study a functional relation was found between peer-mediated, schema-based instruction on the number of steps of a task analysis completed independently correct by students with MS/ID. All peer tutees were able to generalize their skills to solve mathematical word problems delivered by an unfamiliar peer of the opposite gender. All peer tutees also were able to demonstrate maintenance of their skills to solve mathematical word problems delivered by both assigned peers and unfamiliar peers.

(2) What are the effects of peer-mediated, schema-based instruction on the number of correct mathematical problems solved by students with MS/ID? Based on the findings of this study, peer tutees were able to demonstrate the ability to use peer-mediated, schema-based instruction to increase the number of correct mathematical problems solved. All peer tutees were able to generalize their skills to solve mathematical word problems correctly delivered by an unfamiliar peer of the opposite gender. All peer tutees also were able to demonstrate maintenance of their skills to solve mathematical word problems correctly delivered by both assigned peers and unfamiliar peers.

(3) What are the effects of peer-mediated, schema-based instruction on students' ability to discriminate between addition and subtraction in word problems for the *change*

problem type for students with MS/ID? Based on the findings of this study, peer tutees were able to demonstrate the ability to use peer-mediated, schema-based instruction to increase the number of correct discriminations between +/- on mathematical problems. All peer tutees were able to generalize their skills to correctly discriminate between +/- delivered by an unfamiliar peer of the opposite gender. All peer tutees also were able to demonstrate maintenance of their skills to correctly discriminate between +/- delivered by both assigned peers and unfamiliar peers.

(4) What are the effects of peer-mediated, schema-based instruction on the generalization of the learned mathematical skills to an unfamiliar peer on mathematical problems for students with MS/ID? Based on the findings of this study, peer tutees were able to demonstrate the ability to generalize their learned mathematical skills to an unfamiliar peer of the opposite gender on correctly solving mathematical problems. All peer tutees also were able to demonstrate maintenance of their skills to generalize their learned mathematical skills to an unfamiliar peer on mathematical problems for students with MS/ID.

(5) What are the effects of peer-mediated, schema-based instruction on both peer-tutors and peer-tutees social attitudes and perceptions of one another? Findings of this study indicated that both peer tutors and peer tutees social attitudes and perceptions positively increased after participating in peer-mediated instruction. All students indicated a positive correlation between the intervention and the social benefits and academic success demonstrated.

In general, these findings are consistent with previous studies on the use of **systematic instruction** demonstrating that using a task analysis for the total task chaining procedure of mathematical problem solving with the steps being supported through LIPS, to be an effective strategy to teach academics to students with MS/ID in the areas of reading, mathematics, science, and academics (e.g., mathematics, Browder et al., 2008; Spooner, Root, et al., 2016; reading, Browder et al., 2009; Browder, Wakeman, et al., 2006; academic skills in general education, Hudson et al., 2013; science, Spooner, Knight, Browder, Jimenez, et al., 2011; general academic skills, Spooner, Knight, Browder, & Smith, 2011). This research also is consistent with previous studies demonstrating effective methods to provide **mathematical problem solving** instruction to students with MS/ID (Root et al., 2015; Saunders, 2014; Spooner, Saunders, et al., 2015). This research also is consistent with previous studies demonstrating that the use of **peer-mediated instruction** is an effective strategy for the delivery of academic content to students with severe intellectual disabilities (e.g., Carter et al., 2011; Cushing & Kennedy, 1997; Shukla et al., 1999).

Effects of the Intervention on the Dependent Variables

The following effects of the intervention outcomes will be discussed by research question. This investigations contributions to the field will also be included for the following:

Question 1: What are the effects of peer-mediated, schema-based instruction on the number of steps of a task analysis completed independently correct by students with MS/ID?

Results of this study indicated a functional relation between peer-mediated instruction on the number of steps of a task analysis completed independently correct by students with MS/ID for the *change* problem type (Figure 5). Specifically, the number of correct independent responses on word problem skills from the task analysis for all four participants showed a clear increase in response levels and ascending trends across sessions during the intervention condition, compared to a low and stable baseline performance, with no overlapping in data between baseline and intervention phases. All four participants met the mastery criterion of 20 out of 20 steps on the task analysis for 2 consecutive days for all three phases of the intervention condition.

These findings are significant as they relate to a common set of state standards for proficiency in English language arts and mathematics known as the Common Core State Standards (CCSS, 2010) that the National Governors Association Center for Best Practices and the Council of Chief State School Officers developed. The CCSS in mathematics define and detail the content expectations and standards for mathematical practices for grades K-12. Their intent was to provide a rigorous, focused, and structured set of standards to prepare students in the 21^{st} century to be college and career ready upon exiting the high school system. This study contributes to the need for 21st Century Skills (Kilpatrick, Swafford, & Findell, 2001) by demonstrating competence in mathematics for all learners (NCTM, 2000; CCSS, 2010). This study contributes to existing literature because few studies have addressed higher level thinking in mathematics (specifically word problem solving) for students with ASD and moderate ID (Browder et al., 2008).

Mathematical experts have long emphasized the importance of instruction that teaches both conceptual and procedural mathematical knowledge (Fennema, 1972; Peterson et al., 1989). Schema-based instruction is one learning strategy that emphasizes both conceptual and procedural understanding of mathematical word problems, but it is not yet an evidence-based practice for students with MS/ID. Schema-based instruction is an evidence-based practice for students with learning disabilities (Jitendra et al., 2015); however, an established evidence-based practice for students from other disability groups remains a need to be determined when designing instruction for students with MS/ID. The current study adds to the emerging literature base (Root et al., 2015; Saunders, 2014; Spooner, Saunders, et al., 2015) to demonstrate that modified schema-based instruction as well as instructional supports including systematic instruction, visual supports (e.g., graphic organizers), and a task analysis, are effective for this population and adds to the evidence-base for students with MS/ID.

The modified schema-based instruction used in this study included essential components of schema-based instruction as outlined by Jitendra et al. (2015): (a) use of visual representations of the structure to organize information from the problem, and (b) explicit instruction on the problem solving method. The modifications, or enhancements, provided in this study addressed the barriers students with MS/ID face in solving mathematics word problems, including **semantic language** and **executive functioning.**

Semantic language barriers. Solving mathematical word problems can be challenging and cause difficulty for many students with MS/ID because not only do they require calculation, but also comprehension of linguistic information (Fuchs, Seethaler, et al., 2008). Semantic language is a barrier to mathematics problem solving for students with MS/ID because they have to determine "what is happening" in the problem. Key steps of the task analysis assisted students in systematically answering the question "What is happening?" First, in step 1 (read the problem) the peer tutees could ask the peer tutor to read the problem aloud to eliminate stagnation caused by lack of decoding skills for unfamiliar words and allowed peer tutees to focus on *what* was being read opposed to *how* to read the problem. During step 2 (circle the ‘whats’), students identified the key nouns in the problems providing repeated reinforcement of the noun to self-prompt the peer tutee to identify what the problem was about. Step 3 asked the peer tutees to recall the noun identified in the two prior steps to identify the label. Peer tutees were also trained during the modeling session to find the question and look for the label. The label was always the same noun that was circled in step 2 and was consistent with the written structure (formula) of all word problems created for this study. The structural formula each word problem followed assisted in decreasing the difficulty of completing these semantic steps of the task analysis.

Developing an understanding of the underlying mathematical problem structure is imperative to successful problem solving as most errors in word problem solving are the result of students misunderstanding the problem situation, rather than computation errors (De Corte & Verschaffel, 1981). Having peer tutors read the mathematical word problem aloud decreased the linguistic barriers peer tutees may have experienced and allowed the peer tutees to better comprehend the problem, accurately identify the key nouns, and identify the label.

Another semantic support that was provided by this study to assist in overcoming semantic language barriers was the use of visual representations to organize information from the problem and was a key component of schema-based instruction (Jitendra et al., 2015). The use of visual supports are commonly used in teaching adaptive skills (e.g., engagement, transitions, social skills) and typically are seen in the form of pictures, written words, objects within the environment, arrangement of the environment or visual boundaries, schedules, maps, labels, timelines, and scripts (National Professional

Development Center [NPDC], 2010). A strong rationale exists for the effectiveness of visual supports, as mathematical word problem solving requires text-based comprehension and provides the additional semantic support students with MS/ID also need as demonstrated in the emerging literature on its use for students with ASD and/or MS/ID (Root et al., 2015; Saunders, 2014; Spooner, Saunders, et al., 2015). This investigation contributes to this emerging base of literature by providing another demonstration of the effectiveness of using applied visual supports in a mathematical learning task for students with MS/ID.

***Executive functioning barriers*.** Rockwell et al. (2011, 2012) and Neef et al. (2003) laid the foundation for teaching mathematical problem solving with students with ASD and MS/ID through the use of a task analysis and SBI, and this study is a valuable addition to this emerging body of research. In addition to semantics, a second major barrier that students with MS/ID face in solving mathematical word problems is the executive functioning that is required to sustain attention to the task and complete each step correctly. With these executive functioning and working memory deficits in mind, this study included modifications to the instructional techniques and materials or supports typically used in SBI for students with learning disabilities (LD). This study modified the instruction techniques and materials by replacing mnemonics typically used in SBI (Jitendra & Hoff, 1996; Rockwell et al., 2011) with a written task analysis. Task analytic instruction with system of least prompts has been found to be effective at teaching mathematics to students with ASD and MS/ID and can be incorporated into SBI and has been found to be an evidence-based practice (Browder et al., 2008). In a literature review conducted by Spooner et al. (2011) determined that using task analytic instruction with systematic prompting and feedback to teach mathematics skills met the criteria for an evidence-based practice based on the R. H. Horner et al. (2005) with the quality indicators for single-case design research.

This study incorporated the evidence-based practice of using task analytic instruction through total task presentation with systematic prompting and feedback to teach mathematics skills to students with MS/ID. In addition it used a task analysis that served as a self-directed checklist for total task presentation of the mathematical word problems for the peer tutees, and included visual supports (e.g., pictures representations next to each step). The task analysis allowed for students to attend to each step in the chain and self-monitor progress. The inclusion of picture representations next to each step provided additional supports to the written task analysis to compensate for any deficits in reading the peer tutees may have otherwise demonstrated. Additionally, the peer-tutors could provide a read-aloud of steps of the task analysis if the peer tutee requested it read or went beyond the 5s CTD wait time to provide additional support in executive functioning.

The task analysis directed the peer tutees through the steps of solving the mathematical word problem by ensuring that the steps were carried out as a total task, and in a logical sequence. The task analysis also provided opportunity for self-corrections, and error corrections by the peer tutors at each small step of the problem. Isolating an error within an individual step of the task analysis allowed the corrections to be more succinct to the error, and made the overall solving of the mathematical word problem more efficient. The combination of the task analysis with LIPS allowed for maximum independence by the peer tutees. The results of this study not only supports the use of using task analytic instruction with systematic prompting and feedback to teach mathematics skills, but also supports the total task procedure. In a total task procedure, an individual is taught all of the steps in the chain from beginning to end in each teaching trial. The task analysis assists in overcoming executive functioning barriers to mathematical problem solving because it makes each step in the process explicit and provides a consistent, permanent visual.

In addition, measuring the steps completed independently correct of a task analysis allows for an analysis of progress in each step in the chained task, provides evidence of skill growth, and assists in establishing how students are solving the problem by identifying specific errors. Since mastery criteria for this study was set at 20/20 independent correct responses on the task analysis, it was particularly important for students with cognitive disabilities (i.e., MS/ID) where it is projected that mastery of the entire skill (i.e., solving the problem) would not be immediate upon entering intervention. The use of a task analysis as the primary dependent variable to determine movement from one condition to the next is effective as it provides an immediate visual analysis of progress toward mastery. It also allows for clear identification of student error to determine if a pattern of error emerges to intervene with remedial procedures.

The results of this study are consistent with the findings from an emerging literature base (Root et al., 2015; Saunders, 2014; Spooner, Saunders, et al., 2015) that have demonstrated the effective use of task analytic instruction through total task presentation with systematic prompting and feedback to teach mathematics skills to students with MS/ID. This study is distinctive from these studies as it incorporated peer tutors to deliver the intervention. Research has demonstrated that peer instruction can be used to teach academic skills to students with varying needs across grade levels and tutoring programs (Carter & Kennedy, 2006; Carter & Pesko, 2008; Hudson, 2013; Hudson et al., 2014; Jimenez et al., 2012). Peer-mediated instruction has been shown to be successful in providing increased access to general education for students with disabilities (Carter & Hughes, 2005; Carter et al., 2011). This study expands current literature on utilizing peers to deliver instruction, but goes further by including peers to deliver mathematical word problem solving instruction to students with MS/ID. Moreover, this study demonstrates that peer tutors can be taught how to deliver systematic instruction (e.g., LIPS; CTD) combined with a task analysis to provide effective instruction to peer tutees with MS/ID.

Question 2: What are the effects of peer-mediated, schema-based instruction on the number of correct mathematical problems solved by students with MS/ID?

The total number of mathematical problems solved was graphed cumulatively across all conditions and phases of the intervention. The cumulative graph of the number of problems solved by each participant across all conditions (Figure 6) provides a visual representation of the increase in problems solved once peer tutees entered intervention. All four participants were unable to correctly solve any problems in baseline, resulting in an ORR and Slope of 0 for each participant during that condition. Following the beginning the first phase of the intervention condition, Marcus, Carrie, and James were all able to solve one problem and quickly begin solving the word problems presented during each session. Maria did not solve any problems until the fifth session as she had difficulty with step 4 (use my rule). Since mastery criterion was set at 20/20 steps of the task analysis (100%) she did not receive an independent correct response for solving the mathematical word problem until she was able to respond independently correct to all steps of the task analysis. Maria was absent for two consecutive sessions between her fourth and fifth sessions; however, there was no regression of skills learned due to her absence. Starting with her fifth session she was able to continue to reach mastery and correctly solve the problems presented for all remaining sessions. An analysis of the ORR and slope during intervention (PMMI) demonstrates an increase for each participant from baseline to maintenance.

Based on the results of this study, peer tutees were able to demonstrate the ability to use peer-mediated, schema-based instruction to increase the number of correct mathematical problems solved across the intervention and maintenance conditions. These results support the conclusion that PMMI is effective in teaching students to solve mathematical word problems. Since mastery was set at 20/20 steps of the task analysis (100%), this study was a very conservative measure of mathematical problem solving as it requires an entire series of behaviors to be performed correctly (e.g., total task), rather than separate discrete behaviors. The word problems only were considered “solved” if the peer tutee independently was able to correctly complete each step in the task analysis with 100% independent accuracy. The results of this study demonstrate the strength of this intervention by using peer-mediated instruction on mathematical problem solving for students with MS/ID.

Question 3: What are the effects of peer-mediated, schema-based instruction on students' ability to discriminate between addition and subtraction in word problems for the change problem type for students with MS/ID?

Based on the results of this study, peer tutees were able to demonstrate the ability to use peer-mediated, schema-based instruction to increase the number of correct discriminations between +/- on mathematical problems (Figure 7). All peer tutees were able to generalize their skills to correctly discriminate between +/- delivered by an unfamiliar peer of the opposite gender as well as demonstrate maintenance of their skills to correctly discriminate between +/- delivered by both assigned peers and unfamiliar peers.

The ORR, slope, and visual analysis of the cumulative data on the discrimination between +/- on mathematical problems demonstrates PMMI was effective in teaching students with MS/ID to determine the correct operation when presented with a CA and CS *change* problem type. All four participants were unable to correctly discriminate between +/- in baseline, resulting in an ORR and slope of 0 for each participant during that condition. Following the beginning the first phase of the intervention condition, Marcus and Carrie were not able to correctly discriminate between +/- until their fourth sessions. Marcus and Carrie both received incorrect responses for step 7 (selecting + /-) when each began Phase III (CM) of the intervention condition, and appeared to not be attending to the verbs within the word problems. Feedback was provided by the experimenter to the assigned peers asking them to direct Marcus and Carrie to attend to the verbs within the word problem when the peer tutors read aloud the word problems following an incorrect selection of +/-, (e.g., "*Be sure to listen if the problem says s/he* *gets 'more' or if they lose something, pay attention to what they problem is saying happened.*"). Starting with their fourth sessions in Phase III, both Marcus and Carrie were able to attend to the verbs and the action, or '*whats happening*' in the word problems and were able to correctly discriminate one problem, and quickly began to increase the number of discriminations between +/- throughout the remaining sessions. James was able to discriminate between +/- during his third session. The experimenter provided the same feedback to the peer tutors following his first session to ensure James was attending to the verbs and the action, or '*whats happening*' in the word problems using the same verbal prompt as Marcus and Carrie received following his incorrect response to step 7 (+/-). Starting his third session, James was able to correctly discriminate for one problem, then was quickly able to discriminate for both problems presented for each remaining session. Maria was able to correctly discriminate between +/- with her first session in Phase III (CM) of the intervention condition and continued to provide correct responses to step 7 throughout the remainder of the study.

The results of this study are consistent with the findings from an emerging literature base (Root et al., 2015; Saunders, 2014; Spooner, Saunders, et al., 2015) that have demonstrated the effective use of task analytic instruction through total task presentation with systematic prompting and feedback to teach discrimination of the mathematical operations of +/- to students with ASD and/or MS/ID. It's important to note that peer tutees were made to attend to the verbs and action, or '*what's happening*' by the peer tutors, presented in the mathematical word problems to prevent reliance on 'key' words and to demonstrate mastery of conceptual knowledge.

Question 4: What are the effects of peer-mediated, schema based instruction on the generalization of the learned mathematical skills to an unfamiliar peer on mathematical problems for students with MS/ID?

Visual analysis of Figure 5 (open data points) and Table 7 demonstrate the generalization performance of each participant. Each participant was given one generalization probe following mastery of each phase of the intervention conditions and a minimum of one generalization probe during maintenance. During baseline, all peers were unfamiliar to the peer tutees during that condition and no participant correctly solved any mathematical word problems either with the experimenter or the peer tutors. Because there was no continuous data collection on the generalization probes, ORR and slope were not calculated.

Based on the results of this study, peer tutees were able to demonstrate the ability to generalize their learned mathematical skills to an unfamiliar peer of the opposite gender on correctly solving mathematical word problems. All peer tutees also were able to demonstrate maintenance of their skills to generalize their learned mathematical skills to an unfamiliar peer on mathematical problems for students with MS/ID. Understanding that generalization is challenging for students with MS/ID, it is important to include it as a variable for consideration when teaching problem solving to students with MS/ID. Instruction should be thoughtfully planned to include training for generalization, as one of the ultimate goals for students is to generalize their classroom learning to real-world problems (Van de Walle, 2004). Instruction should be planned with strategies to train and facilitate generalization (Cooper et al., 2007; Stokes & Baer, 1977). This study implemented multiple exemplar training (Stokes & Baer, 1977) through the use of varied and novel mathematical word problems during each PMMI training session, as well as the generalization probes. The peer tutees were presented with different and novel problems that were written around real-world themes that typical students would be exposed to in their everyday environments. The sentence structure and format remained within the context of the predetermined mathematical word problem formula, but the themes, nouns, verbs, and action varied. There were 60 different mathematical word problems (30 CA; 30 CS) of the *change* problem type that were created for this study. The benefit of providing a variety of problems was the ability to provide a variety of stimulus and response examples using real-life themes, as well as the ability to program common stimuli. This provided a very cost-effective way to program common stimuli and train multiple exemplars of real-word applications without leaving the classroom.

The generalization probes in this study targeted peer tutees ability to generalize learned mathematical skills delivered by assigned peers to unfamiliar, or non-assigned peers, of the opposite gender. To rule out any other variable altering the peer tutees responses, the setting, materials (i.e., task analysis, graphic organizer, manipulatives, problem solving mat, and written word problems), and delivery of prompts remained constant. The only variable that changed in the generalization probes was the unfamiliar, non-assigned peers of the opposite gender. The presentation and consistency of these common stimuli may have further promoted the peer tutees success in generalizing to the unfamiliar peers (Cooper et al., 2007; Stokes & Baer, 1977). This is a key finding as it provides a clear demonstration that the individual delivering the instruction may not be as essential to success at learning mathematical content as the use of sound evidence-based systematic instructional methods delivered with fidelity. In addition to the inclusion of multiple exemplar training, the generalization effects may have been due to the availability of the problem solving mat and self-instruction checklist, both of which served as visual prompts and self-directed learning strategies (Cooper et al., 2007). These were used in place of the heuristics commonly found in SBI literature, (Jitendra, DiPipi, & Perron-Jones, 2002; Rockwell et al., 2011, 2012) to support students with ASD and MS/ID, who may not have the working memory capacity or literacy skills to relate the letters of the heuristic to the steps for problem solving.

Anecdotally, during the last maintenance session, peer tutors delivered four mathematical word problems (2 CA; 2CS) for a true return to baseline and the experimenter noted that all four students had memorized many of the steps of the task analysis (e.g., steps 1-7) and were able to move through them very quickly, slowing only for step 8 (make sets) where they had to correctly use the manipulative cubes on the graphic organizer to solve the problem as they had to set their marker down and manipulate the cubes. All four quickly finished solving with minimal testing fatigue displayed by the fourth problem. This is an important finding because it suggests that as students become more fluent with skills, some materials, prompts, or additional supports that have guided their behavior may be faded over time. The self-instruction checklist (task analysis) provided structural organization and visual representations of each step, all worked together to reduce cognitive load. As students become more proficient with the steps, they may be able to rely less on these supports, and eventually some steps could be combined or faded (taken out) to move students to solving with less material supports as the repeated practices became memorized steps in problem solving, thus promoting schema-broadening instruction (Fuchs et al., 2008, 2009).

An additional important finding was that in addition to generalizing the skills to an unfamiliar peer of the opposite gender, peer tutees also exhibited using “think-alouds” by stating the upcoming step of the self-instruction checklist (task analysis) aloud without referencing the self-instruction checklist (task analysis). Although this was not a direct measure in this study, the participants were recorded on videotape using this think-aloud strategy. This suggests that students with MS/ID can generalize metacognitive strategies if supported through multiple generalization strategies (e.g., being provided sufficient stimulus examples). These findings remain consistent with the findings from the emerging literature on mathematical problem solving (Root et al., 2015; Saunders, 2014; Spooner, Saunders, et al., 2015). The results also add to previous literature conducted by Courtade, Test, and Cook (2015) that determined these evidence-based practices have been identified for teaching academic skill areas (Browder et al., 2006, 2008; Spooner et al., 2011, 2012), as well as teaching academics in general education (Hudson et al., 2013, Jimenez et al., 2012); specifically, systematic instruction (e.g., system of least prompts, task analysis), in vivo instruction, and numerous opportunities to respond.

Question 5: What are the effects of peer-mediated, schema-based instruction on both peer-tutors and peer-tutees social attitudes and perceptions of one another?

Results from this study indicate an overall increase in peer tutors and peer tutees social attitudes and perceptions of one another. The impact of peer interaction on the lives of adolescents with MS/ID is essential as interaction with general education peers may play a role in academic, functional, and social skill development, as well as contribute to increased social competence, attainment of educational goals, friendship development, and enhanced quality of life (Carter & Hughes, 2005). Within the context of peer relationships, adolescents practice and refine social skills; access support systems, shared activities, and companionship; and learn peer norms and values (e.g., Hartup & Stevens, 1999; Rubin et al., 1998). Typically, adolescents spend proportionately more of their time with their peers as they get older, intensifying the influence of peer interaction on adolescent development (Hartup & Stevens, 1999). The findings from this investigation add to an emerging body of literature to support peer-mediated instruction as an evidence-based strategy to assist students with MS/ID by increasing social benefits and successful academic outcomes (Carter & Kennedy, 2006; Carter et al., 2007; Cushing et al., 2005).

This study sought to glean additional information to go beyond what had previously been investigated by asking questions that delve deeper into genuine responses (e.g., “I feel anxious/nervous when I have to be alone with a peer-tutor.” “Peers with disability make learning in class harder than when they are not there.”). Peer tutees and peer tutors were given a social attitudes and perceptions survey/questionnaire both prior to the intervention and immediately following the conclusion of the study. The survey/questionnaire sought to determine the peer tutees perceptions and attitudes regarding their peer tutors without disabilities, and to determine the peer tutors perceptions and attitudes regarding the peer tutees with disabilities. The survey/questionnaire also addressed perceptions regarding mathematical problem solving (Appendix E). The results found on Table 8 and Table 9 are consistent with previous literature that peer support interventions improve the academic engagement and social interactions of participating students (e.g., Carter et al., 2011; Cushing & Kennedy, 1997; Shukla et al., 1999).

Although nearly all numerical responses on the Likert scale showed a positive increase from pre to post intervention, some written responses were unexpected and worthy of noting. In the **pre** survey/questionnaire, none of the participants stated that they had ever worked with peers before. Three of the five peer tutors stated they did not know students with disabilities even attended their school. Likewise, peer tutees stated that outside of PE, they had no interaction with students in the general population. Two peer tutors (Brittany and Janya) indicated they had prior experience spending time with a person with disability as both said they had a family member that had a disability. Peer tutees indicated that although being around peers without disabilities and attending classes with peers without disabilities made them feel nervous or anxious, they still had desire to spend more time with them and wanted to attend general education classes. All peer tutors indicated that they wanted to be a peer tutor to a student with a disability because they “want(ed) to help the less fortunate” or felt “sorry for them and want(ed) to help them.” Results from the **post** intervention survey/questionnaire provided some unexpected responses. Both Alex and Juan stated that they were going to remain friends with Marcus and James and they now played basketball together in PE where they had not before this study. Alex and Juan also stated that the best part about becoming friends with the peer tutees from this study was the tutees sense of humor. Alex stated he loved laughing with Marcus and James during the free time they had following some sessions. Juan stated that he enjoyed playing an interactive game on his netbook with Marcus and James when he had free time during the study and was surprised at how good they were at playing the game. Brittany stated that she enjoyed visiting with Carrie about makeup and clothes and stated she felt they both had a lot in common. Brittany also enjoyed sharing tutorial videos on her netbook with Carrie during their free time waiting for their session to begin. Janya demonstrated the strongest leadership of all the peer tutors and had placed herself in charge of ensuring all other peer tutors were on task and prepared each day. Janya stated in her post intervention survey/questionnaire that as a result of this study, she felt “closer and more connected” to the peer tutees and students with disabilities in general. She stated that she would like to have peers with disability in her general education classes; however, she felt they did not “go as fast” and would slow the class down. She also stated strong concerns that other students that didn’t know the peers with disabilities would “make fun of them” and use students with disabilities as a means of “entertainment and not real people.” Although Janya stated that she felt students with disabilities were a lot like her, she also felt they lacked the ability or skills to “stand up for themselves” and she felt fearful for her new friends “feelings and confidence being damaged.” The EC teacher told the experimenter after the study concluded that Janya and Brittany had both gone to the EC teacher and requested to become peer tutors in the EC teachers’ classroom. They also had brought additional friends with them that were not participants in this study requesting to become peer tutors in the EC teachers’ classroom. All five peer tutors were invited to attend a field-trip with the EC teachers’ class after the conclusion of this study. This is encouraging in that prior to the beginning of this study, the peer tutors were not even aware that students with disabilities existed in their school. The results of this study have led to the first steps in building a peer mentoring program and moving students towards a more inclusive school community. The results of this study add to a strong body of literature supporting the social and academic benefits of peer-mediated instruction that have well-documented the use of peer support interventions to improve the academic engagement and social interactions of participating students (e.g., Carter et al., 2011; Cushing & Kennedy, 1997; Shukla et al., 1999). Further, this study adds to effective strategies to increase engagement as a prerequisite for learning, and highly correlated with improved academic achievement (Carter & Kennedy, 2006).

Teacher and paraprofessional perceptions of peer-mediated instruction on mathematical problem solving for students with MS/ID. Further analysis of social validity. Additionally, two EC teachers and two paraprofessionals were given pre and post intervention social validity questionnaires. The EC teachers shared core content instruction, with one EC teacher focusing on mathematics and the other EC teacher focusing on English language arts (ELA). Data from two paraprofessionals that worked in both classrooms was also collected. The social validity data questionnaire focused on the importance, feasibility, generalization, social benefits, and cost effectiveness of the study. The social validity questionnaire (Appendix D) was used to measure the perceptions of the EC teachers and Para's on the effectiveness and feasibility of using PMMI to deliver problem solving instruction.

The results of the EC teacher and para social validity questionnaire can be seen in Table 10. Overall, the teacher's perception changed moderately pre to post intervention for most items presented on the questionnaire. The two EC teachers' scores indicated a change in their perception of using peers to deliver instruction as being practical in reducing teacher time spent teaching mathematics one-on-one. The EC teacher that focused on mathematics reported more agreement that mathematical concept skills for students with MS/ID were generalized to their daily mathematics. All teachers who completed the social validity questionnaire strongly agreed that students with MS/ID benefitted socially from this study. Both EC teachers agreed that it was feasible and cost effective on the post-survey after initially reporting some disagreement in the pre intervention questionnaire. Scores reported for the importance for students with MS/ID to learn mathematical word problem solving varied. Overall, all four responded positively to the social validity measure.

Although the special education classroom teachers did not deliver the intervention, they felt it was naturalistic in that the intervention included typical interactions between like age/grade students. Both teachers felt the intervention was academically and socially beneficial, the students enjoyed it, they learned mathematical problem skills and problem solving from the intervention, and their students would like to continue to have peer tutors teach them mathematical problem solving skills in their classrooms. Both teachers stated in the comments section of the questionnaire about the incidental effects of improved attention to task, increased willingness to attempt unfamiliar tasks, and increased student engagement. Most notably, Maria's EC/ELA teacher reported that she was now able to identify and read more words independently than she was able to prior to the intervention. Both EC teachers also stated that they did not feel they had the time to train peer tutors, or an adequate number of paraprofessionals to use peers within general education inclusionary placement for their students with disabilities. However, the EC teachers and paraprofessional's expressed a willingness to have peer tutors come to their self-contained classrooms to work with students with disabilities. The EC/ELA teacher stated that she had invited the peer tutors to accompany her class on an upcoming field trip. The EC/Mathematics teachers' understanding the establishment of friendships between students with disabilities and their nondisabled peers has been one of the most important outcomes sought by school inclusionary efforts (Haring & Breen, 1989; Sailor, 1989; Strully & Strully, 1985), and the results of this study have provided a strong foundation in creating a more inclusionary school environment for this school.

Distal Measure Outcomes

Results from the distal measure (KeyMath-3 Diagnostic Assessment; Connolly, 2007) prior to implementation of the study compared to completion of the study. Based on this study, the results from the distal measure did not reflect any significance between pre and post measures. Table 11 depicts each participant's pre and post raw scores, and their GSV from the KeyMath-3 DA. This study used the Numeracy subtest and sought to determine if the intervention would have an effect on numeracy skills.

Overall the pretest raw scores for each of the participants were very low, ranging from a 3.1-7.9 and posttest raw scores ranged from 5.1-8.9, demonstrating minimal improvements. The general numeracy items represented in the KeyMath3 DA measure did not directly correlate with the components of the intervention and participants were not able to generalize the mathematical skills they had acquired during the intervention to the posttest assessment. Carrie's posttest raw score went down by one point; however, James was able to increase his raw score on the pretest from a 4 to an 8 on the posttest. Although this was a dramatic increase for James, causality was undeterminable as the distal measure did not directly correlate with the intervention and James may have learned the mathematical skills elsewhere.

Themes Derived from Outcomes and Contributions to Prior Literature

Teaching mathematics to students with MS/ID. Solving mathematical word problems can be challenging and cause difficulty for many students with MS/ID because not only do they require calculation, but also comprehension of linguistic information (Fuchs et al., 2008). This study found that by using the strategies outlined within the study, students were able to successfully learn mathematical word problem solving. Developing an understanding of the underlying mathematical problem structure is imperative to successful problem solving as most errors in word problem solving are the result of students misunderstanding the problem situation, rather than computation errors (De Corte & Verschaffel, 1981). This study effectively demonstrated that students with MS/ID can successfully demonstrate a sound understanding of the underlying mathematical problem structure to correctly solve mathematical problems with greater independence. Rockwell et al. (2011, 2012) and Neef et al. (2003) laid the foundation for teaching mathematical problem solving with students with ASD and MS/ID through the use of a task analysis and SBI, and this study is a valuable addition to this emerging body of research (Root et al., 2015; Saunders, 2014; Spooner, Saunders, et al., 2015). The findings of this study are consistent with these emerging studies and demonstrates a successful generalization measure by using peer-mediated instruction of the strategies previously found to be effective. The chained nature of word problem solving makes each step dependent on the successful completion of the prior steps (Browder & Spooner, 2011; Jitendra et al., 2007). Errors made on one step of a task analysis can prevent successful demonstration of conceptual and/or procedural knowledge mastery. This dependence of one step of the task analysis was evident when analyzing student errors during Phase III (CM) for step 7 (+/-). Overall, participants had the most difficulty with correctly discriminating between +/- in the mathematical word problems. If this step was not correct, it was impossible for the participants to correctly solve the problem. Additional error correction and prompting for participants was needed to remediate the incorrect discrimination.

Systematic instruction as an evidence-based practice. This study incorporated several established evidence-based practices for students with moderate and severe disabilities, including those with ASD/ID (Browder et al., 2008; Spooner et al., 2016). Systematic instruction, specifically a system of least prompts and a chaining procedure, were used to teach participants the steps to solving a word problem. Although several previous studies have used a combination of these systematic instruction techniques to teach a chained mathematical task to students with MS/ID (e.g., Browder, Jimenez, et al., 2012; Browder, Root, et al., 2016; Browder, Trela, et al., 2012; Creech-Galloway et al., 2013; Saunders, 2014), this was the first to use these strategies delivered by peer-mediated instruction. In doing so, the current study combined two evidence-based practices: systematic instruction and peer-mediated instruction. Similarly, the literature review conducted by Courtade et al. (2015) that build on the previous literature review determined that evidence-based practices have been identified for teaching academic skill areas (Browder et al., 2006, 2008; Spooner et al., 2011, 2012), as well as teaching academics in general education (Hudson et al., 2013, Jimenez et al., 2012); specifically, systematic instruction (e.g., system of least prompts, task analysis), in vivo instruction, and numerous opportunities to respond. The findings of the current study add a valuable contribution to these existing studies as it successfully demonstrated that the combination of these evidence-based strategies can be delivered by a peer tutor with equitable success.

Additionally, the evidence-based instructional procedure of explicit instruction (e.g., model, lead, test) was effectively used in the current study. Explicit instruction is an essential component of traditional SBI, which is an evidence-based practice itself for students with learning disabilities (Jitendra et al., 2015). Gersten et al. (2009) defined explicit instruction within a mathematical task as having three components: (a) the teacher demonstrates a step-by-step plan (strategy) for solving the problem, (b) this step-by-step plan is specific for a set of problems, and (c) students use the same procedure/steps demonstrated by the teacher to solve the problem. Distinctive to the current study, the experimenter trained peer tutors to use explicit instruction and the peer tutors provided all explicit instruction for the peer tutees. An important component of explicit instruction is providing multiple opportunities to respond, which is also an evidence-based practice for teaching mathematics to students with MS/ID (Archer & Hughes, 2011). The current study provided a minimum of two opportunities for each session delivered by the peer tutors for the peer tutees to practice the strategy within each session.

Peer-mediated instruction. Current research has demonstrated that peer instruction can be used to teach academic skills to students with varying needs across grade levels and tutoring programs (Carter & Kennedy, 2006; Carter & Pesko, 2008; Hudson, 2013; Hudson et al., 2014; Jimenez et al., 2012). Peer-mediated instruction has been shown to be successful in providing access to general education mathematics (Carter & Hughes, 2005; Carter et al., 2011). This study expands current literature by including students with MS/ID and demonstrates that peer-mediated instruction encompasses both inclusionary practices and strides towards equitable access to general education curriculum through the use of peer-mediated instruction. More importantly, this study demonstrated that peer tutees were able to readily generalize their learned mathematical skills to unfamiliar peers of the opposite gender. This indicates that the level of engagement and response to peers was successful and that the systematic methods used could be translated to unfamiliar peers which are more closely aligned to a general education classroom setting where the peer tutor could be easily alternated depending on peer tutor availability.

Planning for generalization. Students with MS/ID have demonstrated the capacity to learn chained skills to complete a mathematical word problem, however; it is known that students with MS/ID often cannot generalize learned skills reliably or stably to different settings, time, people, or materials (Stokes & Baer, 1976; Stokes, Baer, & Jackson, 1974). Up until the work of Stokes & Baer (1977) on generalization, many people expected generalization to occur following training and a passive approach to instructing generalization was common. Stokes & Baer (1977) argued there was a need to actively program generalization rather than passably expect it as an outcome of certain training procedures and stated that generalization requires both emphasis and effective techniques to ensure successful generalization. The current study focused on two strategies to manipulate the stimuli to elicit correct responses by the peer tutees to promote the success of the generalization measure. These two strategies were described by Stokes & Baer (1977) as "programming common stimuli" and "training sufficient exemplars." These two methods focus on the discrimination of events that occur before or concurrent with the response.

First, the programmed common stimuli included the setting in which the training and intervention took place. The setting remained the same throughout the duration of the intervention. The materials used by the peer tutors and peer tutees, including the task analysis (student self-instruction sheet), graphic organizers, word problem solving mat, manipulatives, and mathematical word problem format also remained the same throughout the duration of the intervention. The consistency of these stimuli allowed peer tutees to readily transfer what they had learned with an assigned peer tutor to a non-assigned, unfamiliar peer. The unfamiliar peer tutors served as a new target stimulus within the setting and were sequentially introduced following mastery of each phase of the intervention condition to ensure that peer tutees were able to generalize training across people.

Second, to train sufficient exemplars, the presentation of a variety of themed word problems was used as a means of discrimination training. The use of varied story-based themes for the mathematical word problems provided non-specific stimuli to evoke specific correct responses when novel themes were presented. Peer tutees were able to solve the mathematical word problem regardless of the theme. The mathematical word problems also were formatted to allow the experimenter or the peer tutors to vary the numbers used within the word problems. Providing the peer tutees with different number sets allowed for correct responses across a range of numbers. The strategy of providing sufficient exemplars increased the potential for peer tutees to respond correctly regardless of the numbers presented within the specified range.

Although the parameters of this study were relatively tight in regards to the specific materials and scripted lessons, peer tutees were able to demonstrate generalization of the skills they learned with an assigned, familiar peer to a non-assigned, unfamiliar peer across a range of mathematical word problem themes and number sets. This result reinforces the need to include training generalization components to ensure students with MS/ID can generalize their learned skills across responses, settings, people, materials, and time.

Limitations of the Current Study

This study was conducted in a large, urban school district that has a large special education and mathematics curricula department that provides support to classroom teachers that smaller school districts may not have. The novel nature of this study prompted the experimenter to choose to target the *change* problem type only for this investigation, and the other problem types of *group* and *compare* were not addressed in this study. Students in this study were selected based on the prerequisite skills of having mastered early numeracy skills (such as identifying numbers to 10, counting with 1:1 correspondence, creating sets to 10, and early addition skills). The results may not be applicable to students who have not yet mastered these prerequisite skills. The inclusion of five peer tutors and four peer tutees was relatively small. The results may not be generalizable to the larger population as a whole. Additionally, all students were in middle school and this may affect generalization to other grade level populations.

Directions for Future Research

The findings of this study provide several areas for future research related to using peer-mediated instruction on mathematical word problem solving for students with MS/ID. First, this study facilitates future research to build on in determining if students are able to generalize the mathematical problem solving skills to the general education classroom with the assistance of peer-mediated instruction to support the limited research on inclusionary practices for students with moderate/severe ID. The level of support provided by adults in the classroom can compete with the goals of social and academic inclusion by impeding student learning and growth (Carter & Kennedy, 2006). To alleviate this issue, the well-researched use of classroom peers can be an effective strategy. When leveraging resources, educators are faced with the challenge of meeting all students' needs and often use adult-delivered support (e.g., paraprofessionals, teacher aides) and peer-delivered support can provide the instructional support students with MS/ID may need. Given the current emphasis on documenting students' progress in relation to grade-level content standards, the need to demonstrate that peer-mediated instruction interventions can actually enhance students' academic performance, as well as increase knowledge and skill acquisition, remains a critical need to be explored further to create an evidence-based practice.

Second, this study offers direction in using peer-mediated instruction to teach word problem solving through SBI to students with MS/ID; however, this study focused on middle school aged students. Future studies should include students with MS/ID who are in elementary and/or high schools. It is critical to determine if younger students of elementary age have the capacity to play the role of a peer tutor. Questions remain regarding a maturational level of elementary aged students (e.g., ages 5-12) commensurate with the maturity necessary to serve as a role model or peer tutor for students with MS/ID in the same age range. Additional research also is needed to determine if high school students can demonstrate similar effective peer-mediated instructional practices. As students enter the high school setting, their schedules become less flexible as the level of social interactions increase (e.g., sporting events, prom, pep rallies, clubs/organization memberships) and academic content becomes increasingly more difficult (CCSS, 2010). This added restrictions are compounded with more high stakes standardized testing (e.g., ACT, SAT) further reducing the likelihood that high school students without disabilities in advanced or honors courses would have the time available to provide the level of peer tutoring support necessary to establish a successful relationship between the peer tutor and the peer tutee. Additional research is needed to investigate the use of peer-mediated instruction on mathematical skills for students with MS/ID at the high school level as well to determine its effectiveness and feasibility.

A third direction for future research would include expanding the current study to include grade-aligned academic content areas beyond mathematical problem solving. This study demonstrated that peer-mediated instruction was effective to teach mathematical word problem solving for middle school students with MS/ID; however, the strategies used to teach this skill should be replicated for other specific grade-aligned academic content for students with MS/ID. The research base for using peer-mediated instruction spans nearly 50 years and convincingly demonstrates that this strategy is effective (Cloward, 1967; Cohen et al., 1982; Jimenez et al., 2012; Scruggs et al., 2012).

There remains a paucity of research that has demonstrated the effective use of peer-mediated instruction to deliver grade aligned academic content to students with MS/ID.

Implications for Practice

The findings of this study provide several areas of practical implications related to using peer-mediated instruction on mathematical word problem solving for students with MS/ID. The first implication for practice is the use of self-instruction checklists (task analysis) to students with MS/ID. Providing students with an accessible task analysis can effectively increase their ability to self-monitor by using a self-instruction checklist as well as increase their independence and decrease their reliance on adult instruction. Practitioners can effectively implement the strategy of using a self-instruction checklist (task analysis) with a variety of academic tasks.

Understanding that many academic tasks are chained, the use of a task analysis can effectively provide students with MS/ID a means to correctly and independently complete a task that consists of a series of discrete skills in a prescribed, logical order. Task analytic instruction has an emerging track record of success in teaching students with ASD and/or MS/ID to complete mathematical word problem solving tasks (Root et al., 2015; Saunders, 2014; Spooner, Saunders, et al., 2015). Breaking down the steps of solving a word problem into a task analysis that is provided to the student in an accessible format, for example using pictures paired with words and peers to provide read-alouds, is one way that practitioners can encourage greater independence and less dependence on adult instruction. The process of evaluating a plan and making corrections along the way is essential to developing problem solving skills (Van de Walle et al., 2010). Practitioners could the use of peer tutors to guide instruction and provide immediate error correction through the use of a task analysis in accessible formats into mathematics instruction. Students with MS/ID could increase their mathematical skills, demonstrate gains in solving targeted mathematical problems, demonstrate increased independence, but gain valuable social benefits through peer tutor-tutee interactions. These increases in skills are valuable as they may transfer to other social and academic areas.

A second implication for practice is the use of visual supports to assist in providing students with both the conceptual and procedural knowledge necessary to complete mathematic problem solving tasks. Practitioners can draw on established evidence-based practices such as systematic instruction (e.g., system of least prompts and a chaining procedure) and the use of graphic organizers with manipulatives to provide students with MS/ID with additional supports that can be faded over time. Peer tutors can deliver instruction to direct the peer tutees attention to specific components of the visual supports by using explicit instruction to teach the tutees how to complete the steps of the task analysis and solve the mathematical word problem. The practitioner could easily create visual supports (e.g., graphic organizers and manipulatives) and provide minimal training to peer tutors to effectively use them in delivering instruction to students with MS/ID. Using peer-delivered instruction can allow teachers to assume the role of facilitator within their classrooms, thus providing them with greater opportunity to concurrently interact with multiple students at one time in place of the time-consuming practice on one-on-one instruction. Once peer tutors are trained and visual supports have been created, students with MS/ID can be provided with increased individual, one-on-one instruction through the use of peer tutors. A benefit of using visual supports is that as students with MS/ID demonstrate mastery, the visual supports can be faded, further increasing students' independence.

This leads to a third implication for practice. The use of peer-delivered instruction to teach mathematical problem solving to students with MS/ID can offer an effective and feasible approach to promote access to and progress in the general education curriculum. When peer tutors have been trained and are able to demonstrate replicable fidelity delivering instruction, they can provide the same instructional support to students with MS/ID in general education classes. Using peer tutors within a general education classroom eliminates missed instruction for both the peer tutor and the peer tutee. Peer tutors may strengthen and reinforce their own academic and social skills by teaching peer tutees, and peer tutees can learn social skills and content they may have not previously been exposed to by remaining in a self-contained setting.

Summary

If students with MS/ID are ever going to be transportable to an inclusive setting, there must be alternate modes to deliver instruction aside from the use of adults/teachers. The use of peers to deliver instruction can serve as a catalyst to move students with MS/ID towards inclusion. Investigating the specific strategies to deliver the instruction using peers (e.g., task analysis combined with LIPS) to teach chained tasks, specifically mathematical problem solving, to students with MS/ID was a warranted investigation.

The purpose of this study was to investigate the effects of peer-mediated SBI on the number of correct steps of a task analysis to solve the *change* problem type of mathematical word problems with middle school students with MS/ID. This study also investigated the effects of peer-mediated schema-based instruction on the number of correct mathematical problems solved with MS/ID, and the ability of students with MS/ID to discriminate between addition and subtraction in word problems for the *change* problem type. This study sought to determine if students with MS/ID also were able to generalize the learned mathematical skills to an unfamiliar peer. Finally, this study investigated the effects of peer-mediated instruction on both tutors and tutees social attitudes and perceptions of one another before and after the study is completed. Additionally, the current study used a distal measure to determine if students' mathematical skills on a standardized measure would increase from a pre and posttest measure (KeyMath3 DA).

Peer-mediated instruction has positive benefits for teaching mathematical problem solving for students with moderate/severe ID. The use of peers is time saving, cost effective, beneficial to both the tutor and tutee academically and socially, and may be replicated for other academic areas. This study provides a distinctive contribution to the research literature as it is thought to be the first to investigate the use of peer-mediated instruction on mathematical word problem solving for middle school students with MS/ID. In this study, students with MS/ID were able to solve mathematical word problems through the use of systematic instruction (system of least prompts, task analysis) with embedded SBI with instruction delivered by a peer-tutor through a clear demonstration of a functional relation. Consequently, it serves to add to previous literature that determined evidence-based practices have been identified for teaching academic skill areas (Browder et al., 2006, 2008; Spooner et al., 2011, 2012), as well as teaching academics in general education (Hudson et al., 2013, Jimenez et al., 2012) to students with MS/ID.

This study also demonstrated that students with MS/ID not only can discriminate between addition and subtraction in mathematical word problems, but also can correctly solve mathematical word problems independently over time, and the skills they learned can be generalized unfamiliar peers to deliver the instruction. Both peer tutors and peer tutees reported positive academic and social benefits, and expressed enthusiasm regarding continuing the peer-mediated strategy in the future. This study adds to the growing body of research that evaluates the perceptions and attitudes that students with and without disabilities have of one another (Carter & Common, 2014; Carter & Hughes, 2005, 2006; Carter & Pesko, 2008).

Mathematical experts have said that problem solving is one of the most critical, functional mathematics skills that individuals with MS/ID need to have as it serves as the basis for solving real-world problems (Van de Walle, 2004). This study addressed the need for teaching grade-aligned mathematical skills as well as demonstrated that using peer tutors to deliver mathematical instruction can be successful. The mathematical word problems used in this study used themes and contexts with relevant applications to real-world situations and activities that were meaningful to the students and their everyday lives (Browder, Trela, et al., 2012; Collins et al., 2011). More importantly, this study was able to demonstrate that mathematical problem solving through the use of peer-mediated instruction increased the likelihood that students with MS/ID were able to increase their independence with an academic tasks, and provided social benefits that previously were non-existent. These academic and social benefits can build self-determination skills, and eventually employability skills in individuals with MS/ID.

This study addressed many limitations in current literature. First, it used peer-mediated instruction to deliver grade aligned mathematical content. Second, it targeted teaching mathematics to students with MS/ID, moving beyond basic *numbers and operations* and *measurement* skills of time and money. Third, this study effectively addressed semantic and executive functioning barriers to allow students with MS/ID to demonstrate they can learn the higher order thinking skill of mathematical problem solving. This study provides new evidence that peer tutors can effectively deliver instruction in mathematical word problem solving for students with MS/ID. Moreover, this study was significant in that it served to demonstrate students without disabilities can deliver systematic instructional strategies with fidelity, and students with MS/ID have the capacity to learn grade aligned mathematics with peer supports, when given the opportunity.

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APPENDIX A: PROCEDURAL FIDELITY

PEER-TUTOR DATA:
[5]Overall Peer Fidelity %: __________
IOA on Student Data %:__________
Post conference done w/ teacher: **Y** or **N**

PEER-TUTEE DATA:
Student Independence: ____/10
Problem solved correctly: Y N
Discrimination made: Y N

MEASUREMENT OF TREATMENT FIDELITY FOR SOLUTIONS PROJECT PEER STUDY FOR CHANGE PROBLEM TYPE

Peer-Tutee Code:
Peer-Tutor Code:
Circle one: Assigned Peer Non-Assigned Peer

In vivo Researcher:______
IOA/PF Researcher: ______

Date:							
Start Time:		**Stop Time:**					
Teacher Steps:	Teacher Delivery[1]	**Peer-Tutee Response:** Circle I if peer-tutee performs step with no prompt • Circle each prompt level used, starting from lowest to and stopping at most intrusive • If peer-tutee makes error and T corrects, mark EC • If peer-tutor skips prompt level, mark code "3" in left column					**Notes:**
1. Give cue "Solve the problem"							
2. Asks, "How do we get started?" Then reads the problem (optional)							
3. (1) Read the problem		I[2]	**RS**	**SV**	**M**	**EC**	
4. (2) Circle the what		I	**RS**	**SV**	**M**	**EC**	
5. (3) Find label in ?		I	**RS**	**SV**	**M**	**EC**	
6. (4) Use my rule		I	**RS**	**SV**	**M**	**EC**	
7. (5) Circle numbers		I	**RS**	**SV**	**M**	**EC**	
8. (6) Fill in number sentence		I	**RS**	**SV**	**M**	**EC**	
9. (7) + or -		I	**RS**	**SV**	**M**	**EC**	
10. (8) Make sets		I	**RS**	**SV**	**M**	**EC**	
11. (9) Solve		I	**RS**	**SV**	**M**	**EC**	
12. (10) Write answer		I	**RS**	**SV**	**M**	**EC**	
13. Peer-Tutor re-asks question; students state answer with label		I	**RS**	**SV**	**M**	**EC**	
Totals	/	/	/	/	/	/	
Quality of Peer-Tutor Delivery[3]							
Overall Peer-Tutee Engagement[4]							
IOA/PF Researcher: Did Peer-Tutor affect the learning environment?							

Peer-Tutor Delivery Codes[1]
+/✓ = teacher performs step (e.g., step 1, 2, 16) or waits appropriate time for student to perform steps on checklist
— = does not perform step
1= Wait time too long (>5s before delivering prompt
2 = Wait time too short (<3 s before delivering prompt)
3 = Prompts delivered out of order

APPENDIX A: PROCEDURAL FIDELITY CONT.

[2]Independent Correct Scoring:

- Numbers in parentheses correspond to steps on Peer-Tutee checklist
- "What's next" or "keep going" are not considered prompts (pacing prompts)
- If the Peer-Tutee reads the step but does not perform, the Peer-Tutor can start with a specific verbal prompt. This will not be considered skipping a prompt level.
- If Peer-Tutee automatically reads problem without step 1 code out of 9 steps (steps 3-10).
- Step 3 (1): Peer-Tutee needs to indicate read problem; If you are not taking data on student who communicates "read problem," give teacher a check under teacher delivery but do not circle anything in student response row for step 3.
- Step 2 is optional and only to be used when needed; do not count in total steps if unnecessary (i.e., student communicates "read the problem" independently)
- <u>The teacher stating the step name on student checklist IS considered a RS and NOT an I correct</u>
- Step 5 on PF checklist: Peer-Tutee may write independently or ask Peer-Tutor to label/provide labels
- Steps 11 and 12 (9 and 10): If student solves problem using a strategy other than manipulatives (e.g., finger counting, counting in head, knows number facts), mark both 9 and 10 correct. Make a note in far right column beside step 13 on PF checklist of other strategy used.
- Step 13 (10): If student writes numeral but no label, mark as correct but indicate in far right column "no label."
- Do not count steps 1, 2 & 13 on Peer-Tutee data. Peer-Tutee data should be out of 10.

[3] Quality of Delivery (enthusiastic, engaging, supportive of student) Key:
3 = High (enthusiastic, engaging, supported students, positive attitude, kept pace going)
2 = Moderate (delivery was adequate, included all steps but missed some student feedback, pace was moderate {20-25 min})
1 = Low (boring, missed/skipped steps, discouraging to students, very slow pace {lesson >25 min})

[4] Engagement:
3 = Active engagement
2 = Passive / Cooperative
1 = Not attending
0 = Resistant/Dismissed from Group due to Disruptive Behaviors

[5]If the Peer-Tutor's fidelity falls below 80%, a follow-up training must be scheduled as soon as possible. The Peer-Tutor will watch the recorded lesson with the experimenter and record his/her own procedural fidelity. The researcher and Peer-tutor will discuss steps missed or performed incorrectly. The Peer-tutor will not be able to teach a lesson again until after video conference and fidelity is re-evaluated to be 100% by the experimenter.

APPENDIX B: DATA COLLECTION INSTRUMENT

Student:	**Date/Session**					
10. Write answer	**Writes/Selects numeral and label**	10	10	10	10	10
9. Solve	**Pushes set into final circle**	9	9	9	9	9
8. Make sets	Adds from storage box or pushes into trash can	8	8	8	8	8
7. + or -	**Writes/selects "- or +" in**	7	7	7	7	7
6. Fill-in # sentence	**Writes numerals in # sentence**	6	6	6	6	6
5. Find "how many"	Circles #s in word problem	5	5	5	5	5
4. Use my rule	States rule	4	4	4	4	4
3. Find label in ?	Underlines label	3	3	3	3	3
2. Find the "what"	Circles nouns	2	2	2	2	2
1. Read the problem	S has T read problem	1	1	1	1	1
10. Write answer	**Writes/Selects numeral and label**	10	10	10	10	10
9. Solve	**Pushes set into final circle**	9	9	9	9	9
8. Make sets	Adds from storage box or pushes into trash can	8	8	8	8	8
7. + or -	**Writes/selects "- or +" in**	7	7	7	7	7
6. Fill-in # sentence	**Writes numerals in # sentence**	6	6	6	6	6
5. Find "how many"	Circles #s in word problem	5	5	5	5	5
4. Use my rule	States rule	4	4	4	4	4
3. Find label in ?	Underlines label	3	3	3	3	3
2. Find the "what"	Circles nouns	2	2	2	2	2
1. Read the problem	S has T read problem	1	1	1	1	1

Peer-Tutee Code: **Date/ Session**					
Total # Problems Solved independently Correct					
Total # of Steps Competed Independently Correct					
Total # of Correct Independent (+ or -) Discriminations (in Phases III & Maint. only; see step 7)					
Notes:					

Scoring Procedure	**Criteria for Mastery**
-Mark independent answers with / -Circle total number of independent correct answers -X number of correct discriminations	Correctly answers 2/2 problems independently for 2 consecutive sessions to move to next Phase. Bolded steps = critical steps (steps 6, 7, 9, 10)

APPENDIX C: PRESCREENING TOOL

Pre-Screening Tool Data Sheet

Student/Teacher: ________________________________ Date: ______________

Researcher: ______________________ Video: ________

Skill		Points	C/I	Notes
Number ID	Receptively ID numbers	1	+ -	1 2 3 4 5 6 7 8 9 10
Number ID	Verbally ID numbers*	1	+ -	1 2 3 4 5 6 7 8 9 10
More/less	More Fewer Expressive ID Fewer Expressive ID More	4	+ - + - + - + -	
Same/Different	Different (picture) Same (picture) Different (WP) Same (WP)	4	+ - + - + - + -	
Count manipulatives (scattered, moveable)	3 9	2	+ - + -	
Count pennies (non-moveable)	4 10	2	+ - + -	
Making sets	5 7 10	3	+ - + - + -	
Reading equation	Addition Subtraction	2	+ - + -	Make note of ANY part missed. 4 + 1 = 5 4 - 1 =3
Adding with sets	3+4= 7	1	+ -	Note if solved using different method (e.g., TouchMath, mental math, finger counting, tallies). Did student perform any part of this skill?
Subtracting with sets	7-5 = 2	1	+ -	Note if solved using different method (e.g., TouchMath, mental math, finger counting, tallies). Did student perform any part of this skill?
Identifying signs	Show me + Show me – Draw + Draw –	4	+ - + - + - + -	
Solve	Group Change Compare	3	+ - + - + -	

Score: _____

*If student has difficulty with all of the numbers on page, present on flashcards in random order. Also, if student inverses number (e.g., switches 9 and 6), present on flashcards in random order.

APPENDIX D: SOCIAL VALIDITY QUESTIONNAIRE

Social validity questionnaire for teachers and para-educators.

1. It is important for students with moderate/severe intellectual disability to learn mathematical word problem solving

5	4	3	2	1
Strongly Agree				Strongly Disagree

2. Using peers to deliver instruction was effective in teaching mathematical word problem solving (magnitude of change was significant)

5	4	3	2	1
Strongly Agree				Strongly Disagree

3. Using peers to deliver instruction was practical in reducing teacher time spent teaching mathematics one-on-one.

5	4	3	2	1
Strongly Agree				Strongly Disagree

4. The mathematical concept skills the students with MS/ID learned generalized to their daily mathematics

5	4	3	2	1
Strongly Agree				Strongly Disagree

5. Students with MS/ID benefitted socially from having a peer deliver instruction

5	4	3	2	1
Strongly Agree				Strongly Disagree

6. Having peers deliver instruction was cost effective

5	4	3	2	1
Strongly Agree				Strongly Disagree

Reflection/Comments: (Include benefits and drawbacks to using peers to deliver mathematical word problem instruction)

APPENDIX E: STUDENT PERCEPTION AND ATTITUDE SURVEY

Attitudes and Perceptions Survey for Peer-Tutors

1. I feel anxious/nervous when I have to be alone with a peer with disability

5 4 3 2 1
Strongly Agree — Strongly Disagree

What makes you feel this way or not feel this way:

____

____

2. I enjoy spending time alone with a peer with disability

5 4 3 2 1
Strongly Agree — Strongly Disagree

If 'Agree' why do you enjoy it/what things do you do together:

____

____

3. I would like peers with disability to be in my regular ed classes more often

5 4 3 2 1
Strongly Agree — Strongly Disagree

What classes do you have peers with disability in now?

____

____

What classes would you like to have peers with disabilities in more?

____

____

4. I have partnered with a peer with disability in class before

5 4 3 2 1
Strongly Agree — Strongly Disagree

What class were you in? What activities did you do together?

____

____

5. I have partnered with a peer with disability outside of class

5 4 3 2 1
Strongly Strongly
Agree Disagree
What activity where you doing? How did you choose to partner with them?

____

____

6. Peers with disability make learning in class harder than when they are not there

5 4 3 2 1
Strongly Strongly
Agree Disagree
If 'Agree" what makes it harder in class if they are there?

____

____

7. Learning to solve mathematical word problems can help peers with disability later in life

5 4 3 2 1
Strongly Strongly
Agree Disagree
If 'Agree" how do you think it may help them?

____

____

8. Peers with disability are a lot like me

5 4 3 2 1
Strongly Strongly
Agree Disagree
If 'Agree" how are they alike? If 'disagree' how are they different?

____
____

____
____

9. I enjoy being a peer-tutor to a peer with disability

5 4 3 2 1

Strongly Agree — Strongly Disagree

If 'Agree" what did you like the most? What did you like least?

____
____

____
____

10. I will ask to be a peer-tutor again after this study is over

5 4 3 2 1

Strongly Agree — Strongly Disagree

If 'Agree" what subject and/or activity would you like to be a peer-tutor for?

____
____

____
____

Reflection/Comments:

APPENDIX E: STUDENT PERCEPTION AND ATTITUDE SURVEY CONT.

Attitudes and Perceptions Survey for Peer-Tutees

1. I feel anxious/nervous when I have to be alone with a peer-tutor

5 4 3 2 1
Strongly Agree — Strongly Disagree

What makes you feel this way or not feel this way:

____

____

2. I enjoy spending time alone with a peer-tutor

5 4 3 2 1
Strongly Agree — Strongly Disagree

If 'Agree' why do you enjoy it/what things do you do together:

____

____

3. I would like to have a peer-tutor to be in more regular ed classes with me

5 4 3 2 1
Strongly Agree — Strongly Disagree

What classes do you have with peer-tutors now?

____

____

What classes would you like to have peers with disabilities in more?

____

____

4. I have partnered with a peer-tutor in class before

5 4 3 2 1
Strongly Agree — Strongly Disagree

What class were you in? What activities did you do together?

____

____

5. I have partnered with a peer-tutor outside of class

5 4 3 2 1
Strongly Agree ... Strongly Disagree

What activity where you doing? How did you choose to partner with them?

____

____

6. Being in a regular ed class makes me feel nervous/anxious

5 4 3 2 1
Strongly Agree ... Strongly Disagree

If 'Agree" what makes you feel nervous/anxious?

____

____

7. Learning to solve mathematical word problems can help me later in life

5 4 3 2 1
Strongly Agree ... Strongly Disagree

If 'Agree" how do you think it may help you?

____

____

8. Peers-tutors are a lot like me

5 4 3 2 1
Strongly Agree ... Strongly Disagree

If 'Agree" how are they alike? If 'disagree' how are they different?

____

____

9. I enjoy being with a peer-tutor

5 4 3 2 1

Strongly Agree — Strongly Disagree

If 'Agree" what did you like the most? What did you like least?

____

____

10. I will ask to have a peer-tutor again after this study is over

5 4 3 2 1

Strongly Agree — Strongly Disagree

If 'Agree" what subject and/or activity would you like to have a peer-tutor for?

____

____

Reflection/Comments:

APPENDIX F: STUDENT ASSENTS

Peer Sub-Study (Ley Davis) Student Assent ***Tutee Form***

UNCCHARLOTTE
The University of North Carolina at Charlotte
9201 University City Boulevard
Charlotte, NC 28223-0001
Project Solutions
College of Education
Phone: 704-687-8449
Fax: 704-687-1625

Assent Form for Minors

The Solutions Project: Strategy Instruction to Teach Math Problem Solving

You are being asked to join a math study. You will be taught a new way to solve math word problems. Project staff will come to visit you in your classroom and watch you work with your peer-partner to solve math word problems. We will also videotape you participating in some of the lessons. We hope this project will help you learn.

If you want to be in the study, you will do math every day with your peer-partner. You will learn how to solve math word problems from your peer-partner. Mrs. Ley Davis will be there every day to help your peer-partner teach you the steps for solving word problems and to watch you solve them.

You can ask questions at any time. You do not have to be in the study. Once you start the study, you can stop any time you want and no one will be mad at you.

We hope this new way of learning math will help you and other students learn more math, but we are not sure it will. This study will not hurt you in any way. It is designed to help you.

After we finish the study, we will write a report about the study. We will not use your name, but we will describe you in the study. After we write the report, we will share some things that we found out during the math study.

If you want to be in this study, please sign your name and write the date.

____________________________________ ____________________

Signature of Participant Date

____

Printed Name of Participant

Peer Sub-Study (Ley Davis) Student Assent ***Tutor Form***

The University of North Carolina at Charlotte
9201 University City Boulevard
Charlotte, NC 28223-0001
Project Solutions
College of Education
Phone: 704-687-8449
Fax: 704-687-1625

Assent Form for Minors

The Solutions Project: Strategy Instruction to Teach Math Problem Solving

You are being asked to join a math study. You will be partnering with a student with disability and learn how to teach them a new way to solve math word problems. Project staff will come to visit you in the special education classroom and teach you how to give instructions on solving math word problems to a peer with a disability. You will partner with a peer with disabilities and work with them every day. Project staff will train you how to do this and will watch you work with your peer-partner to solve math word problems. We will also videotape you participating in some of the lessons. We hope this project will help your peer partner with disabilities learn.

If you want to be in the study, you will teach math every day to your peer-partner. Mrs. Ley Davis will be there every day to help you teach you the steps for solving word problems and to watch your peer partner solve them.

You can ask questions at any time. You do not have to be in the study. Once you start the study, you can stop any time you want and no one will be mad at you.

We hope this new way of learning math will help you and other students learn more mathematics, but we are not sure it will. This study will not hurt you in any way. It is designed to help you.

After we finish the study, we will write a report about the study. We will not use your name, but we will describe you in the study. After we write the report, we will share some things that we found out during the math study.

If you want to be in this study, please sign your name and write the date.

____________________________________ ____________________

Signature of Participant Date

____

Printed Name of Participant

APPENDIX G: PARENTAL CONSENT

Peer Sub-Study (Ley Davis) Parental Consent Tutee Form

UNC CHARLOTTE
The University of North Carolina at Charlotte
9201 University City Boulevard
Charlotte, NC 28223-0001

Parental Informed Consent for Parents of Students with Disabilities

What are some things you should know about this research study?

You are being asked to give permission for your child to participate in a research study. To join the study is voluntary. You may refuse for your child to join, or withdraw your consent for your child to be in the study, for any reason, without penalty. Research studies are designed to obtain new knowledge. This new information may help people in the future. Your child may not receive any direct benefit from being in the research study. There also may be risks to being in research studies. Details about this study are discussed below. It is important you understand this information so that you can make an informed choice about your child being in this research study. You will be given a copy of this consent form. You should ask the researchers named below any questions you have about this study at any time.

What is the purpose of this study?

Our team has developed a method to teach students with moderate/severe intellectual disability and/or ASD how to master the concepts critical to solving word problems independently. While concurrently conducting the main study, we would like to also conduct sub-studies to determine if the concepts we have found success with can be generalized to other strategies (e.g., using an iPad, using a calculator; and using peers to deliver instruction). This study will be a '*sub-study*' of The Solutions Project, and will also serve as my dissertation study. The purpose of this sub-study will be to investigate the effectiveness of using ***general education peers*** to deliver mathematical word problem solving instruction.

Your child is being considered for this study because he or she has the prerequisite skills to begin working towards solving math word problems. The intervention will include using read alouds and a standard problem format to make the written problem accessible to nonreaders. Your student will be taught how to solve math word problems from a general education peer. They will use manipulatives and a student self-instruction checklist to solve math word problems. Mrs. Luann Ley Davis, (the primary researcher) will be present at all times to monitor and direct all student activity/learning.

Are there any reasons you should not be in this study?
Your child should not be in this study if he or she does not have a disability.
How many people will take part in this study? The Peer Sub-Study will recruit 5 general education peer-tutors and 4 middle school students with a disability to participate.
How long will your part in the study last?
Depending on how quickly the students learn the mathematical concepts, inclement weather, absences, holidays, workdays, etc., it is estimated that the study will last approximately eight weeks in length. Mrs. Ley Davis will come out to work your students' school and work with them every day to maintain consistency and to offset the issues mentioned. Each day Mrs. Ley Davis comes out (after the initial peer training/teaching) should take between 15-20 minutes, depending on each student. In short, she will teach the peer-tutor how to teach the steps of mathematical word problem solving. Your student will work with their peer-tutor to learn math word problem solving. Mrs. Ley Davis will monitor, guide, and take data. Only five general education peers and four students with disability will be selected. Once the study is underway, Mrs. Ley Davis will only work with one tutor/tutee pair (2 students) at a time, so all peers/students will not be needed every day, only one tutor/tutee pair, thus reducing the time needed for each tutor/tutee pair.
What will happen if your child takes part in the study?
We have worked with teachers of students with autism and moderate/severe intellectual disability over the past two years to develop math lessons based on current research. These lessons will include the tutor (general education peer) reading aloud the problem and teaching their peer-tutee (student with a disability) to solve the problem step-by-step with prompting and praise.
What are the possible benefits of being in this study?
This research is designed to benefit students with moderate and severe intellectual disability with enhanced math skills. Your child may benefit by learning to solve word problems and establishing relationships with peers.
What are the possible risks or discomforts involved from being in this study?
There are minimal risks. Your child may experience some nervousness about being observed or videotaped during implementation of the intervention. This risk will be minimized by using praise and encouragement during the instruction and by discontinuing videotaping if your student becomes too uncomfortable. .
What if we learn about new information or findings during the study?
You will be given any new information gained during the course of the study that might affect your willingness for you to have your child continue participation.
How will information be protected?
All paper records for this study will be kept in locked file cabinets. All electronic or computer records will be password-protected. Only members of the research team will have access to records that identify your child.

Participants will not be identified in any report or publication about this study. Although every effort will be made to keep research records private, there may be times when federal or state law requires the disclosure of such records, including personal information. This is very unlikely, but if disclosure is every required, UNC-Charlotte will take steps allowable by law to protect the privacy of personal information. In some cases, your child's information in this research study could be reviewed by representatives of the University, research sponsors, or government agencies (e.g., the FDA) for purposes of quality control or safety.

For purposes of student evaluation and research dissemination to professional audiences, some of the intervention sessions will be video-recorded. As part of your child's participation in this study, your child will be video-recorded. The investigators will take precautions to safeguard the video-recordings of your child by keeping them on a secure network drive or in a locked file cabinet. These video-recordings will be coded by an identification number rather than your child's name or any personal information. Upon the completion of this project, the individual recordings will be archived on secure networks at UNC Charlotte. Access to the video-recordings will be restricted to research personnel on this study unless you provide the additional video consents shown at the end of this form.

What if you want to stop before your part in the study is complete?

You can withdraw your child from this study at any time without penalty. The investigators also have the right to stop your child's participation at any time. This could be because your child has had an unexpected reaction, fails to respond to the intervention, or because the entire study has stopped.

Will you receive anything for being in the study?

There is no payment for your child's participation.

Will it cost you anything to be in the study?

It will not cost you anything to be in this study.

Who is sponsoring this study?

This research is funded by the Institute of Education Sciences through the U.S. Department of Education. This means that the research team is being paid by the sponsor for doing the study. The research does not, however, have a direct financial interest with the sponsor or in the final results of the study.

What if you have questions about the study?

You have the right to ask and have answered, any questions you may have about this research. If you have questions about the study (including payments), complaints, concerns, or if a research-related injury occurs, you should contact the researchers listed on the first page of this form.

What if you have questions about your rights as a research participant?

All research on human volunteers is reviewed by a committee that works to protect your rights and welfare. If you have questions or concerns about your rights as a research subject you may contact, anonymously if you wish, the Institutional Review Board at 704-687-1888 or by email to uncc-irb@uncc.edu.

Please detach the last 2 pages, fill-in the forms, and return to your child's teacher if you are willing to have your child participate.

Participant's Agreement

I have read the information provided above. I have asked all the questions I have at this time. I voluntarily agree for my child to participate in this study.

Child's Name

Signature of Parent Date

Printed Name of Parent

Signature of Research Team Member Obtaining Consent Date

Luann Ley Davis
Printed Name of Research Team Member Obtaining Consent

Contact Information (for mailing materials)

Address:

Phone Number:

Email:

<u>Video Permission</u>
In addition to the use of the video recordings that are essential to your participation in this project, it would be helpful to be able to use the recordings of you in other ways. Giving us permission to do this is optional and will in no way affect your or your child's ability to participate in the study. We would like you to indicate how you are willing for us to use these video recordings by initialing below. You are free to initial any number of spaces from zero to all of the spaces. We will only use the video recordings in ways that you agree to. In any use of the video recordings, we will not give any identifying information about you beyond what appears in the recordings. **Please initial:**

____The video recordings can be used in professional presentations.

____The video recordings can be used in educational trainings and university classrooms.

____The video recordings can be used for publications (e.g., instructional DVDs) related to this intervention program or study.

_____The video recordings can be used for web-based content related to this intervention program or study.

____

Signature of Parent Date

____

Printed Name of Parent

Peer Sub-Study (Ley Davis) Parental Consent Tutor Form

UNCCHARLOTTE
The University of North Carolina at Charlotte
9201 University City Boulevard
Charlotte, NC 28223-0001

Parental Informed Consent for Parents of Student Peers working with Students with Disabilities

<u>What are some things you should know about this research study?</u>
You are being asked to give permission for your child to participate in a research study. To join the study is voluntary. You may refuse for your child to join, or withdraw your consent for your child to be in the study, for any reason, without penalty. Research studies are designed to obtain new knowledge. This new information may help people in the future. Your child may not receive any direct benefit from being in the research study. There also may be risks to being in research studies. Details about this study are discussed below. It is important you understand this information so that you can make an informed choice about your child being in this research study. You will be given a copy of this consent form. You should ask the researchers named below any questions you have about this study at any time.

<u>What is the purpose of this study?</u>
Our team has developed a method to teach students with moderate/severe intellectual disability and/or ASD how to master the concepts critical to solving word problems independently. While concurrently conducting the main study, we would like to also conduct sub-studies to determine if the concepts we have found success with can be generalized to other strategies (e.g., using an iPad, using a calculator; and using peers to deliver instruction). This study will be a '*sub-study*' of The Solutions Project, and will also serve as my dissertation study. The purpose of this sub-study will be to investigate the effectiveness of using ***general education peers*** to deliver mathematical word problem solving instruction.
Your child is being considered for this study because he or she has been recommended by the staff at your students' school as a student that would be a great peer tutor. The intervention will include using read alouds and a standard problem format to make the written problem accessible to nonreaders. Your student will be taught how to deliver math instruction to a peer with a disability. They will use manipulatives and a student self-instruction checklist to solve math word problems. Mrs. Luann Ley Davis, (the primary researcher) will be present at all times to monitor and direct all student activity/learning.

Are there any reasons you should not be in this study?
Your child should not be in this study if he or she does not feel comfortable working with a peer that has a disability.
How many people will take part in this study? The Peer Sub-Study will recruit 5 general education peer-tutors and 4 middle school students with a disability to participate.
How long will your part in the study last?
Depending on how quickly the students learn the mathematical concepts, inclement weather, absences, holidays, workdays, etc., it is estimated that the study will last approximately eight weeks in length. Mrs. Ley Davis will come out to work your students' school and work with them every day to maintain consistency and to offset the issues mentioned. Each day Mrs. Ley Davis comes out (after the initial peer training/teaching) should take between 15-20 minutes, depending on each student. In short, she will teach your student (peer-tutor) how to teach the steps of mathematical word problem solving. Your student will teach the peer with a disability. Mrs. Ley Davis will monitor, guide, and take data. Only five general education peers will be selected to be tutors. Once the study is underway, Mrs. Ley Davis will only work with one tutor/tutee pair (2 students) at a time, so all peers/students will not be needed every day, only one tutor/tutee pair, thus reducing the time needed for each tutor/tutee pair.
What will happen if your child takes part in the study?
We have worked with teachers of students with autism and moderate/severe intellectual disability over the past two years to develop math lessons based on current research. These lessons will include the tutor (your student) reading aloud the problem and teaching their peer-tutee (student with a disability) to solve the problem step-by-step with prompting and praise.
What are the possible benefits of being in this study?
This research is designed to benefit students with moderate and severe intellectual disability with enhanced math skills. Your child may benefit by learning to solve word problems and establishing relationships with peers that have a disability.
What are the possible risks or discomforts involved from being in this study?
There are minimal risks. Your child may experience some nervousness about being observed or videotaped during implementation of the intervention. This risk will be minimized by using praise and encouragement during the instruction and by discontinuing videotaping if your student becomes too uncomfortable. .
What if we learn about new information or findings during the study?
You will be given any new information gained during the course of the study that might affect your willingness for you to have your child continue participation.
How will information be protected?
All paper records for this study will be kept in locked file cabinets. All electronic or computer records will be password-protected. Only members of the research team will have access to records that identify your child.

Participants will not be identified in any report or publication about this study. Although every effort will be made to keep research records private, there may be times when federal or state law requires the disclosure of such records, including personal information. This is very unlikely, but if disclosure is every required, UNC-Charlotte will take steps allowable by law to protect the privacy of personal information. In some cases, your child's information in this research study could be reviewed by representatives of the University, research sponsors, or government agencies (e.g., the FDA) for purposes of quality control or safety.

For purposes of student evaluation and research dissemination to professional audiences, some of the intervention sessions will be video-recorded. As part of your child's participation in this study, your child will be video-recorded. The investigators will take precautions to safeguard the video-recordings of your child by keeping them on a secure network drive or in a locked file cabinet. These video-recordings will be coded by an identification number rather than your child's name or any personal information. Upon the completion of this project, the individual recordings will be archived on secure networks at UNC Charlotte. Access to the video-recordings will be restricted to research personnel on this study unless you provide the additional video consents shown at the end of this form.

What if you want to stop before your part in the study is complete?

You can withdraw your child from this study at any time without penalty. The investigators also have the right to stop your child's participation at any time. This could be because your child has had an unexpected reaction, fails to respond to the intervention, or because the entire study has stopped.

Will you receive anything for being in the study?

There is no payment for your child's participation.

Will it cost you anything to be in the study?

It will not cost you anything to be in this study.

Who is sponsoring this study?

This research is funded by the Institute of Education Sciences through the U.S. Department of Education. This means that the research team is being paid by the sponsor for doing the study. The research does not, however, have a direct financial interest with the sponsor or in the final results of the study.

What if you have questions about the study?

You have the right to ask and have answered, any questions you may have about this research. If you have questions about the study (including payments), complaints, concerns, or if a research-related injury occurs, you should contact the researchers listed on the first page of this form.

What if you have questions about your rights as a research participant?

All research on human volunteers is reviewed by a committee that works to protect your rights and welfare. If you have questions or concerns about your rights as a research subject you may contact, anonymously if you wish, the Institutional Review Board at 704-687-1888 or by email to uncc-irb@uncc.edu.

Please detach the last 2 pages, fill-in the forms, and return to your child's teacher if you are willing to have your child participate.

Participant's Agreement

I have read the information provided above. I have asked all the questions I have at this time. I voluntarily agree for my child to participate in this study.

____
Child's Name

____
Signature of Parent Date

____
Printed Name of Parent

____
Signature of Research Team Member Obtaining Consent Date

Luann Ley Davis
Printed Name of Research Team Member Obtaining Consent

Contact Information (for mailing materials)

Address:

Phone Number:

Email:

Video Permission
In addition to the use of the video recordings that are essential to your participation in this project, it would be helpful to be able to use the recordings of you in other ways. Giving us permission to do this is optional and will in no way affect your or your child's ability to participate in the study. We would like you to indicate how you are willing for us to use these video recordings by initialing below. You are free to initial any number of spaces from zero to all of the spaces. We will only use the video recordings in ways that you agree to. In any use of the video recordings, we will not give any identifying information about you beyond what appears in the recordings. **Please initial:**

____The video recordings can be used in professional presentations.

____The video recordings can be used in educational trainings and university classrooms.

____The video recordings can be used for publications (e.g., instructional DVDs) related to this intervention program or study.

_____The video recordings can be used for web-based content related to this intervention program or study.

____
Signature of Parent   Date

____
Printed Name of Parent

APPENDIX H: PEER TUTOR EXPLICIT SCRIPT

Steps to task analysis student self-instruction checklist with scripted least intrusive prompts; tutor training

Instructional Cue: Tutor says "*Let's get started solving our word problems! Solve this word problem. Use your checklist, mat, and graphic organizer to help you*" and places the first of two problems on the tutees mat. Note: You can use pacing prompts which are NOT coded as prompts, such as "how do we get our problem started" (step 1 only), "keep going," and "what's next"? Do not read individual steps to the tutee unless the student points to the step and asks you to read.			
Step 1: Read the Problem			
Independent Response	**Least Intrusive Prompts**		
↓	**Verbal**	→ **Specific Verbal**	→ **Model/Incorrect**
Simply read the problem unless the tutee needs reinforcement for asking appropriately.	**Step 1 says read the problem.**	**Ask me to read the problem.** Wait for the tutee to ask.	**Say "read the problem please."** Wait for the tutee to ask, then read.
Step 2: Circle the "whats"			
Independent Response	**Least Intrusive Prompts**		
↓	**Verbal**	→ **Specific Verbal**	→ **Model/Incorrect**
Great job! The two "whats" are (noun #1) and (noun #2).	**Step 2 says circle the whats.**	**Find the "whats" in the problem and circle them. Remember the "whats" have pictures over them.**	Point to 1st picture and say, **Here is the 1st 'what-' (state noun #1). Circle it.** Wait for the tutee to circle, then repeat for 2nd 'what.'
Step 3: Find label in question			
Independent Response	**Least Intrusive Prompts**		
↓	**Verbal**	→ **Specific Verbal**	→ **Model/Incorrect**

Excellent job! The question asks, (read question), and you found the label- (state label).	**Step 3 says find label in question.**	**Can you find the question mark?** Wait for the tutee to find "?," then read the question. **The question says, (read question and highlight). Can you find the label or what we are solving for?** Wait for the tutee to find label in question, then prompt tutee to underline it and fill it in number sentence if s/he does not do it automatically.	Point to the "?" mark. **Here is the question. It says- (read question and highlight). Remember, the label is what we are solving for.** Point to the respective words as you read, **This question says, "how many (read label)/how much (read label)," so the label is (state label). Underline it.** Wait for the tutee to underline.
Step 4: Use my Rule			
Independent Response	**Least Intrusive Prompts**		
↓	**Verbal**	→ **Specific Verbal**	→ **Model/Incorrect**
***Change*: "You got it! 1 thing- (noun), add to it or take away, change."**	**Step 4 says use my rule.**	**Change: This is a Change problem. It is change because there is one thing-(noun). Can you tell me the rule using your hands and the word from the problem?** Wait for the tutee to respond.	Model the hand motion with chant. Wait for the tutee to repeat. Provide physical guidance if needed and break into chunks.
Step 5: Circle the numbers			
Independent Response	**Least Intrusive Prompts**		
↓	**Verbal**	→ **Specific Verbal**	→ **Model/Incorrect**
Nice work! For feedback, restate summary of sentences with numbers in them (e.g., "There were 3 sheep in the pen and 1 sheep got out.")	**Step 5 says circle the numbers.**	**How many (noun) were there to start with?** Wait for the tutee to respond. **How many (noun) did it change by?** Wait for the tutee to respond.	Point to 1st number and say, **circle (#). This is the starting amount.** Wait for the tutee to circle. Point to 2nd number and say, **circle (#). This is the amount it changed by.** Wait for the tutee to circle. Then summarize using sentences with numbers (see 1st column for example).
Step 6: Fill-in number sentence			
Independent Response	**Least Intrusive Prompts**		

↓	Verbal	→ Specific Verbal	→ Model/Incorrect
Nice work filling in the number sentence!	**Step 6 says fill-in number sentence.**	**Fill-in the number sentence using the numbers you circled in the word problem.** Wait for the tutee to fill-in number sentence.	Point to 1st number **(#)** in word problem and then point to the first box, **write (#) here.** Point to the 2nd number in word problem **(#)**, and then point to the second box, **write (#) here**.

Step 7: + or –
DISCRIMINATION STEP FOR ADDITION & SUBTRACTION

Independent Response	Least Intrusive Prompts		
↓	Verbal	→ Specific Verbal	→ Model/Incorrect
Yes, (ADD/SUBTRACT)! You are right!	**Step 7 says add or subtract.**	**Remember, we have to look for what happened in our word problem. Look in this sentence** (point to 2nd sentence with #) **and find the clue word.** Reread sentence and wait for the tutee to find the action verb or key word. **Do you need to add or subtract to solve the problem?** Wait for the tutee to say "add/subtract." Tutee should write "+/-" in number sentence. If not, prompt: **write (plus/minus) in the number sentence.**	**What happened in our word problem? Listen to this sentence** (reread 2nd sentence with number). **The clue word is (action verb/key word).** Act out or demonstrate clue word. **Did I add (noun) or take away (noun)?** Wait for the tutee to say "add/subtract." Tutee should write "+/-" in number sentence. If not, prompt: **write (plus/minus) in the number sentence.**

DISCRIMINATION STEP FOR ADDITION & SUBTRACTION:
We have to look for what happened in our word problem. This will help us figure out if we ADD or SUBTRACT. The second sentence with a number has clue words that tell us what happened (model pointing to second sentence with noun initially, and then fade your support so tutee has to locate during later trials). This sentence says…(reread sentence emphasizing the action/clue word, such as "more" or "fewer"). We have to look for the change action and the change amount. Does our clue word describe adding or subtracting to solve our problem?

"Keep going with your steps."			
Step 8: Make Sets			
Independent Response	**Least Intrusive Prompts**		
↓	**Verbal**	→ **Specific Verbal**	→ **Model/Incorrect**
Awesome job! **There were # (noun) to start with and you (added/took away) #.**	**Step 8 says make sets.**	**How many (noun) were there to start with? Make a set here** (point to "start" oval). Wait for student to respond. **Do you need to add or subtract?** Wait for the tutee to respond. If no response/incorrect, point to symbol in number sentence. **How many (noun) did it change by?** Wait for the tutee to respond. **(Add/take away) (#).** Wait for the tutee to perform action. If no response/incorrect response, model adding/taking away and have the tutee repeat.	Point to 1st number in number sentence and then to "start" oval as you say: **We need to make a set of (#) here to represent the number of (noun) there were to start with.** Wait for the tutee to make set. **Now, we need to (add/take away) (#) to represent how much (noun) changed by. Can you (add # / take away #)?** Wait for the tutee to perform action. If no response/incorrect response, model adding/taking away and have the tutee repeat.
Step 9: Solve			
Independent Response	**Least Intrusive Prompts**		
↓	**Verbal**	→ **Specific Verbal**	→ **Model/Incorrect**

Nice work! State numeral and label (e.g., 2 sheep).	**Step 9 says solve.**	**Move your changed set to the end and count.** Wait for the tutee to move set to "end" oval and count.	**Watch me first.** Move changed set to "end" oval and count. Move set back to "start" and say **Your turn.** Wait for the tutee to repeat.
Step 10: Write and State Answer			
Independent Response	**Least Intrusive Prompts**		
↓	**Verbal**	→ **Verbal & Gesture**	→ **Model**
Nice work! You're right! Read number sentence with answer and label (e.g., 3 sheep take away 1 sheep equals 2 sheep).	**Step 10 says write and state answer.**	**Count and write your answer in the number sentence.** Tutee should fill-in solution in number sentence. Point to the answer (# and label) on the tutees problem solving map and say **read me the answer.** Prompt tutee to say label if he/she does not.	**The answer is (# and label).** Write the solution in the number sentence and Be sure to say answer with label. Erase and say **"Your Turn! What was the answer to our problem?** Student should repeat with numeral and label.