EFFECTS OF A MULTI-COMPONENT INTERVENTION PACKAGE ON ACADEMIC SKILLS FOR STUDENTS WITH SEVERE DISABILITIES

by

Chelsi Rose Brosh

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Approved by:

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Dr. Fred Spooner

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Dr. Charles Wood

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Dr. Shawnee Wakeman

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Dr. Drew Polly

ABSTRACT

CHELSI ROSE BROSH. Effects of a multi-component intervention package on academic skills for students with severe disabilities. (Under the direction of DR. FRED SPOONER)

The current study evaluated the effects of a multi-component intervention package (modified schema-based instruction (MSBI) with systematic feedback in the consequent event) on mathematical problem-solving and embedded non-targeted science and English language arts (ELA) comprehension for three elementary students with moderate and severe intellectual disability (ID). Using systematic instruction with a system of least prompts, a task analysis and a graphic organizer with manipulatives, participants learned to solve group word problems: using addition to solve for the part-part-whole relationship. In addition to learning how to solve addition word problems, participants were also taught grade-aligned science and ELA concepts using non-targeted information (NTI) presented as instructive feedback in the consequent event. Generalization of mathematical problem-solving to a digital presentation using an iPad was also measured. In addition, this study also examined participant's ability to generalize mathematical problem-solving skills when stimulus supports (i.e., task analysis and graphic organizer) were faded from the instructional package. Results showed a functional relation between MSBI and mathematical problem-solving and between embedded NTI as systematic feedback in the consequent event and science and ELA knowledge. The findings of this study provide several implications for practice for using multi-component intervention packages to teach academic skills (MSBI to teach mathematical problem-solving while simultaneously presenting NTI as systematic feedback to teach discrete academic skills) to students with moderate and severe ID. Limitations of the current study and suggestions for future research are discussed.

DEDICATION

First, I dedicate this dissertation to my mother and father who have always encouraged me to follow my dreams. This is as much your accomplishment as it is mine, and I am forever grateful for your undying support and encouragement. Thank you for giving me the opportunity to pursue my dreams. Second, I dedicate this dissertation to my sister. Paige, I would not be who I am without you. To say that we are a team is an understatement and I could have never achieved this accomplishment without you.

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Chapter One: Introduction

Statement of the Problem

Federal policy and legislation has resulted in significant educational advances for students with moderate and severe disabilities. In 2001, schools became accountable for all students learning language arts, mathematics, and science (No Child Left Behind Act of 2001, NCLB; Every Student Succeeds Act of 2015, ESSA). Not only are schools required to provide access to grade-aligned content, they also are required to report on adequate yearly progress (AYP) on state and district-wide assessments (NCLB, 2002). It also is important to note the impact of the passage of the Individuals with Disabilities Education Act (IDEA) Amendments of 1997. This legislation mandates that all students have access to the general curriculum and specially designed instruction that addresses the unique needs of each student. Because schools are held accountable for AYP for all students and all students must have access to grade-aligned content, it is important to further investigate academic interventions for students with moderate and severe disabilities.

Combined with advocacy and legislation, the field of behavior analysis (BA) has greatly enhanced learning opportunities and the quality of life for individuals with severe disabilities in recent decades (Spooner & Browder, 2015). The first study to support the use of operant procedures, an extension of Skinner's experimental analysis of behavior (EAB), with a human participant was conducted by Fuller (1949). In this investigation, a person with a severe disability who was institutionalized was taught to raise his arm using a sugar-milk solution as a reinforcer. To further elaborate, the participant in this study was said to be in a vegetative state and staff members at the institutions thought he be unable to learn. After being deprived of food, staff members reinforced vertical hand-raising behavior by inserting the sugar-milk solution into the individuals mouth. Over the course of four experiments, the individuals rate of responding increased to approximately three vertical arm movements per minute. Interestingly, the individual also opened his mouth while raising his arm, indicating his desire for staff members to insert the sugar-milk solution into his mouth. This flagship study concluded that individuals with limited repertoires and complex challenges could learn skills using shaping procedures and reinforcement strategies.

Applied research in the area of BA analyzes variables with intent to improve the behavior under study (Baer, Wolf & Risley, 1968). Further, applied research that examines socially significant behavior is called applied behavior analysis (ABA). As the field of BA and ABA continued to advance, most work was conducted in institutional settings and demonstrated that students with moderate and severe disabilities could learn skills such as toileting (Azrin & Foxx, 1971), dressing (Azrin, Schaeffer, & Wesolowski, 1976), feeding (Ball, Seric, & Payne, 1971; Minge & Ball, 1967), and tooth brushing (Horner & Keilitz, 1975). During this time, Brown and colleagues (1979) argued that students with severe disabilities needed the opportunity to learn functional and age appropriate skills (Spooner & Browder, 2015). This argument pushed researchers to investigate the effects of behavior analysis on functional skill acquisition for students with moderate and severe disabilities and provided a vast array of evidence supporting the acquisition of important and socially significant behavior for this population. Given the standards-based reform and legislation that supports teaching academic content to all students, it also is important to investigate how the strategies of ABA have influenced the development of evidence-based practices (EBP) which are utilized in academic interventions.

ABA and EBPs. With federal policy and legislation raising the bar for academic instruction and inclusion of students with moderate and severe disabilities, educators are tasked with the challenge of planning and implementing effective instructional practices that best meet the needs of the diverse population they serve. Given the requirement to align core instruction to state and national standards, teachers often prioritize instructional targets and balance access to grade-aligned content with individualized and functional goals. Because educators sometimes find creating access to grade-level academic content for students with significant disabilities confusing (Browder et al., 2007), it is crucial to turn to instructional strategies based on behavior analysis and EBPs to best meet the diverse needs of this population.

Teaching academics to students with moderate and severe disabilities. Over a decade ago, researchers started to analyze published research on instructional practices for students from complex and diverse populations. Spooner, Knight, Browder, and Smith (2012) conducted a review of the literature published between 2003 and 2010 to explore EBPs for teaching academics to students with moderate and severe disabilities. Using the criteria and quality indicators established by Horner et al. (2005), a review of 18 studies established time delay and task analytic instruction as EBP for teaching academics to this population. Additionally, the studies reviewed taught chained and discrete responses using systematic prompting and feedback (i.e., time delay, system of least prompts, stimulus prompting/fading), error correction procedures and praise, task analytic instruction, massed, embedded, and distributed trials, and naturalistic teaching. Authors found that instructional components based on the principles of behavior analysis are effective in teaching chained and discrete academic skills for students with moderate and severe disabilities. One additional finding that is important to note is that researchers combined prompting procedures (i.e., time delay or system of least prompts) with methods of reinforcement (Spooner et al., 2012). While most research conducted has investigated literacy, there has been some work in investigating teaching grade-aligned mathematics and science for students with moderate and severe disabilities (Spooner et al., 2012). This work provides evidence that these strategies are effective in teaching skills across academic content areas (e.g., literacy, mathematics, and science).

Teaching mathematics to students with moderate and severe disabilities. To begin the investigation on mathematical practices, Spooner, Ahlgrim-Delzell, Harris, and Wakeman (2008) conducted a comprehensive literature review and meta-analysis on teaching mathematics to individuals with moderate and severe disabilities. Of the 68 experimental studies examined, most studies addressed numbers and computation (counting, calculation, or number matching) or measurement (time or money, Browder et al., 2008). Additionally, very few studies focused on algebra, geometry or data analysis. The work of Browder and colleagues also identifies EBPs for teaching mathematics for students with significant disabilities. Specific prompt fading procedure such as least intrusive prompts and time delay with feedback (i.e., systematic instruction), in vivo instruction (i.e., teaching real-life application for the principles of mathematics) and opportunities to respond (i.e., numerous opportunities to learn and practice desired responses) are identified as EBPs for teaching mathematics to this population. Authors note that instruction in mathematics for students with moderate and severe disabilities might be more effective if students are provided with opportunities to apply skills in real-life contexts (Browder et al., 2008). Following the work completed by Spooner et al. (2008), additional literature reviews investigating the current state of teaching mathematics to students with moderate and severe disabilities have been conducted (King, Lemons, & Davidson, 2016; Lemons, Powell, King, & Davidson, 2015; Spooner, Root, Saunders, & Browder, 2017), providing the field with further information on best practices for this complex population.

King, Lemons, & Davidson (2016) conducted a review of the literature published before May of 2014 specifically focusing on teaching mathematics to students diagnosed with autism spectrum disorder (ASD). Authors found that approximately 80% of interventions addressed computation and functional skills and most studies utilized promoting and contingent consequences delivered by teachers in one-on-one sessions. Lemons, Powell, King, and Davidson (2015) conducted a review of the literature published between 1989 and 2012 specifically focusing on teaching mathematics to students diagnosed with Down syndrome (DS). Authors found that most interventions focused on early mathematics skills (i.e., numeration, basic facts, computational procedures and measurement) and had favorable outcomes, however no studies were identified as meeting the criteria for methodological rigor. Most recently, Spooner, Root, Saunders and Browder (2017) conducted an updated EBP review, extending the work of Browder et al. (2008), to include literature published between 2005 and 2016 that addressed teaching mathematics to students with moderate and severe disabilities. Authors found a modest expansion in the scope of mathematical content addressed, specifically teaching problem-solving to students with moderate and severe disabilities. Additionally, authors identified systematic instruction, technology-aided instruction, graphic organizers, manipulatives, and explicit instruction as EBPs for teaching mathematics to students with moderate and severe disabilities. While the most recent literature reviews show a slightly expanded scope of content addressed and consistent instructional practices for teaching mathematical skills to students with complex learning needs, additional work is needed to teach students to problem solve, expand the scope of scope of mathematical content addressed, and investigate EBPs for teaching mathematics (Spooner et al., 2017).

Teaching mathematical problem-solving to students with moderate and severe disabilities. As shown in the modest expansion in the scope of mathematical literature published between 2005 and 2016 (Spooner et al., 2017), an increased emphasis on teaching mathematical problem-solving to students with moderate and severe disabilities has emerged. One promising strategy to teach mathematical problem-solving to students with moderate and severe disabilities is modified schema-based instruction (MSBI) ((Browder et al., 2017; Ley Davis, 2017; Root, 2017; Root & Browder, 2016; Root, Browder, Saunders, & Lo, 2016; Root, Spooner, Saunders, & Brosh, 2017; Saunders, Lo, & Browder, 2016). Modified from the schema-based approach of teaching problem-solving to students with high incidence disabilities (Jitendra & Hoff, 1996), MSBI combines schema-based instruction (SBI) with systematic instruction and evidence-based stimuli supports to best meet the needs of students with moderate and severe disabilities. While published research on teaching mathematical problem-solving to students with moderate and severe disabilities using MSBI shows promising results, additional research is needed to replicate results and further investigate the components of MSBI.

Teaching English language arts (ELA) to students with moderate and severe disabilities. Browder, Wakeman, Spooner, Ahlgrim-Delzell, and Algozzine (2006) conducted a comprehensive review of 128 studies on teaching reading to individuals with significant cognitive disabilities. Authors compared studies to the National Reading Panel's (2000) components of reading instruction to provide a synthesis of the research on reading for individuals with students with moderate and severe disabilities. Results indicated that most studies focused on sight word identification (43%), fluency (26%), comprehension (15%) and vocabulary instruction taught through picture identification (15%). Few studies focused on phonics and decoding (>1%) and phonemic awareness (0%)., and comprehension. This review supports the use of systematic prompting techniques and mass trial instruction. Authors note that additional work is needed to provide access to all components of reading instruction to this population and to investigate the effects of phonemic instruction for students with moderate and severe disabilities and students who use assistive and augmentative communication (AAC) devices.

To expand the work of identifying EBPs in the area of ELA, Browder, Ahlgrim-Delzell, Spooner, Mims and Baker (2009) conducted a literature review to investigate the application of time delay as an instructional procedure to teach word and picture recognition to students with severe disabilities. Authors analyzed a total of 30 articles published between 1975 and 2007. Using the criteria proposed by Horner et al. (2005) of having at least 5 studies meeting all quality indicators, at least 3 researchers represented, at least 20 participants across the set of studies and at least 3 geographic locations represented, time delay was found to have sufficient evidence to be considered an EBP. Results indicated strong support for using time delay to teach students with moderate disabilities sight words with some support for teaching symbol recognition to students with severe disabilities. Authors note that future research is needed to investigate the theoretical foundation of the practice and how it is used in diverse settings. Additionally, work is needed to investigate how sight word and symbol identification can be used to further reading instruction and comprehension for this population.

Teaching science to students with moderate and severe disabilities. Minimal research has been done to explore science instruction for students with severe disabilities. Courtade, Spooner, and Browder (2007) conducted a comprehensive review of experimental studies published between 1985 and 2005 on teaching science to students with significant disabilities. Eleven studies were identified, with most of the studies focusing on science in personal and social perspectives. In the single study experiments identified, all the studies suggest that individuals benefit from highly specialized instructional techniques, such as modeling, errorless learning, and time delay (Courtade et al., 2007). Courtade and colleagues note that the interventions utilized in the science studies identified incorporated response prompt methods similarly found in evidence-based reading and mathematics research. This finding could suggest that evidence-based instructional strategies are not content specific, but rather applicable to a wide range of skills for students with moderate and severe disabilities.

While the field has identified specific strategies and practices that are effective in teaching specific academic content, it also is important to recognize the overlap between academic domains. For example, graphic organizers have been effective in teaching mathematics, literacy, science, and social studies. Additionally, the use of behavior analytic principles is effective in teaching a variety of functional and academic skills. It is important to use strategies that are most effective in skill acquisition and easily generalizable. One strategy with evidence to support its effectiveness is embedding non-targeted information (NTI) in academic and functional instructional packages. NTI is a strategy to concurrently teach non-targeted academic and functional content during non-related interventions (Wolery, Schuster, & Collins, 2000). Over two decades of research supports the effectiveness of embedding NTI in chained tasks to increase instructional efficiency and produce broader learning (Wolery et al., 1991).

Purpose of Study and Research Questions

The purpose of this study is to investigate the effects of multi-component instructional package (modified schema-based instruction (MSBI) with systematic feedback in the consequent event) on mathematical problem-solving and embedded non-targeted science and ELA concepts using instructive feedback in the consequent event for students with moderate/severe intellectual disability (ID). Further, this research combines EBPs and research-based strategies for students with moderate and severe disabilities to create access to grade-aligned academic content across domains. While some research supports the use of MSBI to teach mathematical problem-solving to students with moderate and severe disabilities, there is a limited amount of work investigating the acquisition of non-targeted literacy and science knowledge embedded in mathematical interventions. The following research questions will be addressed in this study.

1. What is the effect of a multi-component instructional package (MSBI with systematic feedback in the consequent event) on the number of steps independently solved correct on a task analysis for solving addition mathematical word problems by students with moderate/severe ID?
2. What is the effect of a multi-component instructional package (MSBI with systematic feedback in the consequent event) on non-targeted science concepts by students with moderate/severe ID?

3. What is the effect of a multi-component instructional package (MSBI with systematic feedback in the consequent event) on non-targeted ELA concepts by students with moderate/severe ID?
4. What is the effect of a multi-component instructional package (MSBI with systematic feedback in the consequent event) on generalized problem-solving to an iPad by students with moderate/severe ID?
5. What is the effect of a multi-component instructional package (MSBI with systematic feedback in the consequent event) without the student checklist on the number of steps independently solved correct on a task analysis for solving addition mathematical word problems by students with moderate/severe ID?
6. What is the effect of a multi-component instructional package (MSBI with systematic feedback in the consequent event) without the student checklist and graphic organizer on the number of steps independently solved correct on a task analysis for solving addition mathematical word problems by students with moderate/severe ID?
7. What are the perceptions of teachers and students with moderate/severe ID on a multi-component instructional package (MSBI with systematic feedback in the consequent event) on mathematical word problem-solving and the acquisition of non-targeted science and ELA concepts?

Significance of Study

This study contributes to the work of general curriculum access for students with moderate and severe disabilities in many ways. By recognizing the time constraints and the challenges associated with general curriculum access in the classroom, this study combines strategies that are proven effective for teaching academic skills to this population. While most research focuses on one academic domain (i.e., literacy, mathematics, science), this study is significant in that it combines EBPs and the principles of behavior analysis to teach core content across domains and standards. By addressing content across domains and standards in one intervention package, teachers potentially have more time to address individualized goals and functional skills in the classroom, creating a balance between academic and functional skills instruction.

Next, this study adds to the work of Browder et al. (2017) supporting the use of MSBI to teach students with moderate and severe disabilities how to solve mathematical word problems. The National Council of Teachers of Mathematics (NCTM, 2000) identifies problem-solving as the cornerstone of mathematical learning. Teaching mathematical computation simply addresses how to solve problems; however, it does not teach individuals when and why to apply the skills. If individuals are unable to solve problems, the usefulness of mathematical ideas, knowledge, and skills are severely limited (NCTM, 2000, p.182). Schema-based instruction (SBI) is an evidence-based practice for teaching mathematical word problem-solving to students with mild disabilities (Jitendra, Nelson, Pulles, Kiss, & Houseworth, 2016) and has many instructional features that benefit students with moderate and severe disabilities. For example, visual representations help to summarize information, cognitive strategy instruction aids with comprehension, and strategy instruction assists with priming the mathematical problem structure (Jitendra et al., 2016).

SBI uses a conceptual teaching approach that combines mathematical problem-solving and reading comprehension strategies (Jitendra, 2008). The main components of

SBI are (a) identify the problem structure to determine problem type, (b) visually represent the structure of the problem and organize information from the problem, and (c) explicit instruction on the schema-based problem-solving method (Jitendra et al., 2015). Individuals with intellectual disabilities (ID) have difficulties identifying relevant information, translating problems to mathematical equations and solving problems using basic mathematics computation skills (Erez & Peled, 2001; Jitendra et al., 1998; Montague, 1997). While this approach has been evidence to support its effectiveness for students with high incidence disabilities, additional supports are needed for students with moderate and severe disabilities. For example, additional problem structure might be needed to support comprehension, concrete visual diagrams might assist with organization of information, and the use of a task analysis might support student independence for solving mathematical word problems.

MSBI combines SBI with the principles of behavior analysis and EBPs for students with moderate and severe disabilities, including a task analysis, a read aloud, and systematic prompting and error-correction. Additionally, visual supports and explicit structure is given to the supports in the intervention package. There is a growing body of literature to support the use of MSBI to teach word problem-solving for students with moderate and severe disabilities (Browder et al., 2017; Ley Davis, 2017; Root, 2017; Root & Browder, 2016; Root, Browder, Saunders, & Lo, 2016; Root, Spooner, Saunders, & Brosh, 2017; Saunders, Lo, & Browder, 2016). While studies support the effectiveness of MSBI and mathematical problem-solving for students with moderate and severe disabilities, implementing such interventions take excessive time and energy, making the intervention difficult to implement in the classroom setting. One possible solution for this and a strategy that has been proven to be a successful method to accomplish the goal of increasing teaching efficiency is embedding non-target information during instruction (Wolery, Holcombe-Ligon, Werts, & Cipolloni, 1993). When teachers embed non-targeted information within instructional trial sequences, students can incidentally learn content without direct instruction (Smith, Shuster, Collins, & Kleinert, 2011). By embedding literacy comprehension questions in mathematical word problems using instructive feedback in the prompt and consequent events, (Fiscus, Schuster, Morse, & Collins, 2002) teachers increase instructional efficiency by allowing a student to acquire more stimuli (Wolery & Doyle, 1992).

Finally, this study contributes significantly by adding to the research to support embedding non-targeted content within discrete and chained tasks. Through the principles of behavior analysis and embedding systematic feedback in the consequent event, this study will investigate the participants' ability to acquire non-targeted, grade aligned academic content across domains. The research to support embedding non-targeted information in chained and discrete tasks is largely based on embedding academic content in functional skill instruction (Collins, Karl, Riggs, Galloway, & Hager, 2010; Fiscus, Schuster, Morse, & Collins, 2002; Karl, Collins, Hager, & Ault 2013; Taylor, Collins, Schuster, & Kleinert, 2002; Wall & Gast, 1999). Few studies investigate embedding core content in focused intervention packages (Collins, Evans, Creech-Galloway, Karl, & Miller, 2007; Collins, Hall, Branson, Holder, 1999; Falkenstine, Collins, Schuster, & Kleinert, 2009) and embedding functional knowledge within core content instruction (Collins, Hager, Creech-Galloway, 2011). This investigation adds to the research supporting interventions that embed non-targeted information for students with moderate and severe disabilities.

By combining the work of Browder and colleagues and Collins and colleagues, this study will significantly add to the research to support general curriculum access through multi-component instructional packages. Additionally, this study will also provide a practical solution for embedding multi-academic, grade-aligned instructional content in one intervention package, providing teachers with a time efficient means for addressing general curriculum access for students with moderate and severe disabilities.

Delimitations

It is important to recognize the delimitations of this study. First, purposeful selection will be used when identifying participants for this study. Participants will be selected based on prerequisite skill repertoire, including the ability to count with one-to-one correspondence, make sets up to nine, and identify numbers 0 to 10. Participants also will be selected based on their communication ability. Preference was given to students who have a consistent mode of functional communication with the ability to expressively respond (vocally or via an augmented and alternative communication device (AAC)) to vocal requests. Because of the selection and inclusion screening procedures, future replication might be challenging.

Second, this study will be implemented in a self-contained classroom for students with moderate and severe disabilities. While students will be given access to grade-aligned academic content, instruction will not occur in the general education classroom or by the general education teacher. The setting of this study has the potential to hinder incidental learning opportunities, peer interaction, and direct access to general education content as presented to students who participate in the general education curriculum.

Third, this study will target one problem type. Participants will not be required to discriminate or distinguish key information from math word problems to identify problem type. Additionally, students will not be required to distinguish between math function (i.e., deciding whether to add or subtract in the problem). This investigation will focus solely on solving group word problems using addition. Due to the age of participants and the scope of mathematical instruction, addition is typically introduced prior to the introduction of subtraction and distinguishing between operations.

Definitions of Terms

Applied Behavior Analysis (ABA). Applied behavior analysis is the science in which the principles of behavior are applied to improve socially significant behavior (Baer et al., 1968, 1987; Cooper, Heron, & Heward, 2007).

Consequent Event. Following a students' response during direct instruction (Fiscus, Schuster, Morse, & Collins, 2002).

Evidence-based Practices (EBP). Originating in the field of medicine (Odom, Brantlinger, Gersten, Horner, Thompson, & Harris, 2005), EBPs are intended to address the gap between research and practice. Evidence-based practices (EBP) are teaching practices that have scientific evidence to supports their effectiveness.

General Curriculum Access. Providing students with disabilities to the same age- and grade-equivalent curriculum as their typically developing peers across all academic domains.

Graphic Organizer. A visual tool that shows the relative positions of elements and their relationships to one another to help students conceptually understand and solve problems (Ives & Hoy, 2003).

Instructive Feedback. Presenting extra information following students' responses during direct instruction. Students are not expected to respond to this information (Werts, Wolery, Gast, & Holcombe, 1996)

Modified Schema-based Instruction (MSBI). A strategy based on schema-based instruction (SBI) that embeds elements of systematic instruction and applied behavior analysis (ABA) to provide additional structure and support to problem-solving instruction. Key elements of MSBI include the use of graphic organizers, rules associated to specific problem types, the use of a task analysis, and the use of prompting and reinforcement.

Manipulatives. Concrete or virtual objects that aid in understanding and solving abstract mathematical concepts and problems (Bouck et al., 2014).

Non-targeted Information (NTI). Embedding non-related content to instruction or daily routines to enhance learning opportunities for students with disabilities.

Prompting. Any assistance (verbal, gestural, or physical) provided to a learner to assist in acquiring or engaging in a targeted behavior or skill (Wong et al., 2015).

Reinforcement. With his work in operant conditioning, B.F. Skinner discovered that the behavior of an organism could change using reinforcement which is provided after a desired response (1938). Reinforcement increases the likelihood of a behavior occurring in the future.

Schema-based Instruction (SBI). Schema-based instruction (SBI) uses a conceptual teaching approach that combines mathematical problem-solving and reading comprehension strategies to teach individuals to problem solve (Jitendra, 2008). Three essential elements of SBI include (a) identification of the problem structure to determine the problem type, (b) use of visual representations of the structure to determine problem type and to organize information from the problem, and (c) explicit instruction on the schema-based problem-solving method (Jitendra et al., 2015).

Support Stimuli. Instructional tools or prompts used to help an individual make a desired response and develop stimulus control a natural cue or response and a controlling prompt.

Systematic Instruction. Originating from the principles of behavior analysis, systematic instruction has over 60 years of research to support its effective in teaching discrete, chained, community and daily living skills to individuals with disabilities (Spooner, Browder, & Mims, 2011).

System of Least Prompts. A strategy for transferring stimulus control ( ) that consists of a target stimulus, hierarchy of at least two prompts, and the opportunity to respond. If an error or no response is made following the presentation of the target stimulus, the least intrusive prompt is delivered an additional opportunity to respond is provided. This process continues until all of the prompts in the least-to-most hierarchy have been delivered or a correct response is made (Doyle, Wolery, Ault, & Gast, 1988).

Task Analysis. A task analysis involves breaking a complex skill into smaller, teachable units (Cooper et al., 2007). The purpose of using a task analysis is to make the teaching process more manageable during teaching and skill acquisition (Wong et al., 2015).

Time Delay. Time delay is a nearly errorless stimulus transfer procedure used to facilitate learning (Touchette, 1971). Within instruction or an activity, a brief delay occurs between the opportunity to use the skill and instructions or prompts to allow the learner to respond without assistance (Wong et al., 2015). Time delay procedures focus on fading prompts to increase independence.

Chapter Two: Review of Literature

With an increased emphasis on accountability and the inclusion of students with severe disabilities in statewide testing (NCLB, 2001; 2016), it is important to identify effective interventions and strategies to teach grade-aligned content across academic domains. The following chapter will provide a foundation for the proposed multi-component instructional package to teach mathematical problem-solving, grade-aligned science standards, and literacy comprehension to students with severe disabilities. Prior to introducing the multi-component instructional package, a brief review of the history of general curriculum access for students with severe disabilities will be reviewed. Next, the primary components of the proposed multi-component instructional package will be reviewed to include the academic domains, targeted skills, and standards. As shown in the theory of change in Figure 1, three primary components are proposed in a multi-component instructional package to provide access to the general curriculum across multiple academic domains for students with severe disabilities. The three components include: MSBI, NTI, and behavior analysis.

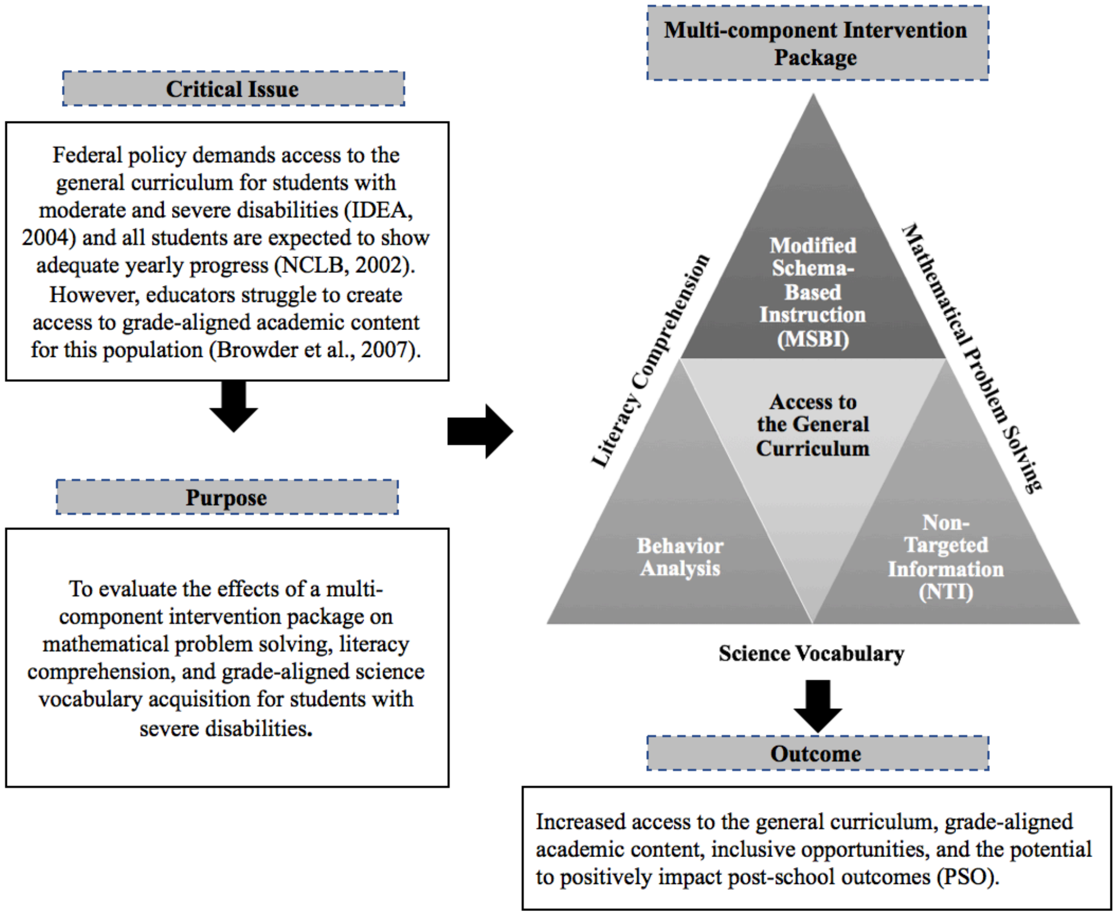


Figure 1. Theory of Change. Based on the demand to provide general curriculum access to students with moderate and severe disabilities, it is critical to identify and establish practices that combine EBPs to address academic skills across domain areas.

History of General Curriculum Access

With the passing of the original federal law (Education for All Handicapped Children Act, P. H. 94-142, 1975), many children with severe disabilities went to school for the first time (Spooner & Browder, 2015). As a result of the complexities associated with meeting the needs of this population in the public school setting came rapid developments in pedagogy which resulted in a shift toward more inclusive environments and increased expectations for students with severe disabilities (Dukes & Darling, 2017;

Spooner & Browder, 2015). Over 25 years later, the No Child Left Behind (NCLB) Act of 2001 (2006) has increased school accountability and the inclusion of grade-aligned academic content (English language arts, mathematics, and science) for all students. Research has been done to identify EBPs and evaluate the work of academic interventions that meet the needs of individuals with severe disabilities.

English Language Arts

Browder, Wakeman, Spooner, Ahlgrim-Delzell and Algozzine (2006) conducted a comprehensive review of 128 studies on reading instruction for individuals with significant cognitive disabilities. Studies included in the review were (a) published in a peer-reviewed journal in English between 1975 and 2003, (b) included at least one participant with a diagnosis of significant cognitive disability, (c) had a targeted intervention teaching reading or picture identification as the primary focus, including experimental data, and (d) utilized an experimental or quasi-experimental design. After coding for reading components, the comprehensive review revealed that most studies targeted vocabulary, specifically identifying functional sight words (Browder et al., 2006). Approximately one third of the studies targeted picture identification; however less than one third of the studies included contained a measure of comprehension (Browder et al., 2006). Only 10% (*n*=13) of studies targeted phonics instruction and only 4% (*n*=5) of studies targeted phonemic awareness. Continuing, only 36 studies (*n*=28%) targeted fluency.

The work of Browder et al. (2006) revealed that students with severe disabilities can learn to identify sight words, pictures, and symbols related to literacy. The results of this study also identified strong evidence for teaching students with significant cognitive disabilities to read using systematic prompting in massed trial format. Additionally, research supports using systematic prompting, such as time delay, to teach sight word identification (Browder et al., 2006). Further research is needed to explore how to address phonemic awareness, phonics, and comprehension. Authors suggest that future research might indicate that practices effective in teaching students without disabilities might be effective in teaching students with severe disabilities and/or that this population needs specialized and individualized supports to learn to read (Browder et al., 2006).

Browder, Ahlgrim-Delzell, Spooner, Mims and Baker (2009) conducted a literature review to investigate the effects of using time delay to teach literacy to students with severe disabilities. A total of 30 articles published in peer-review journal in English between the years of 1975 and 2007 were included in the review. Each article was reviewed for meeting sufficient evidence utilizing the quality indicator standards by Horner et al. (2005). The seven quality indicators reviewed include sufficient description of the (a) participants and setting, (b) dependent variable, (c) independent variable, (d) baseline procedures, (e) experimental control/internal validity, (f) external validity, and (g) social validity. Of the 30 peer-reviewed articles reviewed, authors found that 22 articles met all seven quality indicators proposed by Horner et al. (2005). The results of this literature review found an adequate number of experiments (n=22) were implemented across five different states with over 66 participants to be considered an EBP for teaching early literacy skills (e.g., picture and sight word recognition). Authors also indicate the importance of utilizing quality indicator standards and clearly defining the targeted practice. For this literature review, authors specifically examined studies that defined time delay as a delay in teacher prompting, not student responding. Future research should explore how practices are defined and combined with specific strategies when exploring the evidence base to identify EBPs for teaching grade-aligned English language arts to individuals with severe disabilities.

To continue the work of identifying EBPs for teaching grade-aligned content to students with severe disabilities, Hudson and Test (2011) conducted a literature review to determine the level of evidence for using shared story reading to promote literacy. Shared story reading is an intervention used to promote access to age-appropriate literature through reader-listener interactions in which a story is read aloud and student interaction with the ready and the story is supported. Literature published in peer-reviewed journals or doctoral dissertations involving participants with extensive support needs using shared story reading as the intervention to measure literacy skills were included in the review. Using the quality indicators developed by the National Secondary Transition Technical Assistance Center (NSTTAC; Test et al., 2009), six total studies were reviewed to identify the presence or absence of a strong description of the (a) participants, (b) setting, (c) dependent variables, (d) independent variables, (e) procedures, (f) results, and (g) social validity. Using the 20 indicators established by NSTTAC (2009), all six studies were found to meet 19 of the 20 quality indicators, meeting the standard for acceptable quality research by NSTTAC. The results of this literature review indicate a moderate level of evidence for establishing shared story reading as an EBP for promoting literacy for students with severe disabilities.

Science

A comprehensive review of the literature was conducted to evaluate the EBPs in teaching science content to students with severe developmental disabilities between 1985 and 2009 (Spooner, Knight, Browder, Jimenez, & DiBiase, 2011). The purpose of this review was to identify the degree to which science content was taught to students with severe disabilities and to evaluate instructional procedures utilized in science as EBP. Studies included in the review (a) utilized single-subject design, (b) were published in a peer reviewed journal in English between 1985 and 2009, (c) included at least one participant who was classified as having a severe developmental disability, and (d) included an intervention that focused on teaching science content (Spooner et al., 2011).

A total of 17 articles were included in the review. Out of the 17 total articles, five studies were identified as having a strong level of evidence (30%) and an additional nine studies (52%) were identified as meeting a moderate level of evidence. These 14 studies (82%) were conducted using systematic instruction and evaluated to identify and determine EBPs for teaching science content to students with severe disabilities. Of the 14 studies, six studies (42%) utilized task analytic instruction, seven studies (50%) utilized constant time delay, and one study (>1%) utilized progressive time delay. Systematic instruction was embedded in general education lessons in 5 of the 14 (36%) quality studies reviewed. Additionally, 12 of the 14 studies (86%) used multiple systematic instruction strategies within the same intervention (Spooner et al., 2011).

Six of the eight science standards outlined in the National Science Education Standards by the National Research Council (NSES; NRC, 1996) were found across the 14 quality and acceptable studies included in the review (Spooner et al., 2011). One study addressed unifying concepts (>1%), six studies fell within the standards of physical science (43%), three studies addressed life science (21%), three studies fell within the standard of earth and space science (21%), and one study addressed science as inquiry

(>1%). Additionally, this review sought to identify how to teach science to students with severe disabilities. The outcomes suggest that components of systematic instruction may be effective in teaching science skills, specifically using a task analysis to teach chained tasks and time delay to teach discrete skills in science.

Mathematics

Browder, Spooner, Ahlgrim-Delzell, Harris, and Wakeman (2008) conducted a comprehensive review and meta-analysis of 68 studies on teaching mathematics to individuals with moderate and severe disabilities. Authors included articles that (a) were published in peer-reviewed journals in English between the years of 1975 and 2005, (b) included at least one participant diagnosed as having a significant cognitive disability, (c) had an intervention that focused on teaching academic mathematics skills; and (d) used an experimental or quasi-experimental design for group or single-subject studies (Browder et al., 2008). A frequency analysis of the coded National Council of Teachers of Mathematics (NCTM) components and corresponding mathematics skills showed 37 studies (40.3%) addressed numbers and operations (e.g., counting, calculations and matching numbers), 36 studies included measurement skills involving money and time (53%) and two studies addressed algebra (e.g., solving word problems, determining equivalence, and quantifying sets) skills (3%). Additionally, two studies (3%) focused on geometry skills (recognizing and matching shapes) and two studies (3%) focused on data analysis and probability, including graphing within self-monitoring.

To continue, the work of Browder et al. (2008) sought to identify EBPs to recommend for teaching mathematics for students with significant cognitive disabilities. Systematic instruction was found to have the strongest evidence of support and was identified as an EBP to teach mathematics to students with significant cognitive disabilities (*n*=34; 50%). Next, strong support was found for in vivo instruction. In vivo instruction included participants applying learned skills to real-world settings (e.g., store, restaurant) utilizing the mathematics skills (Browder et al., 2008). Browder et al. (2008) identified the need to extend the work to identify effective methods to other subgroups within the population, provide more examples of effective methods, and expand the scope of mathematical content address. Authors suggest additional research is needed in all components of mathematics to evaluate the extent to which students can learn and generalize these skills for enhanced life outcomes (Browder et al., 2008).

Some work has been done to investigate the effects of mathematical interventions for students who are identified as having a specific diagnosis of Down syndrome (Lemons, Powell, King, & Davidson, 2015) and ASD (King, Lemons, & Davidson, 2016). Lemons, Powell, King, and Davidson (2015) conducted a literature review to identify math interventions for children and adolescents diagnosed with Down syndrome. This review sought to identify empirically validated interventions that demonstrate sufficient methodological rigor for children and adolescents with Down syndrome. Nine studies published in English, peer-reviewed journals between the years of 1989 and 2012 with participants diagnosed with Down syndrome between the ages of 5 and 21 years were included in the review. Each article was coded using adapted rubrics from Jitendra, Brugess, and Gajria (2011) to determine a level of evidence available for interventions addressing mathematical instruction for children and adolescents diagnosed with Down syndrome. Results indicate that most studies focused on early mathematical skills (e.g., one-to-one correspondence and number identification) with favorable outcomes, however no studies included in the review met the standard for having adequate research quality. Additional work is needed to investigate and increase rigor and methodology on interventions used to teach mathematics to individuals with Down syndrome, including individuals with severe disabilities.

King, Lemons, and Davidson (2016) conducted a literature review to identify math interventions for children and adolescents diagnosed with ASD. Twenty-one studies published in English, peer-reviewed journals before May 2014 including participants identified as having a diagnosis of ASD and interventions directly related to the development of mathematical skills were included. Using the quality standards identified by What Works Clearing House (2014), each article was reviewed and coded for meeting the standards set as having sufficient evidence. Consistent with Browder et al. (2008), authors note that explicit instruction with prompting and positive consequences remain the standard for addressing the mathematical needs for students with disabilities. While there is some research to support mathematical instruction utilizing video modeling, assistive technology, and peer tutoring, additional work is needed to validate these instructional techniques. Results indicated that most studies reviewed targeted computational or functional skills and utilized prompting and consequence-based procedures. Additional work is needed to further define, investigate, and explore interventions that address higher level mathematical skills and specific intervention practices.

Most recently, Spooner, Root, Saunders, and Browder (2017) conducted an updated review of the published research on teaching mathematics to students with moderate and severe developmental disability published between 2005 and 2016. In their review, Spooner et al. (2017) parallel the work of Browder et al. (2008) by using similar inclusion criteria and coding of studies by NCTM standards and effect sizes to quantify single-case data using a common metric. After screening a total of 63 studies screened, 36 studies were found to meet the inclusion criteria to be included in the review. Authors found the majority of studies addressed the NCTM standards of numbers and operations (n=23; 64%) and algebra (n=11, 30%). The additional articles reviewed addressed measurement skills (n=7; 19%), geometry (n=5; 13%), and data analysis skills (n=2; >1%). It is important to note that seven studies addressed more than one NCTM standard.

The majority of skills targeted in published research between 2005 and 2016 fall within the NCTM standard of numbers and operations and include early numeracy skills, counting on, calculating a percentage, addition, and subtraction (Spooner et al., 2017). In the last decade, an increased focus on algebra and grade-aligned geometry with a decreased focus on measurement in research on mathematics for individuals with moderate and severe disabilities has been found (Spooner et al., 2017).

It also is important to recognize the EBPs used across interventions. Five EBPs were utilized in the high and adequate quality studies in the review: systematic instruction, technology aided instruction (TAI), graphic organizers, manipulatives, and explicit instruction. Systematic instruction is defined as the use of time delay, system of least prompts, most-to-least prompts, simultaneous prompting, stimulus prompting/fading and the use of chaining (Browder et al., 2008). TAI includes the use of electronic devices or a virtual network that is used intentionally to increase or improve daily living, productivity, and recreation capabilities (Odom et al., 2015). Graphic organizers, specifically designed for mathematics, are diagrams that show the relative position of elements and their relationship to one another to help conceptually organize and solve a problem (Ives & Hoy, 2003). Manipulatives are defined as virtual or concrete objects that aid in the understanding and solving of abstract mathematical concepts (Bouck, Satsangi, Taber Doughty, & Courtney, 2014). Explicit instruction is defined as a series of supports and scaffolds that guide the learning process in small steps with clear explanations and demonstrations of the targeted skill with embedded practice and feedback until mastery is achieved (Archer & Hughes, 2011).

In the review conducted by Spooner et al. (2017), systematic instruction (e.g., time delay, prompting, fading, chaining) was used in the majority of studies (53%). It is important to note that over 86% of single-case design studies included in the review utilized systematic prompting (19 of 22). TAI was utilized in nine of the 36 studies included in the review (25%). Eight of the included studies utilized graphic organizers (22%). The use of manipulatives was found with 14 of the included studies (39%). And finally, explicit instruction was utilized in eight of the studies reviewed (22%).

The work of Spooner et al. (2017) provides additional evidence that students with moderate and severe disabilities can learn grade-aligned mathematics across standards. Additionally, an increase in published research, slight expansion in the scope of standards addressed in research, and the use of EBP has increased following the 2008 review conducted by Browder et al. While there was only a slight expansion on the scope of content addressed, the overall research published on teaching mathematics to students with moderate and severe developmental disability has increased in frequency from 2.7 published studies per year to 3.2 (Spooner et al., 2017). Prior to this review, only one study targeted problem-solving (Neef, Neeles, Iwata, & Page, 2003). Spooner et al. found an increased focus on problem-solving (e.g., Browder, Trela, et al., 2012; Creech-Galloway et al., 2013; Jimenez et al., 2008; Root, 2016). In addition to the slight expansion of the scope addressed, the work of Spooner et al. (2017) supports the use of TAI, manipulatives, graphic organizers, and explicit instruction as EBPs for teaching mathematics to learners with moderate and severe disabilities.

Authors suggest a need for future research to expand on problem-solving and expand the scope of content of skills addressed in research. Replication is needed to identify and compare components of various treatment packages. It also is critical to address skill generalization and show conceptual understanding under various conditions and application within context (Spooner et al., 2017).

Teaching Mathematical Problem-solving

In the past decade, research on teaching problem-solving to students with severe disabilities has increased (Spooner et al., 2017). In reviewing the current literature on teaching problem-solving, it is important to consider the history of teaching problem-solving to students with disabilities. The following section will discuss in detail the components of mathematical problem-solving, SBI, MSBI, and the current literature that supports teaching students with severe disabilities to solve mathematical word problems using MSBI.

Mathematical Problem-Solving

Mathematical competency, specifically in problem-solving, is utilized daily. In everyday life, individuals are required to solve problems that require computation (e.g., having enough money to make a purchase or enough ingredients to make a recipe. Competent problem- solvers might have increased accessibility and independence in the community due to their understanding of solving simple problems. Without problem-solving instruction, individuals only learn how to compute for a final solution, rather than the why and when to use and apply mathematical skills (Browder et al., 2017).

For students to be successful problem-solvers, it is critical for students to learn viable strategies for solving. First, students must learn how to adequately identify key information presented in the problem, plan to solve using appropriate strategies and techniques, and carry out the computational work (Goldman, 1989). In teaching students to be successful problem-solvers, instruction should emphasize both conceptual understanding and efficient execution of processes and strategies. SBI has been shown to effectively teach mathematical word problem-solving to students with high incidence disabilities (Jitendra, Nelson, Pulles, Kiss, & Houseworth, 2016; Jitendra et al., 2015).

Schema-Based Instruction (SBI)

SBI is a strategy that involves identifying the underlying problem structure before solving the problem. Students are taught to represent the information in the problem visually (e.g., schematic diagram), execute a plan for solving using a heuristic taught through direct instruction, and check the solution (Jitendra et al., 2015). Jitendra and Hoff (1996) suggest that three steps are required to successfully solve word problems; problem schemata, action schemata, and strategic knowledge. First, the individual must be able to define the schemata, or the necessary information to recognize and represent the situation depicted in the problem. After successfully defining the problem schemata, one must be able to identify the semantic relations underlying the word problem. That is, the individual must be able to identify the action that needs to take place to solve the problem. During this step in the problem-solving process, the individual must also adequately plan for solving the sequence of steps required to problem solve. Finally, the third and final step required to problem-solve is to identify and utilize a set of procedures that can be effectively executed to reach a solution (Marshall, 1990, 1993).

Prior to identifying a specific mathematical operation to successfully solve a word problem, a student must be able to identify, interpret, and organize key information presented in the problem. SBI uses schema identification instruction to highlight a logical structure that organizes the information presented in verbal or written word problems (Marshall et al., 1987). Students are then taught to organize the information and compose a representation of the problem prior to solving.

There are three problem types that characterize most additional and subtraction word problems: group, compare, and change (Jitendra & Hoff, 1996). Group problems, which utilize addition, involve two distinct groups that combine to form a larger, new group. Compare problems utilize subtraction, in which two distinct groups or values are compared to one another to identify the difference between the two. The change problem type, which is dynamic in that the problem-solver must identify which operation to use (addition or subtraction) involves a beginning amount that is manipulated. The beginning amount either increases, by adding to the starting amount, or decreases, by taking away from the starting amount. An example of each problem type is found in Table 1.

Table 1.

Word Problems by Problem Type

Problem Type	**Example**
Group	Mark has 2 shirts. He also has 4 pairs of pants. How many pieces of clothing does Mark have?
Change	Lori had $5.00. She spent $3.00 at the store.

	How much money does Lori have left?
Compare	Marshall has 9 dog toys. Martin has 5 dog toys. How many more dog toys does Marshall have than Martin?

There is research to support the effectiveness of using SBI to teach students with high-incidence disabilities to successfully solve mathematical word problems. In a seminal study conducted by Jitendra and Hoff (1996), third and fourth grade students with learning disabilities were taught to solve mathematical word problems using a schema-based direct instruction strategy. Using a multiple probe across participant design, students were taught to solve change, group, and compare problems. Results also showed that students were able to distinguish between word problem type and maintain performance level after intervention ceased. It is important to note that this study was conducted with three elementary participants diagnosed with learning disabilities and further replication is necessary to explore schema-based instructional strategies for students with varying and complex learning needs.

To extend the research on schema-based strategy instruction, Jitendra, DiPipi and Perron-Jones (2002) investigated the effects of mathematical problem-solving for four middle school students diagnosed with learning disabilities who were identified as low-performing in mathematics. Using a multiple probe across participant design, all students were able to learn to successfully solve multiplication and division word problems. Most specifically, students were taught to (a) identify the problem type by drawing a picture and (b) develop a plan for setting up the mathematical sentence for one-step and multistep problems prior to solving (Jitendra et al., 2002). Results generalized to novel word problems and students successfully maintained the effects of the strategy instruction following the termination of the intervention.

Due to the various and complex steps needed to solve a word problem (Parmar, Cawley, & Frazita, 1996) and linguistic challenges (Fuchs et al., 2008), solving word problems can be particularly challenging for students with more complex learning needs. Even with SBI, deficits in literacy, comprehension, and language for students with moderate and severe disabilities present barriers for accessing and understanding key information presented in word problems (Browder et al., 2017). It is important to consider modifications that might be necessary to help individuals access SBI. Some research has been done to investigate the use of a modified schema-based intervention package.

Modified Schema-Based Instruction (MSBI)

Students with disabilities may have deficits in working memory, organization, and attention. These deficits may cause additional difficulties when learning to solve mathematical word problems. In addition to providing extensive practice in each component of word problem-solving, it is important to turn to practices and strategies that are proven effective for students with severe disabilities. To make schema-based instruction more accessible to students with complex needs, an intervention package based on MSBI can be utilized and contains the following components (e.g., read alouds, task analysis, graphic organizers, manipulatives, visual supports).

Read alouds. To reduce cognitive load and increase accessibility, mathematics problems and each step of the problem-solving process is presented using a read aloud method in MSBI (Root, 2017; Root, Browder, Saunders, & Lo, 2017; Root, Saunders, Spooner, & Brosh, 2017; Saunders, 2014). For non-readers, or individuals who requested additional support, the information needed to solve the problem was presented orally. Read alouds provide assistance with reading requirements for individuals who are not proficient readers or individuals who lacked the prerequisite skills necessary to access the information presented in a written format (Browder et al., 2007; Neef et al., 2003).

Task analysis. A task analysis involves breaking a chained behavioral skill into smaller, more digestible, components in order to teach a new skill (Wong et al., 2014). A self-instruction checklist with visual supports is provided to individuals, outlining the specific steps necessary to solve the problem (Root, 2017; Root, Browder et al., 2017; Root, Saunders et al. 2017; Saunders, 2014). The self-instruction checklist breaks down the problem-solving method in an easy-to-follow and more digestible format for students needing more explicit guidance. Compared to traditional SBI which utilizes heuristics to aid students in the problem-solving process, task analytic instruction reduces working memory and eliminates the requirement of prerequisite literacy skills necessary to understand and follow a heuristic (Saunders, 2014).

Graphic organizers. To help reduce working memory deficits, a graphic organizer providing a visual representation of the problem is presented to help organize key information (Zahner & Corter, 2010). Graphic organizers help to visually represent the problem and action associated to the problem. Compared to traditional SBI which requires individuals to draw or create their own visual representations of the problem, MSBI presents color-coded graphic organizers with visual supports and teaches key problem components (e.g., identifying what the problem is about and the action that takes place in the problem, Browder et al., 2017; Saunders, 2014).

Manipulatives. To help students who lack mathematics fact recall, manipulatives or representations made on paper may be needed to help represent the problem for individuals who need more support (Bouck et al., 2014). Manipulatives are utilized in MSBI as small counters to represent quantity amounts and manipulated on a graphic organizer to help organize, represent, and solve for the final amount. Manipulatives can be presented virtually using a technology platform (Saunders, 2014) or using concrete objects (Root, 2017; Root, Browder et al., 2017; Root, Saunders et al. 2017; Saunders, 2014). While both virtual and concrete manipulatives use may be appropriate for providing additional support in the problem-solving process, virtual manipulates may help individuals achieve mastery with greater accuracy and achieve increased independence (Bouck et al., 2014) and might be preferred by individuals when given the option between concrete or virtual manipulative use (Saunders, 2014).

Visual supports. Visual supports are concrete representations that provide information about an activity, routine, or expectation that aids in the acquisition of skill development and mastery (Wong et al., 2014). Visual supports are provided in each word problem with key information presented in the form of pictorial representation, on the self-instruction checklist to aid with understanding the steps necessary to follow the problem-solving process, and on the graphic organizers to help with visually organizing the information presented in the problem and solving for the final amount (Root, 2017; Root, Browder et al., 2017; Root, Saunders et al. 2017; Saunders, 2014).

Research to Support MSBI

Browder et al. (2017) developed an intervention to teach students with moderate intellectual disability to solve addition and subtraction word problems. Throughout this three-year project, additional studies (Root, 2017; Root, Browder et al., 2017; Root, Saunders et al. 2017; Saunders, 2014) were conducted to field test and evaluate specific components of the intervention.

Saunders (2014) investigated the effects of SBI delivered through computer-based video instruction (CBVI) on the acquisition of mathematical problem-solving skills and the ability to discriminate problem type for three elementary students diagnosed with ASD and moderate ID. Additionally, this study investigated the participants' ability to generalize skills to a paper-and-pencil format. Using a single-case multiple probe across participant design, participants learned to solve and discriminate word problems using scripted lesson plans, task analytic instruction, read alouds, video modeling, rules associated to problem types, graphic organizers, story grammar instruction, story mapping, and the use of virtual manipulatives. Results showed a functional relation between SBI delivered through CBVI and each participant's ability to solve, discriminate, and generalize word problem-solving skills. The results of this study indicated that SBI could be modified with appropriate and necessary supports (i.e., scripted lesson plans, task analytic instruction, read alouds, video modeling, rules, graphic organizers, story grammar instruction, story mapping, and virtual manipulatives) to meet the diverse and complex needs of individuals diagnosed with ASD and moderate ID. Additional research is needed to investigate the generality of results and to identify key components of the intervention package.

Root (2017) invested the effects of MSBI on algebra problem-solving for four middle school students diagnosed with ASD and moderate ID. Using a multiple probe across participants design, participants learned to solve group word problems that involved the missing-whole and missing-part of an equation. In addition to mathematical problem-solving, key math vocabulary was taught using constant time delay (CTD). Participants were taught how to use an iPad that displayed a task analysis with embedded verbal prompts to complete each step of the algebra word problem using a self-instruction sheet. Results showed a functional relation between CTD and the acquisition of mathematics vocabulary terms and between MSBI and algebra word problem-solving. Additionally, participants were able to generalize problem-solving skills when supports were faded. Additional work should investigate the use of MSBI to address higher level mathematical problem-solving.

Root, Browder et al. (2017) evaluated the effects of MSBI on the mathematical word problem-solving skills of three elementary students diagnosed with ASD and moderate ID. Using a multiple probe across participants with an embedded alternating treatment design, participants learned to solve one-digit compare mathematical word problems using a problem-solving mat, graphic organizer, self-instruction sheet, and subtraction word problems. Materials were presented to participants as laminated sheets and concrete manipulatives or via technology device (iPad 3). The SMARTnotebook© software was used to display the graphic organizer and the virtual manipulatives. Results showed a functional relation between MSBI and word problem-solving across all participants. Additionally, when given a choice between conditions (virtual or concrete materials), all participants preferred the virtual condition. Participants were able to maintain treatment effects following completion of the intervention. The results of this study show promising evidence that individuals with ASD and ID who have significant support needs can learn to solve word problems given manipulatives, graphic organizer, task analysis, and systematic instruction. Future research should investigate which specific components of the intervention contribute to student outcomes and generalization of students' mathematical problem-solving (Root, Browder et al., 2017).

Root, Saunders et al. (2017) investigated the effects of MSBI on solving personal finance word problems for middle school students diagnosed with moderate ID. Using a multiple probe across participants design, participants learned to solve two-digit addition and subtraction compare word problems using a calculator or iDevice (i.e., iPhone or iPad). Participants were given a worksheet with a compare word problem and graphic organizer, laminated self-instruction sheet, and a calculator or iDevice. After identifying important information from the problem (i.e., if the problem was related to something on sale or leaving a tip), participants were taught to follow the steps of a task analysis and solve for the final answer. Results showed a functional relation between MSBI with a calculator or iDevice on solving group word problems with two digits and a decimal point across all participants. While this study shows promise that individuals with moderate ID can learn to solve two-digit addition and subtraction word problems related to personal finance scenarios, additional work is needed to investigate the generalizability of the intervention. Future research should focus on solving problems embedded in real scenarios across various settings.

Browder et al. (2017) investigated the effects of MSBI with an embedded pictorial task analysis, graphic organizer and systematic prompting with feedback on teaching addition and subtraction mathematical problem-solving to students with moderate ID. Using a multiple probe across student dyad design, eight participants (four dyads) were taught to discriminate between problem types and solve using a self-instruction checklist, graphic organizers, manipulatives, rules, and story-based word problems. Results showed a functional relation between MSBI, discrimination between problem type, and solving for the correct solution. Additionally, participants were able to generalize results to the SMARTboard™ and were able to solve some problems presented in video format. This study showed promise that instruction could be effective when delivered in small group format. Future research should investigate the effects of MSBI on solving addition and subtraction word problems, as well as solving higher level mathematical problems, for individuals with complex and diverse learning needs. A component analysis is necessary to identify the most relevant instructional practices embedded in the intervention package.

Summary

Saunders (2014), Root (2017), Root, Browder, et al. (2017) and Root, Saunders, et al. (2017) have modified the work of Jitendra and Hoff (1996) to meet the needs of students with severe disabilities. By providing systematic and explicit supports (e.g., read alouds, task analytic instruction, graphic organizers, and visual supports), the instructional package has shown promise in teaching students with severe disabilities to solve mathematical problem-solving. With the multiple instructional components included in the MSBI approach, additional research is needed to investigate the addition of embedded instructional content and skill development within this problem-solving model.

Acquisition of Functional and Academic Content When Presented as NTI

To increase instructional efficiency and produce broader learning (Wolery et al., 1991), it is important to identify strategies that allow students to acquire skills and behaviors that are not directly taught (Wolery, Schuster, & Collins, 2000). Over two decades of research supports the use of non-targeted information (NTI, “non-target stimuli,” Wolery et al., 2000) to concurrently teach non-targeted academic and functional content to individuals with moderate and severe disabilities. Stimuli presented during instructional sessions that are not directly taught can be classified as non-targeted information (NTI, Wolery et al., 2000). Literature supports embedding NTI in the antecedent or consequent event using a response prompt procedure during academic and functional skill instruction to teach non-targeted academic and functional content to individuals with moderate and severe disabilities. There are two approaches for embedding functional and academic content when presented as NTI: (a) identifying core content that can be embedded into functional applications, and (b) identifying functional application to embed within the core content (Collins, Karl, Riggs, Galloway, & Hagar, 2010).

Response-prompting procedures are identified as an EBP for teaching students with moderate to severe disabilities (Collins, 2007; Westling & Fox, 2009). Response prompting procedures that have resulted in effective and efficient instruction of NTI include (a) constant and progressive time delay, (b) simultaneous prompting, (c) system of least prompts, and (d) graduated guidance. A brief review of the literature supporting response prompt procedures used to embed NTI in functional and academic content is presented.

Constant and Progressive Time Delay

Time delay is a procedure that focuses on fading the use of prompts utilized during instructional activities (Touchette, 1971; Neitzel & Wolery, 2009). The two types of time delay procedures are progressive and constant (Cooper, Heron & Heward, 2007. When using a constant time delay procedure, there is no delay between the instruction and prompt when a learner is first learning a skill whereas in progressive time delay a gradual increase is presented between the instruction and prompt delivered (Neitzel & Wolery, 2009). The three main components of constant and progressive time delay include a cue and target stimulus (antecedent), the learner response (behavior), and the feedback delivered in the consequent event. Both constant and progressive time delay procedures have been used to embed NTI in functional and core content instruction.

Stinson, Gast, Wolery, and Collins (1991) investigated the use of progressive time delay to teach four students, ages nine and ten years old, with moderate intellectual disabilities to read sight words while embedding definitions of the target words incidentally in consequent statements. Using a multiple probe across stimuli design, all students acquired their target words (bakery information, danger applications, pharmacy, housewares, etc.) and at least 50% of the incidental and observational words and definitions exposed as non-targeted information (i.e., “Where do you buy cakes?” and “Caution means to be careful”). In this study, instruction was delivered in a small-group setting, allowing students to learn through observation of the other students target words and incidental information. Authors note that additional research should be conducted to investigate the format of instruction for students with moderate to severe disabilities.

A study conducted by Collins, Branson, and Hall (1995) investigated the effects of constant time delay on reading key words from cooking products with embedded definitions presented as incidental information in the feedback statements delivered by peer tutors. Using a multiple probe across stimuli design, results indicate that four teenage students diagnosed with moderate to severe disabilities were taught to identify keywords (instant hot chocolate mix, muffin mix, and microwave popcorn) using constant time delay and acquired some non-targeted cooking definitions (i.e., add, hot, water, cup, stir, etc.). For example, individuals were taught to identify to identify the words ‘cup’ and ‘spoon’ and acquired cooking definitions such as ‘stir’ and ‘mix.’ Results of this study generalized across materials, persons, and settings. While this study shows the potential effects of using peer tutors to provide systematic classroom instruction, further research should investigate ways to include peer tutors in more age-appropriate and leisure activities.

Fiscus, Schuster, Morse, and Collins (2002) investigated whether students with moderate to severe disabilities would acquire related information presented as instructive feedback embedded in the prompt and consequent event and unrelated instructive feedback delivered in the consequent event. Using a multiple probe across behavior design, results indicated CTD was effective in teaching three of the four elementary students all three food preparation skills (i.e., preparing cheesing and crackers, waffles with syrup, and chocolate milk) and three of the four students were taught some of the related instructive feedback stimuli (i.e., reading words related to the recipe). Three of the four students were taught 100% of the unrelated instructive feedback stimuli while the fourth student acquired 80% of the information. Authors note that embedding instructive feedback stimuli when teaching chained task may result in students learning additional information.

Extending the constant time delay research base by embedding non-targeted information in the task directive when teaching communication skills, Roark, Collins, Hemmeter, and Kleinert (2002) investigated constant time delay for teaching receptive identification with embedded non-targeted manual signs presented in the antecedent condition. Using a multiple probe across behavior design, four secondary students with moderate to severe disabilities were taught to receptively identify packaged food items (i.e., chocolate, coffee, eggs, spaghetti, etc.) using constant time delay and acquired the non-targeted manual signs associated with the packaged food items with an average of 60% in the final probe. As the researcher asked the participant to point to specific packaged food items, the researcher paired the food items presented with its appropriate manual sign, however did not request the participant to sign the item identified. Authors note that additional research should compare constant time delay with other prompting procedures when including non-targeted information.

Collins, Hager, and Galloway (2011) investigated the effects of embedding functional content during core content (English language arts, science, and mathematics) instruction for thee middle school students with moderate disabilities. Using a multiple probe across behavior design replicated across participants, results indicated that all students acquired, maintained, and generalized functional and core content presented within the same lesson. To embed functional content with core content, participants were taught to identify information found in the news adding to grade level sight word and vocabulary (language arts), cooking skills or appropriate dress based on weather conditions adding to the properties of elements in the periodic table (science), and computation of sales tax for items appearing in advertisements adding to order of operations (mathematics).

Falkenstine, Collins, Schuster, and Kleinert (2011) investigated the acquisition of academic skills as chained and discrete tasks presented as NTI for secondary students with moderate to severe disabilities. Using a multiple probe design with conditions across behaviors replicated across participants, results indicated that all participants acquired their targeted stimuli (identifying time) utilizing the CTD procedure and showed gained on non-targeted discrete (identifying quarter until, quarter after, and half past the hour) and chained tasks (setting time on a wristwatch). This investigation adds to the literature base, demonstrating that both core content from the general curriculum and functional skills from the student's individualized education plan (IEP) can be addressed simultaneously.

Simultaneous Prompting

One effective response prompting procedure to teach individuals with moderate and severe disabilities discrete and chained tasks is simultaneous prompting (Morse & Schuster, 2004). Simultaneous prompting is an errorless learning response prompt procedure that involves the presentation of the discriminative stimulus (S^D), or task direction, followed immediately by the presentation of a controlling prompt (Morse & Schuster, 2004).

A study conducted by Parrott, Schuster, Collins, and Gassaway (2000) evaluated the effectiveness of simultaneous prompting to teach students with moderate to severe disabilities a chained task (i.e., handwashing) with non-targeted information (i.e., hot and cold water, the palm and back of your hand) presented in the consequent event as instructive feedback. Using a multiple probe across participant design, simultaneous prompting was effective in teaching five primary-aged participants to follow a 16-step task analysis to wash their hands and all students acquired some of the non-targeted information presented as instructive feedback. Authors not that additional research should investigate the effects of student history and the number of exposures on the acquisition of instructive feedback stimuli.

A study conducted by Smith, Schuster, Collins, and Kleinert (2011) investigated the effects of simultaneous prompting on acquisition, maintenance, and generalization of identifying functional sight words (i.e., food items from local restaurants) with embedded classification of food items (non-targeted) in the task directive for high school individuals with moderate to severe disabilities. Using a multiple probe across behavior and replicated across participant design, results indicated that all participants successfully identified the target words (onion loaf, steak, cobbler, etc.) and classified the menu items into categories as a result of the treatment package. Authors indicate that additional work should examine simultaneous prompting with embedded NTI in the S^D when teaching skills aligned with grade level academic core content.

Fetko, Collins, Hager, and Spriggs (2013) evaluated the effects of using peer tutors to teach a chained leisure skill (i.e., an UNO card game) using simultaneous prompting with embedded science core content (i.e., a host is an organism in which a parasite lives; a meter is a basic unit for volume, an asteroid is a rocky ball of ice, and chromosomes are threadlike structures that contain genetic information) facts presented as non-targeted information during instructive feedback. Using a multiple probe across participant design, results indicated that all students met or made progress toward criterion on the leisure skill and two of the three students acquired all four core content facts. Two of the three participants in this study were diagnosed with moderate intellectual disability with the third participant being diagnosed with a learning disability. It is important to note that while one participant diagnosed with a moderate ID did not meet criterion on the leisure activity, he did acquire 100% of the core content facts. Interesting, the second participant diagnosed with moderate ID reached criterion for the leisure activity but acquired 0% of the core content facts. The findings of this study indicate the need for further research on including core content during functional and leisure activities.

Karl, Collins, Hager, and Ault (2013) investigated the effects of a simultaneous prompting procedure in teaching four secondary students with moderate intellectual disability to acquire and generalize core content (i.e., interpreting the meaning of jargon, solving real word mathematical problems, describing the effects of forces on the motion of objects) embedded in a functional, cooking activity. Using a multiple probe design, results indicated that all participants learned core content during a cooking activity. Participants in the study learned to read and define age appropriate content, compute percentages in an applied problem, and identify applications of force. Authors note that embedding core content within functional activities can help increase the efficiency of instruction. Further research is needed to investigate other systematic instructional strategies when embedding core content in functional activities.

System of Least Prompts

The system of least prompt utilizes a least-to-most prompting procedure in which a hierarchy of prompts is used to teach discrete and chained tasks (Neitzel & Wolery, 2009). Within this prompting system, the first level of prompts constantly allows the learner to respond independently and the remaining levels are sequenced based on the level of assistance required. The last level of the hierarchy results in the learner performing the behavior correctly (Neitzel & Wolery, 2009). Currently there is one study (Taylor, Collins, Schuster, & Kleinert, 2002) that investigated the effects of a system of least prompts on the acquisition of NTI for individuals with moderate and severe disabilities.

Taylor, Collins, Schuster, and Kleinert (2002) investigated the effects of a system of least prompt procedure with multiple exemplars to teach laundry skills with embedded multiple exemplars of non-targeted information (i.e., functional laundry sight words) presented as instructive feedback during instruction. Using a multiple probe across student design, results indicate that 4 high school students with moderate disabilities acquired and generalized the target laundry skills and identified most the non-targeted functional sight words. This study demonstrates that individuals with moderate disabilities can learn non-targeted information presented in the consequent event; however, additional research is needed to identify functionally appropriate vocabulary and definitions for non-targeted information.

Summary

There is a growing body of research to support the acquisition of non-targeted information in the consequent feedback event during functional and academic instruction. For students with moderate and severe disabilities, it is important to address not only grade-aligned core content and functional skills but also to target individualized goals and skill deficits. This poses teachers with a difficult task of balancing and prioritizing what and when to teach specific skills. To maximize the efficiency of instruction and best utilize time, it is important for educators to utilize strategies that help address multiple skill domains at once. By presenting non-targeted information in the consequent event during instructional sessions, individuals are presented with more content further enriching their educational experience by presenting not only core and functional content but also addressing individualized goals and skills.

Combining MSBI and NTI as a Multi-Component Intervention Package

To date, one study has been published combining MSBI and the presentation of NTI as instructive feedback in the consequent event to embed literacy instruction within mathematical problem-solving for students with moderate and severe disabilities. Brosh, Root, Saunders, Spooner and Fisher (in press) evaluated the effects of combining MSBI with NTI to address mathematical problem-solving and ELA acquisition for elementary students diagnosed with intellectual and developmental disability. A multiple probe across participants design showed a functional relation between MSBI and mathematical word problem-solving. With intent to increase teaching efficiency, the embedded NTI targeted identifying the definition of noun and verb, and identifying nouns and verbs from the math problem. All students successfully acquired the skill of identifying the nouns in the problem and providing the definition of the word 'noun', however two of the three participants struggled to acquire identifying the definition of and finding the verbs in the word problem. While all participants increased their acquisition of non-targeted literacy concepts, two participants demonstrated further skill acquisition following the use of CTD. This study provides promising evidence for embedding NTI within the chained task of mathematical problem-solving.

Barriers to Accessing the General Curriculum for Students with Severe Disabilities

While we have made significant gains on providing access to the general curriculum for students with severe disabilities, it is important to identify the barriers that inhibit access to such instruction. Figure 2 shows potential barriers and challenges associated with general curriculum access. By identifying such barriers, future research and practice can plan to effectively overcome potential obstacles when providing access to the general curriculum for students with severe disabilities. Five barrier to accessing the general curriculum for students with severe disabilities include few exemplar models (Olson, Leko, & Roberts, 2016), ambiguity and confusion (Timberlake, 2014), collaboration (Ballard & Dymond, 2017), perceived accessibility (Ballard & Dymond, 2017), and interpretation of standards (Dukes & Darling, 2017).

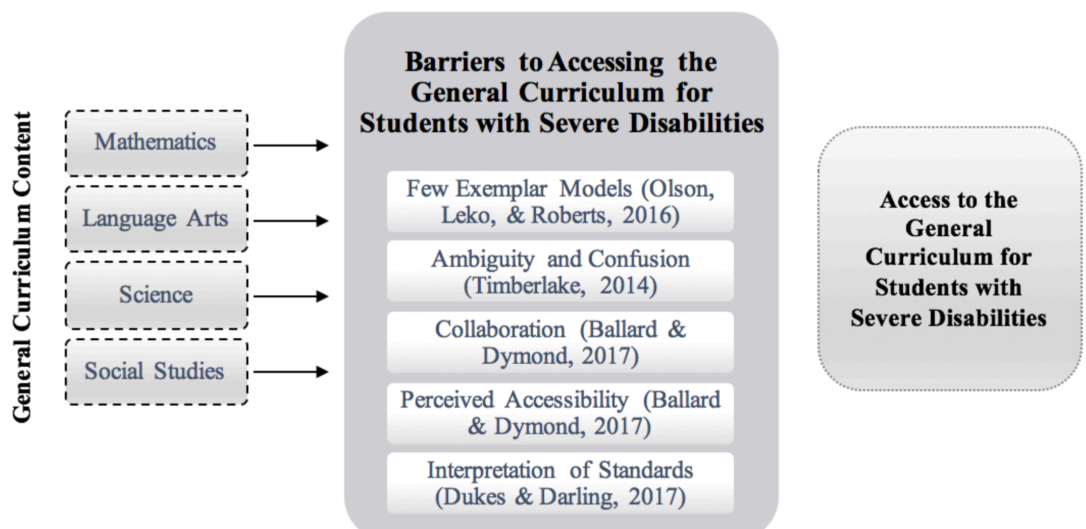


Figure 2. Barriers to general curriculum access for students with severe disabilities. By identifying barriers to providing access to the general curriculum for students with

moderate and severe disabilities, educators and practitioners can better design and plan for overcoming such obstacles.

Few Exemplar Models. Over the past two decades, additional focus has been placed on providing general curriculum access to all students. It is important to note that there are few exemplar models which make replication and teacher training particularly difficult. When considering the needs of students with complex learning needs and severe disabilities, it is difficult for education institutions to best understand how to restructure the placement, curriculum, and education setting (Olson et al., 2016). To overcome this barrier, individuals who work in education must look to current research and implication for practice, further placing an increased emphasis on the need to identify EBPs.

Ambiguity and Confusion. Teachers continuously make decisions regarding the level of access to the general curriculum based on the ability level and skillsets of their students (Timberlake, 2014). Teachers perceptions, personal values on inclusion and the perceived value of general curriculum content also impacts the level to which their students access the general curriculum content (Timberlake, 2014). It is important to recognize this as a barrier to accessing the general curriculum due in large to the inequity of educational exposure due to classroom or teacher placement. It is crucial to further educate professionals in the field to increase understanding of the importance of general curriculum access and proficiency of implementing EBPs across academic standards.

Collaboration. It is important to identify obstacles associated with collaborative practices between general and special education teachers. Most specifically, collaborative concerns related to insufficient time (Carter & Hughes, 2006; Coots et al., 1998; Matzen et al., 2010), poor communication (Ballard & Dymond, 2017), and concerns with home and school collaboration (Downing & Peckham-Hardin, 2007) potentially acts as barriers to effectively plan for general curriculum access for students with severe disabilities. In most cases, special educators do not receive specialized training on general curriculum content. Collaboration between professionals is often required for successful integration of general curriculum content in programming and instruction for students with severe disabilities.

Perceived Accessibility. Ballard and Dymond (2017) identified designing suitable adaptations and modifications adaptation to general curriculum access as a potential barrier for students with severe disabilities. Adaptation and modifications that were not (a) sufficiently substantive, (b) individualized; and (c) aligned or relevant to academic standards (Coots et al., 1998; Downing & Peckham-Hardin, 2007; Matzen et al., 2010) were identified as potential concerns. Additionally, insufficient time to prepare adaptations (Downing & Peckham-Hardin; Ruppar et al., 2011) and lack of content expertise (Carter & Hughes, 2006; Downing & Peckham-Hardin; Matzen et al., 2010) posed challenges to providing access to general curriculum content for students with severe disabilities.

Interpretation of Standards. A gap between interpretation of the standards and the development of academic and life skills for students with severe disabilities exists (Dukes & Darling, 2017). While a great amount of work has been done in writing standards, additional work needs to be done in identifying how students with severe disabilities will best access such standards. It also is necessary that educators and systems look to adapting these standards in practical and meaningful ways for students with severe disabilities.

Summary

It is important to reflect on what we know about general curriculum access for students with severe disabilities. While we have made significant advances in providing access to academic instruction and the general curriculum for students with severe disabilities, there is still work to be done. Future research should focus on realistic interventions that are easy-to-implement, adapted, and accessible for students with complex learning needs. It is important to take what we know is effective (Browder et al., 2007), and apply evidence and research-based strategies to increase accessibility for all students.

Behavior Analysis

To enhance academic instruction, the science of behavior analysis can be applied to instructional programs to increase systematic presentation and the use of direct instruction (Skinner, 1938; 1953). Behavior analysis (BA) is the study of principles of learning and behavior (Skinner, 1938). BA looks to relationships between an antecedent (e.g., what occurs immediately before), behavior, consequence (e.g., what occurs immediately following), and the environment to enhance learning and skill acquisition. Applied behavior analysis (ABA) is the science derived from the principles of behavior and applied to improve socially significant behavior (Baer, Wolf, & Risley, 1968; 1987; Cooper et al., 2009). ABA is used to identify the variables responsible for improvement in behavior change and skill acquisition. There are a number of strategies identified as EBP (Wong et al., 2014) utilized in ABA that can be applied to instructional practices for individuals with moderate and severe ID (e.g., modeling, prompting, reinforcement).

Modeling

Modeling is the demonstration of a desired behavior that results in the imitation of the behavior by the learner which leads to the skill acquisition (Wong et al., 2014). For modeling to be effective, a learner must attend to the behavior of a competent individual who is performing the skill correctly. Modeling can be an easy, practical, and successful way to enhance skill acquisition through the demonstration of the desired behavior, especially if the learner has already acquired some of the components required for imitation (Cooper et al., 2007).

Prompting

Prompting procedures are foundational to the use of many EBPs and are often used in conjunction with practices such as time delay and reinforcement (Wong et al., 2014). A prompt includes any verbal, gestural, or physical assistance provided to a learner to aid in the acquisition of a targeted behavior or skill (Wong et al., 2014). Provided by a competent peer or adult, prompts are typically used during the skill acquisition phase, or when a learner is learning to perform a new skill.

Reinforcement

The most important element of behavior change programs is reinforcement (Cooper et al., 2007; Flora, 2004; Northup, Vollmer, & Serrett, 1993). It is a foundational EBP that is almost always used in conjunction with other EBPs (e.g., prompting, Wong et al., 2014). Used to acquire or maintain skills, reinforcement establishes a relationship between the learner's behavior and/skill and the consequence of that behavior/skill (Wong et al., 2014). For reinforcement to occur, the desired behavior or skill must maintain or increase in frequency. Reinforcement can be described as (a) any new stimulus being added to the environment, or increased in intensity, or (b) an already present stimulus being removed, or reduced in intensity. These two characteristics describe what is also known as positive and negative reinforcement.

Positive reinforcement occurs when a behavior is followed immediately by the presentation of a stimulus and as a result the behavior occurs more frequently in the future (Cooper et al., 2007). In comparison, negative reinforcement occurs when a behavior is followed immediately by the withdrawal of a stimulus (Cooper et al., 2007). Negative reinforcement is also referred to as escape or avoidance.

Summary

ABA offers a foundation for systematic application of environmental changes (Cooper, 1982). By utilizing and embedding what we know is effective in producing behavior change and skill acquisition, instructional packages can be further enhanced and designed for increased learning for students with complex learning needs. Looking at student learning simply as behavior allows scientists, educators, and practitioners to apply the principles of behavior to systematically enhance the delivery of instruction. Future research should investigate academic interventions that embed the science of ABA to meet the needs of diverse and complex learners.

General Summary of the Literature

It is critical to identify effective interventions and strategies that are feasible and applicable to use in the classroom setting for students with severe disabilities. To allow educators to meet the diverse needs of students with severe disabilities, intervention packages should be designed to address both academic and functional skills. The three components of the intervention package, including MSBI, non-targeted information

(NTI), and behavior analysis, were introduced. A review of the history of general curriculum access and the literature was presented. While the field of education has advanced significantly over the past two decades, further work is needed to increase accessibility of academic instruction and interventions, provide academic opportunities that are inclusive, embed general curriculum access with functional living and individualized skills, and eliminate barriers for accessing the general curriculum for students with severe disabilities.

Chapter Three: Methodology

This multi-component intervention package combines EBPs and research-based strategies for students with moderate and severe disabilities to create access to grade-aligned academic content in mathematics, ELA, and science. The purpose of this study is to investigate: (a) the effect of a multi-component instructional package (MSBI with systematic feedback in the consequent event) on the number of steps independently solved correct on a task analysis, (b) the effect of a multi-component instructional package (MSBI with systematic feedback in the consequent event) on non-targeted science concepts, (c) the effect of a multi-component instructional package (MSBI with systematic feedback in the consequent event) on non-targeted ELA concepts, (d) the effect of a multi-component instructional package (MSBI with systematic feedback in the consequent event) on generalized problem-solving to an iPad, (e) the effect of a multi-component instructional package (MSBI with systematic feedback in the consequent event) without the student checklist on the number of steps independently solved correct on a task analysis, (f) the effect of a multi-component instructional package (MSBI with systematic feedback in the consequent event) without the student checklist and graphic organizer on the number of steps independently solved correct on a task analysis, and (g) the perceptions of teachers and students with moderate/severe ID on a multi-component instructional package (MSBI with systematic feedback in the consequent event) on mathematical word problem-solving and the acquisition of non-targeted science and ELA concepts. The following chapter provides additional information about the participants, setting, materials, variables and data collection, procedures, and social and procedural fidelity.

Participants

Utilizing purposeful sampling, three elementary students diagnosed with moderate or severe ID were recruited to participate in this study. Participants were selected based on the following inclusion criteria: (a) participation in a special education program under the eligibility category of moderate or severe ID; (b) having an IQ of 72 or below, or test scores that show significant skill deficits; (c) participation in alternate assessment aligned with alternate achievement standards; (d) having the early numeracy skill of identifying numbers 0-9; (e) having the early numeracy skill of making sets up to 9; and (f) the ability to respond to vocal requests.

Consent forms were provided to legal guardians of potential participants prior to beginning the study. See Appendix A for the parental consent form. Following receipt of the signed consent form, the primary interventionist reviewed student records to access eligibility and screen participants based on inclusion criteria. Prior to beginning the screening process, student assent was given by completing the student assent form and/or giving vocal consent to the primary researcher. See Appendix B for the student assent form.

Screening procedures. A prescreening assessment was administered to each participant prior to beginning the intervention. The purpose of the prescreening assessment was to identify the present level of performance of each potential participant and to determine if each participate possessed the prerequisite skills required to participate. Skills that were assessed during the assessment and were required for participation included identifying the written numerals 0-9, making sets up to 9 using concrete manipulatives, and the ability to respond to vocal requests. Skills were assessed in random order utilizing a mass trial format. Skills that were assessed, but not required for participation in the study, included the identification of mathematical symbols (plus sign, minus sign, equal sign), filling in a number sentence, labeling and using manipulatives on a graphic organizer, and the ability to answer comprehension questions following a four sentence paragraph or short story. Additionally, students were assessed to determine if they could independently solve addition word problems. If participants were able to solve addition word problems independently, they were not included in this study.

Lauren. Lauren was an 11 year-old Caucasian female in the fourth grade. Lauren was diagnosed with Down syndrome and moderate ID. Lauren received all academic instruction by a special education teacher in a self-contained classroom for students diagnosed with moderate and severe ID. She receives occupational therapy (OT), speech/language services, and physical therapy (PT) weekly in the school setting. As reported by her educational evaluation, the Brigance Diagnostic Inventory of Early Development, 2nd edition, Lauren is functioning significantly below her same-aged peers in the areas of literacy, mathematics, social/emotional development, daily living, and language development. At her most recent evaluation, a full scale IQ score could not be obtained due to the amount of verbal clarification of directions and multiple repetitions of teaching items that extended outside of the standardized boundaries of the evaluation instrument. According to her most recent adaptive behavior assessment, Adaptive Behavior Assessment System for Children, 2nd edition (ABAS-II), Lauren is functioning in the extremely low range as evident by teacher (standard score of 69) and parent (standard score of 43) reports.

According to her most recent psychological evaluation, the Differential Ability Scale, 2nd edition (DAS-2; Elliot, 2007), Lauren scored in the .1 percentile (very low range) on the Verbal Comprehension subtest, in the 1st percentile (very low range) on the Picture Similarities subtest, in the 2nd percentile (very low range) on the Naming Vocabulary subtest, and less than the .1 percentile (very low range) on the Pattern Construction subtest. Additionally, she scored in the 1st percentile (very low range) on the Matrices subtest, less than the .1 percentile (very low range) on the Early Number Concepts subtest, and less than .1 percentile (very low range) on Matching Letter-Like Forms. Compared to an average composite score of 90-109, Lauren had a Verbal Composite score of 57, scoring in the .2nd percentile in the very low range. She had a Nonverbal Composite score of 63, scoring in the 1st percentile in the very low range. She had a Spatial Composite score of 34, scoring less than the .1st percentile in the very low range. Finally, Lauren had a General Conceptual Ability score of 45, scoring less than the .1st percentile in very low range.

According to an adaptive behavior evaluation, the ABAS-II, her teacher reports a standard score of 43, less than the .1 percentile and in the extremely low range on the General Conceptual Composite, a standard score of 50, less than the .1 percentile and in the extremely low range on the Conceptual Composite, a standard score of 58, in the .3 percentile and in the extremely low range on the Social Composite, and a standard score of 43, less than the .1 percentile and in the extremely low range on the Practical Composite. According to the parent report, her parents report a standard score of 42, less than the .1 percentile and in the extremely low range on the General Conceptual Composite, a standard score of 50, less than the .1 percentile and in the extremely low range on the Conceptual Composite, a standard score of 58, in the .3 percentile and in the extremely low range on the Social Composite, and a standard score of 42, less than the .1 percentile and in the extremely low range on the Practical Composite.

Tim. Tim was an 11-year old Caucasian male in the fourth grade. He is diagnosed with cerebral palsy and an ID. Tim receives all academic instruction by a special education teacher in a self-contained classroom for students with moderate and severe ID. Tim receives PT, OT, and speech/language services weekly in the school setting. Additionally, he receives PT and OT outside of the school setting. Tim uses a personal power wheelchair independently to access his environment. He wears bilateral ankle-foot orthoses (AFO')s and a Sitting Walking And Standing Hip orthosis (SWASH) brace. He sits in an adapted classroom chair for a variety of academic activities and uses a stander daily. At his most recent evaluation, a full scale IQ score could not be obtained.

During his most recent educational evaluation, results indicated his performance between 12-21 month level with most of his skills clustered around the 15th month of development. These results indicate well below average development. On his most recent speech/language evaluation, Tim's language comprehension skills range between 12 and 24 months with most of the skills clustering around the 21 month level. These results indicate his speech/language ability as well below average development. During his most recent motor evaluation, Tim's fine and gross motor skills fell between the 6 month level and the 8th month level, indicating well below average development.

Edwin. Edwin was an 11-year old Hispanic male in the fourth grade. He is diagnosed with an ID and receives all academic instruction by a special education teacher in a self-contained classroom for students with moderate and severe ID. Edwin receives speech/language services weekly in the school setting. On the Leiter International Performance Scale-Revised, Edwin obtained a full IQ score of 64. Based on the results of this evaluation, it is highly probable (<90%) that Edwins nonverbal ability falls within the range of 57-71, suggesting Emir performs significantly lower than his typically developing peers.

According to a language evaluation, Receptive One-Word Picture Vocabulary Test, 4th edition (ROWPVT-4), Edwin displays weakness in his receptive language skills and struggles to identify age appropriate vocabulary. He received a standard score of 55 (average range 85-115) on the assessment. According to his most recent adaptive behavior assessment, ABAS-II, Edwin is functioning in the extremely low range as evident by two teacher ratings (General Adaptive Composites of 53 and 66).

As reported in his current individual education program (IEP), Edwin displays deficits in expressive language, pre-reading, pre-mathematics, and pre-writing skills. These deficits adversely impact his ability to communicate and interact with others, access all areas of his school environment, engage in higher levels of academic learning, and attend for long periods of time.

Setting

This study took place in a public elementary school in a suburban district in the southeast United States. Approximately 800 students attend the elementary school with classrooms for students in kindergarten through grade five. Of the students enrolled, approximately 45% of students were White, 26% are African American, 24% were Hispanic, and 2% of the student population identified with more than one race/ethnicity. Seventy percent of the student population was identified as receiving free or reducedpriced lunch, or being from a low socio-economic background. Of the student population, approximately 13% of students were identified as having a disability.

All participants received all academic instruction from a special education teacher in a self-contained setting for individuals with moderate and severe ID. Participants were included with their typically-developing peers during special area classes (art, music, physical education), lunch, recess, and special school events. Intervention sessions took place in the participants' self-contained classroom during time allocated for mathematics instruction. Sessions were conducted one-on-one with each participant in the teachers office, a small room with an intervention table and minimal distractions. A doctoral candidate studying special education implemented all sessions. The student was a Board Certified Behavior Analyst (BCBA) and a licensed special education teacher with over 10 years of experience working with students with moderate and severe ID.

Experimental Design

A single-case multiple probe across participants' design (Gast & Ledford, 2014; Horner & Baer, 1978) was utilized in this study. All participants entered baseline together. A minimum of five data points per participant was collected during baseline. After a stable trend is observed, the first participant indicating the greatest need entered intervention. During this time, the remaining participants continued in baseline. Intermittent baseline probes were administered at a minimum of every 8 sessions and concurrently as each participant entered intervention.

Data were collected daily during each session across all phases. The interventionist graphed the number of independent correct steps completed on the student self-monitoring checklist across all phases. Visual analysis was used to determine trends, change in level, and functional relationships between dependent and independent variables.

After the first participant showed a stable trend in the number of steps completed independently on the task analysis, the second participant began a cluster of three baseline sessions prior to entering intervention. This systematic process continued until all the participants entered intervention. A generalization probe was administered to each participant prior to entering a new phase of the intervention.

Dependent variables.

Seven dependent variables were measured in this study. The seven dependent variables include (1) addition word problem-solving, (2) generalization of addition word problem-solving to an iPad, (3) acquisition of science NTI, (4) acquisition of ELA NTI, (5) faded stimulus support (student checklist), (6) faded stimuli supports (student checklist and graphic organizer), and (7) teacher and student perception.

Addition word problem-solving. The primary dependent variable related to solving addition word problems measured the number of steps independently solved correct on a task analysis. This variable was measured by the number of points received by independently performing the steps on the student checklist (task analysis). A total of 10 points were possible for each problem presented.

Generalization of addition word problem-solving to an iPad. Related to addition word problem-solving, the ability to generalize addition problem-solving using an iPad was measured. This variable was measured by the number of points received by independently performing the steps on the student checklist (task analysis). A total of 10 points were possible for each problem presented. All materials and stimuli supports were digitized and presented to the individual on the iPad.

Acquisition of science NTI. Science concepts based on Next Generation Science Standards were measured as NTI. Table 2 shows the science concepts addressed.

Table 2.

Science Concepts Based on Next Generation Science Standards Presented as NTI in Addition Mathematical Word Problems

Next Generation Science Standards K-2		
Discipline	**Disciplinary Core Idea**	**Sample Non-Target Science Information**
From Molecules to Organisms: Structures and Processes	Energy Flow in Organisms	Plants need water and light to live and grow.
Matter and Its Interactions	Chemical Reactions	When water freezes, it turns into a solid. When ice melts, it turns into a liquid.

Measured using a pre- and post-test, the acquisition of non-targeted science concepts was measured. Prior to beginning the study, participants were probed on non-targeted science concepts following the presentation of an addition word problem. Each participant was given three opportunities to answer questions related to non-targeted science concepts prior to beginning intervention. After participants achieved mastery on solving addition word problems, a post-test measuring science NTI was administered.

Acquisition of ELA NTI. ELA knowledge based on Common Core State Standards were measured as NTI. Table 3 shows the ELA concept addressed.

Table 3.

ELA Information Based on Common Core State Standards Presented as NTI in Addition Mathematical Word Problems.

English Language Arts Standards		
Language	Conventions of Standard English	Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

Measured using a pre- and post-test, the acquisition of non-targeted ELA concepts was measured. Prior to beginning the study, participants were probed on non-targeted ELA concepts following the presentation of an addition word problem. Each participant was given three opportunities to answer questions related to non-targeted ELA concepts prior to beginning intervention. After participants achieved mastery on solving addition word problems, a post-test measuring ELA NTI was administered. ELA knowledge based on Common Core State Standards were measured as NTI. Table 3 shows the ELA concept addressed.

Faded stimulus support (student checklist). After achieving mastery on addition word problem-solving, the participant was presented with an addition word problem without the student checklist. The ability to maintain acquired addition problem-solving skills with faded stimulus supports (i.e., student checklist) was measured. This variable was measured by the number of points received by independently performing the steps on the task analysis without the checklist present.

Faded stimuli support (student checklist and graphic organizer). After presented with an addition word problem without the student checklist, the participant was presented with an addition word problem without the student checklist and the graphic organizer. The ability to maintain acquired addition problem-solving skills with faded stimuli supports (i.e., student checklist and graphic organizer) was measured. This variable was measured by the number of points received by independently performing the steps on the task analysis without the checklist and graphic organizer present.

Teacher and student perception. Teacher and student perception was measured using social validity questionnaires and surveys. Teacher and classroom staff were presented with a 4 question rating scale and an open-ended questionnaire related to procedures and outcomes of the intervention. Students were given a yes/no checklist and responded vocally or with a thumbs up/thumbs down. Participants were also given the opportunity to give additional information about the intervention with an open-ended question format (i.e., participants were asked if they wanted to say anything else) following the intervention.

Data was collected using a task list based on the student checklist. See figure 3 for the student checklist. Only independent correct responses were counted as correct. During intervention, prompt levels were recorded using a least-to-most hierarchy. Mastery criteria was 80% (8 out of 10 steps on the task analysis with step 10 being a critical step for mastery) and solving to identify the correct answer for two consecutive or two out of three sessions. See Appendix C for the data collection tool utilized in this study.

Procedural Reliability and Fidelity

To ensure reliability and fidelity across all phases of intervention, intervention sessions were recorded and a second trained observer scored each session for interobserver agreement (IOA) and procedural fidelity. Using the steps of the scripted lesson plan, the trained observer collected reliability and fidelity data on the data collection sheets used throughout the intervention.

Interobserver agreement. IOA on all dependent variables was collected for a minimum of 30% of all sessions across each phase for each participant. Using the same data sheet utilized during intervention phases, a second trained observer recorded student responses via video recording samples and collected data on all variables. IOA was evaluated using an item analysis and calculated by dividing the total number of agreements by the total number of disagreements and multiplied for total percentage (Kazdin, 1982).

Procedural fidelity. Procedural fidelity on the implementation of the multi-component intervention package including MSBI with embedded NTI was collected for a minimum of 30% of all sessions across each phase for each participant. Using the same data sheet utilized during intervention phases, a second trained observer recor`1ded interventionist behavior related to the steps of implementation via video recording samples. Fidelity was evaluated using an item analysis and calculated by dividing the total number of agreements by the total number of disagreements and multiplied for total percentage (Kazdin, 1982).

Materials

A self-monitoring task analysis presented as a student checklist, graphic organizer with manipulatives, mnemonic, number sentence, and thematic word problems were used to in the multi-component intervention package to teach participants to conceptually understand and solve addition word problems. The materials and procedures used in this study were adapted from the work of Browder et al. (2017). All materials were evaluated for validity by content experts in the areas of severe disabilities and elementary mathematics.

Student checklist. A task analysis, presented as a self-monitoring checklist, was used as a stimulus support throughout the intervention. The student checklist included a 10-step task analysis that pairs visual cues with each step to provide additional visual support to emerging readers. The steps of the task analysis were (1) read the problem or ask to have the problem read, (2) find the whats, (3) find the label in the question, (4) label the graphic organizer, (5) circle the numbers, (6) fill in the number sentence, (7) make sets, (8) use the rule, (9) solve, and (10) write the answer. Using the self-monitoring checklist, participants sequentially checked off the steps required to solve the addition word problems. Two versions of the student checklist were used throughout the intervention. For participants who had motor capabilities of using writing utensils independently, the student checklist was laminated and participants were given a dry erase marker to check off each step of the problem-solving task. For students who had limited motor skills, an adapted checklist was provided with laminated check marks that attached to the checklist using Velcro. Figure 3 shows the task analysis presented as a self-monitoring checklist to participants during baseline and intervention.

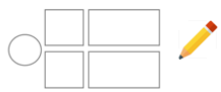
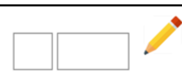
1.			Read the problem or ask to have the problem read.
2.			Find the whats.
3.		How many ___?	Find the label in the question.
4.			Label the graphic organizer.
5.			Circle the numbers.
6.			Fill in the number sentence.
7.			Make sets.
8.			Use the rule.
9.			Solve.
10.			Write answer.

Figure 3. Student self-monitoring checklist. The self-monitoring checklist will be laminated and presented to participants with a dry erase marker.

Graphic organizer. A graphic organizer focusing on the group problem type was utilized in this study. The graphic organizer had two small circles with arrows that led into one large circle. Each circle had a space available to label what the circle represented within the addition word problem. The graphic organizer was approved by an elementary mathematics expert for content validity. For participants who had mobility challenges and motor deficits, an adapted graphic organizer was used. The adapted graphic organizer had strips of Velcro which allowed for manipulatives to be easily secured and organized. Strips of Velcro were used rather than individual pieces to eliminate the chance that the participant would attend to non-relevant stimuli of the graphic organizer (i.e., placing a manipulative on each piece of Velcro rather than attending to the task of making sets). Figure 4 represents the graphic organizer used to visually depict the part-part-whole relationship in the addition process.

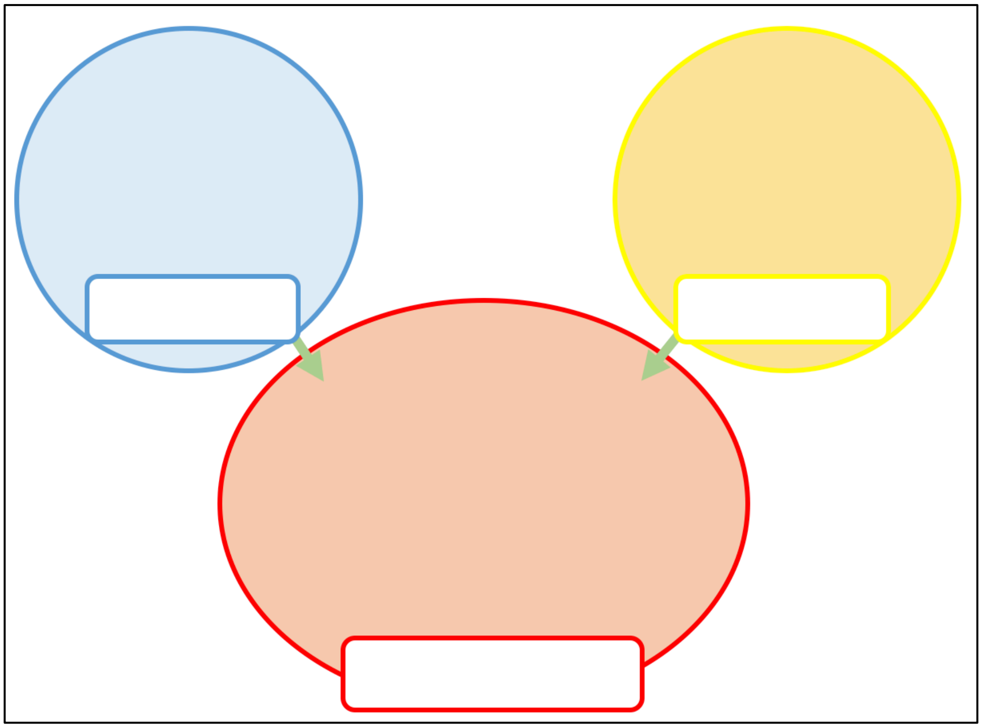


Figure 4. Group graphic organizer. The group graphic organizer used in this study was color-coded and visually represented the concept of combining two small groups into one large group. A place to label each small group was present to ensure conceptual understanding associated with solving the word problem.

Manipulatives. Participants were presented with an array of concrete manipulatives to use when solving the mathematical word problem. Manipulatives were small wooden blocks with Velcro attachments. The manipulatives presented were used on both versions of the graphic organizer (graphic organizers with and without Velcro strips). Small wooden blocks were used as manipulatives to accommodate for fine motor challenges as the three-dimensional blocks were easy to grab and maneuver.

Mnemonic. Participants were taught a problem-solving mnemonic to support conceptual understanding and the behaviors associated with solving the word problem. The mnemonic served as the problem-solving 'rule' and was paired with gross motor movements. The problem-solving rule was 'small group, small group, big group' and was paired with making two circles with each of your hands and combining your hands to make one large circle to represent the end result. The rule and hand motions could be used over the graphic organizer to support the behavior of creating two small sets and combining the sets into one large group.

Number sentence. Participants were provided with a blank number sentence. Throughout the problem-solving process, participants used the information presented in the word problem to fill in the number sentence with the two amounts and mathematical symbol. After solving for the final amount, the participant completed the number sentence by writing the answer to the mathematical equation. Different from previous studies (Root, 2017; Root, Browder et al., 2017; Root, Saunders et al. 2017; Saunders, 2014), the number sentence was presented in a vertical format. The number sentence consisted of three blank boxes for students to transfer the numbers from the word problem and the final amount and a blank circle for the mathematical symbol. Additionally, spaces for the label were present to aid with conceptual understanding. Participants who had the ability to write used a dry erase marker to complete the number sentence on laminated cardstock. For participants with motor deficits, an adapted number sentence was provided with Velcro number and mathematical symbol response options to place on a number sentence with Velcro supports. Figure 5 shows an example of the number sentence.

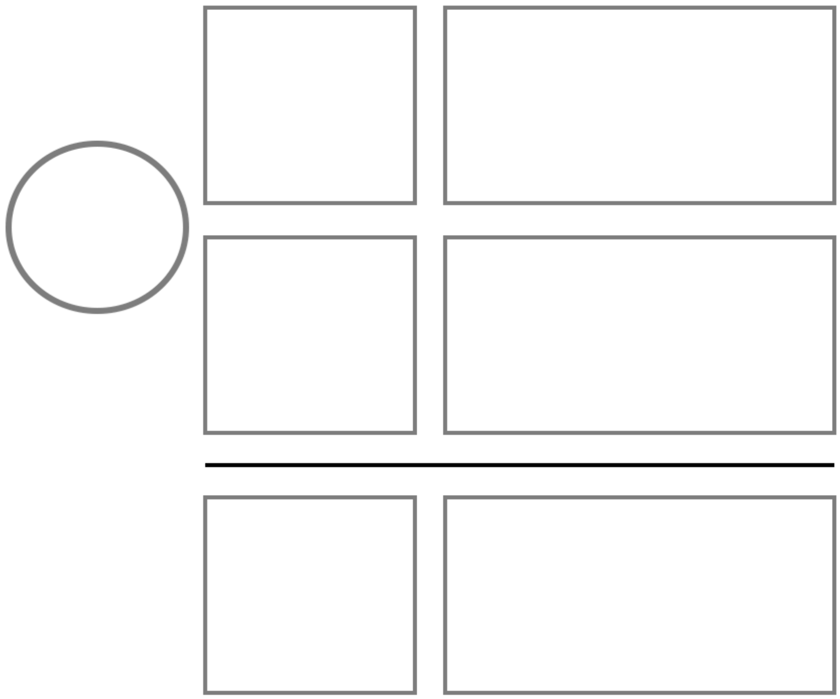


Figure 5. Example of number sentence. Participants used dry erase marker or Velcro response options to complete the number sentence with the numbers from the word problem. Participants then decided which mathematical symbol (addition sign or subtraction sign) to use. After solving for the final amount with manipulatives on the graphic organizer, participants then completed the number sentence by writing or placing the final amount in the equation.

Word problems. Word problems used in this study were developed using a consistent formula (Neef et al., 2003), easy-to-decode words and common verbs (Stein et al., 2006), and common names from diverse cultures (Xin et al., 2008). The word problems were presented as mathematical short stories with 4 predictable sentences; sentence 1 was an anchor sentence to identify the theme, sentence 2 identified the first small group and quantity, sentence 3 identified the second small group and quantity, and sentence 4 identified the question with label. In each word problem, a space was provided for the quantity of each small group and the interventionist completed the word problem by filling in a number 1-9 in both spaces prior to presenting the problem to the participant. Ten word problems per theme were developed and used in the baseline phase of the study. Twelve word problems per theme were developed and used during the intervention phase of the study. For the generalization phase, 4 word problems per theme were developed and used. And finally, 4 word problems per theme were developed and used during the phase with faded stimuli supports. Word problems were written based on science content and presented as thematic units, aligning with the academic content presented as systematic feedback throughout the intervention. Figure 6 shows an example of a word problem from the thematic unit on living things. A sample of word problems used can be found in Appendix D.

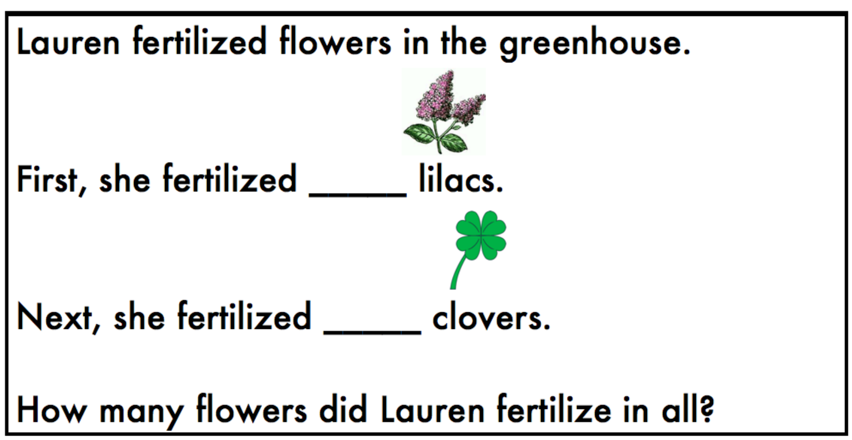


Figure 6. Example of word problem. This word problem is based on the science discipline, From *Molecules to Organisms: Structures and Processes*, and non-targeted science concepts embedded in the mathematical problem-solving chain will address characteristics of living things (i.e., “A plant needs sunlight and water to grow.”). Also,

participants were presented with embedded ELA information to address defining and identifying the noun from the problem (i.e., "Lilacs and clovers are flowers. Flowers are things. Nouns are people, places, and things. Flowers are nouns.").

Presentation of the materials. Participants were provided with all materials necessary to solve the mathematical word problem. For participants needing additional support, visual response options were provided in a field of 4. For example, 4 images were presented to the participant to label the graphic organizer. Rather than writing the 'whats' and the 'label' with a dry erase marker on the graphic organizer, participants labeled the graphic organizer by placing the visual response options in the correct circles.

For participants with motor deficits who needed explicit organization of the materials, a problem-solving board was used. All materials and response options were securely attached to a foam board and presented to the participant. For participants who used a wheel chair or stander, the problem-solving board provided additional and ample space to access and maneuver the materials needed to solve the word problem.

Procedures

Baseline of Word Problem Solving. Prior to beginning intervention, each participant was introduced to the materials (e.g., student checklist, graphic organizer and manipulatives, word problem, number sentence) that were available in the multi-component intervention package. The interventionist explained the purpose of each support stimuli and explained to the participant that he/she could use the materials to solve the word problem. Table 4 shows how the components of the intervention package were introduced to each participant.

Table 4.

Introduction of Components of Multi-intervention Package During Baseline

Component	**Example of How Components Were Introduced to Participant**
Word Problem	"This is the word problem. You are going to try to solve this word problem. If you need help reading, you can ask me."
Student Checklist	"This is your checklist. It shows the steps that you can use to solve the word problem. The checklist has the steps written and these images to help you."
Graphic Organizer	"This is a graphic organizer. The graphic organizer can help you organize the information presented in the problem. You can use the manipulatives on the graphic organizer to help you solve."
Manipulatives	"These are manipulatives. You can use the manipulates as counters on the graphic organizer to help you solve for the final amount."
Number Sentence	"This is a number sentence. You can use the information from the word problem to fill in the number sentence."
Response Options	"Here are some pictures and numbers that you can when you solve the word problem. You can Velcro these numbers or pictures to the number sentence or graphic organizer to help you."

All materials were placed on the desk in front of the participant. If the student asked to have the problem read aloud, the interventionist read the problem aloud to the student. The interventionist presented the word problem and the verbal cue, "Can you solve the problem?" to the participant. After the participants' attempt to solve, the interventionist asked the participant to identify their final answer. Next, the interventionist asked the participant to identify the science and ELA concept based on the theme of the word problem. The questions were presented vocally presented to the participant and visual response options were provided. No prompting, feedback, or error correction was provided during baseline. Prior to beginning intervention and changing phases, a generalization probe was administered for each participant.

Baseline of NTI. Prior to beginning intervention, each participant was asked to identify the non-targeted ELA and science concepts. The interventionist presented the questions orally and each participant was given at least 4 opportunities to respond to each ELA and science question. The questions presented as NTI included, 1) "what is a noun?", and 2) "what happens when ice melts?" or "what does a plant need to grow?". The questions related to non-targeted concepts were asked after the presentation of the addition word problem.

Intervention. For the first two days of intervention, the interventionist modeled each step of the student checklist with active participation using a model-lead-test format with a system of least prompts. During modeling, participants were encouraged to actively participate and follow along in the problem-solving process. The interventionist explicitly introduced the purpose of all materials presented and modeled the problem-solving process while verbally explaining the steps to the participant. During modeling, no data were collected.

Following the modeling phase, participants began intervention utilizing a system of least intrusive prompting (LIP). The interventionist provided the participant with the student checklist, graphic organizer, manipulatives, number sentence, and response options. The interventionist then presented the word problem to the participant and gave the cue, "Show me how to solve this problem," to the participant. Using a response delay, if the participant did not respond to a specific step on student checklist within 10 seconds of the cue, the interventionist followed a system of least intrusive prompts by providing the participant with a verbal prompt, followed by a specific verbal prompt, then a model of the correct response. If an error was made, the interventionist immediately modeled the correct response for the participant. Following each step of the task analysis, instructive feedback in the consequent event (Fiscus, Schuster, Morse, & Collins, 2002) was presented to the participant to reinforce the acquisition of science and ELA concepts. Following the last step of the student checklist, participants were asked the question in the word problem to check for conceptual understanding.

Mastery was achieved by scoring a minimum of 8 (out of 10) points, to include solving for the correct answer, must be achieved for 2 consecutive or 2 out of 3 sessions. One addition word problem worth 10 points was administered to each participant during each session. Following mastery of solving for the correct answer on addition word problems, each participant entered the generalization phase.

Generalization. Generalization probes measured the participants' ability to generalize the skill of solving addition mathematics word problems to an iPad. During the generalization phase, materials were digitized and presented on an iPad to each participant and procedures from the intervention phase were directly replicated. After achieving mastery on solving addition word problems with the concrete stimuli supports of the intervention, participants were given two generalization probes to test for generalization to the iPad. A system of least prompts was used with a 10 second response delay. The interventionist embedded NTI as instructive feedback during the steps of problem-solving.

Faded stimuli supports. After two generalization probes, the interventionist faded concrete stimuli supports to test for acquisition and maintenance. During the first phase of faded stimuli supports, the student checklist was removed from the intervention package. All procedures remained the same, and the participant was asked to solve the problem. In the final phase of faded stimuli supports, the student checklist and the graphic organizer was removed from the intervention package. During each phase, the interventionist instructed the participant to solve the problem without the support(s). The interventionist also explained to participants that they could create their own checklist or graphic organizer if necessary. During this phase, a system of least prompts was utilized with a 10 second response delay. NTI was embedded as instructive feedback during the steps of problem-solving.

After achieving mastery on solving the addition word problems, a post-test was presented to measure the acquisition of non-targeted ELA and science concepts. Students were orally presented with the same questions presented during baseline (i.e., "what is a noun?", and "what happens when ice melts?" or "what does a plant need to grow?"). Each participant was given 2 or 4 opportunities to respond.

Chapter Four: Results

Interobserver Agreement

A second observer collected interobserver agreement (IOA) data using permanent product (video) observations for a minimum of 30% of all sessions in each phase for each participants. IOA was conducted using an item-by-item analysis in which the number of agreements on steps completed was divided by the total number of agreements and disagreements and multiplied by 100 (Kazdin, 1982). Data indicated the mean IOA across all participants was of 99.1% (range 97.5-100) during baseline, 93.3% (range 90-100) during intervention, 96.6% (range 90-100) during generalization to an iPad, and 98.3% (range 95-100) during generalization with faded supports.

Lauren. A second observer collected IOA data during 40% (2 out of 5 sessions) of baseline sessions, 36.3% (8 out of 22 sessions) of intervention sessions, 50% (1 out of 2 sessions) of generalization sessions in which participants generalized problem-solving to an iPad, and 100% (2 out of 2 sessions) of generalization sessions in which support materials used throughout intervention were faded for Lauren. IOA across baseline sessions indicated 100% agreement. IOA across intervention sessions indicated 90% agreement. IOA across generalization to the iPad indicated 90% agreement. IOA across generalization sessions with faded supports indicated 100% agreement.

Tim. A second observer collected IOA data during 40% (4 out of 10 sessions) of baseline sessions, 37.5% (3 out of 8 sessions) of intervention sessions, 50% (1 out of 2 sessions) of generalization sessions in which participants generalized problem-solving to an iPad, and 100% (2 out of 2 sessions) of generalization sessions in which support materials used throughout intervention were faded for Tim. IOA across baseline sessions indicated 100% agreement. IOA across intervention sessions indicated 90% agreement. IOA across generalization to the iPad indicated 100% agreement. IOA across generalization sessions with faded supports indicated 100% agreement.

Edwin. A second observer collected IOA data during 33.3% (4 out of 12 sessions) of baseline sessions, 50% (2 out of 4 sessions) of intervention sessions, 50% (1 out of 2 sessions) of generalization sessions in which participants generalized problem-solving to an iPad, and 100% (2 out of 2 sessions) of generalization sessions in which support materials used throughout intervention were faded for Edwin. IOA across baseline sessions indicated 97.5% agreement. IOA across intervention sessions indicated 100% agreement. IOA across generalization to the iPad indicated 100% agreement. IOA across generalization sessions with faded supports indicated 95% agreement.

Procedural Fidelity

To verify the degree to which the intervention package was implemented as designed, a second observer assessed procedural fidelity across a minimum of 30% of sessions across each phase of the intervention for each participant. Procedural fidelity data were collected on MSBI implementation and the presentation of NTI. Procedural fidelity data were collected using permanent product (video) recording and the data collection instrument (APPENDIX C) utilized throughout implementation. Procedural fidelity was calculated on mathematical problem-solving by dividing the number of steps performed correctly by the interventionist by the total number of steps on the checklist and multiplying by 100.

The mean procedural fidelity for all participants in baseline was 97.1% (range 92.8-100). The mean procedural fidelity for all participants during intervention was 100%

(range 100-100). The mean procedural fidelity for all participants during generalization to the iPad was 95.2% (range 92.8-100). The mean procedural fidelity for all participants during sessions in which instructional supports were faded was 97.6% (range 96.4-100).

Baseline. Procedural fidelity data were collected by a second observer during 40% of baseline sessions for Lauren (2 out of 5 sessions), 40% of baseline sessions for Tim (4 out of 10 sessions), and 33.3% of baseline sessions for Edwin (4 out of 12 sessions). Mean procedural fidelity for all three participants during baseline was 97.1% (92.8-100).

Intervention. Procedural fidelity data were collected by a second observer during 36.3% of intervention sessions for Lauren (8 out of 22 sessions), 37.5% of interventions sessions for Tim (3 out of 8 sessions), and 50% of intervention sessions for Edwin (2 out of 4 sessions). Mean procedural fidelity in intervention was 100% for Lauren (range 100-100), 100% for Tim (range 100-100), and 100% for Edwin (range 100-100).

Generalization to the iPad. Procedural fidelity data were collected by a second observer during 50% of generalization sessions for Lauren (1 out of 2 sessions), 50% of generalization sessions for Tim (1 out of 2 sessions), and 50% of generalization sessions for Edwin (1 out of 2 sessions). Mean procedural fidelity in the generalization to the iPad phase was 92.8% for Lauren (range 100-100), 92.8% for Tim (range 100-100), and 100% for Edwin (range 100-100).

Fading of instructional supports. Procedural fidelity data were collected by a second observer during 100% of sessions with faded instructional supports for Lauren (2 out of 2 sessions), 100% of sessions with faded instructional supports for Tim (2 out of 2 sessions), and 100% of generalization sessions for Edwin (2 out of 2 sessions). Mean procedural fidelity in the generalization to the iPad phase was 96.4% for Lauren (range 92.8-100), 96.4% for Tim (range 92.8-100), and 100% for Edwin (range 100-100).

Results for Question 1: What is the effect of a multi-component instructional package (MSBI with systematic feedback in the consequent event) on the number of steps independently solved correct on a task analysis for solving addition mathematical word problems by students with moderate/severe ID?

Figure 7 shows the effects of the multi-component intervention package on the acquisition of mathematical problem-solving. The graph shows the number of steps on the task analysis performed independently correct by each participant across all phases. During baseline, all participants showed a low level of stable responding, with each participant scoring zero points. During intervention, all participants showed a change in level or an increasing trend with no overlapping data from baseline sessions. Visual analysis of the graph indicated a functional relation between a multi-component instructional package (MSBI with systematic feedback in the consequent event) on the number of steps independently solved correct on the task analysis (i.e., participants ability to solve addition mathematical word problems) for all three participants.

Lauren. During the five baseline probes, Lauren received 0 points across all problems presented. When presented with and introduced to the materials, Lauren did not attend to or interact with the materials when given the cue to solve the problem. Data indicated a low and stable rate of responding across all baseline sessions. After the introduction of the multi-component intervention package, an immediate effect was observed with a slight change in level and an overall gradual increasing trend was observed. There was no overlap in data across phases. During the first intervention session, Lauren successfully completed step 1 (read the problem) and step 8 (use the rule) independently. Lauren was then able to consistently identify the mathematical operation required to solve the addition problem by independently placing the addition sign in the correct location on the number sentence. After three sessions of steady responding, a booster session was administered. During the booster session, the interventionist used a model-lead-test format to systematically review the steps of the student checklist with Lauren. After the first booster session Lauren showed consistent and gradual growth, independently identifying the 'whats' in the problem (step 2), identifying the label (step 3), circling the numbers in the problem (step 5), and placing the numbers in the correct order on the number sentence (step 6). On the steps that required dynamic responding (i.e., making sets on the graphic organizer, counting for the total amount, writing the answer in the number sentence after counting for the total amount), Lauren demonstrated a variability in responding. After the twenty-first session, a second booster session was administered. During the second booster session, the interventionist used a model-lead-test format to systematically practice the behaviors associated with making sets (step 7), combining sets to solve (step 9), and writing the answer (step 10). After the second booster session was administered, Lauren was able to solve for the correct answer, including correctly performing the skills associated with the critical steps of the solving the addition word problem. Throughout intervention, Lauren needed consistent pacing prompts to remain on-task and to use the materials presented.

Tim. During the 10 baseline probes, Tim received 0 points across all problems presented. Data indicated a low and stable rate of responding across all baseline sessions. When presented with and introduced to the materials, Tim would make comments about the pictures or numbers, however did not attempt to read or solve the problem. After beginning the intervention, an immediate change in level and trend occurred. After two sessions of modeling, Tim jumped to 6 points on the first intervention session and 7 points on the second intervention session, indicating an immediate jump in performance and an overall positive trend. On the third day of intervention, Tims performance showed a slight reduction in points (scoring 6 out of 10) due to a counting error that occurred when Tim was solving. On the fourth day of intervention, Tims performance jumped to 8 points, showing a stable rate of responding for the remaining intervention sessions. Due to counting errors or difficulty writing the correct answer after counting for the final amount, Tim needed consistent presentation of the intervention before scoring 8 out of 10 points, including the critical steps (i.e., making sets, using the rule, counting to solve for the correct answer, and writing the answer) for two consecutive sessions.

Edwin. During the twelve baseline probes, Edwin received 0 points across all problems presented. Data indicated a low and stable rate of responding across all baseline sessions. Before being asked to solve the addition word problem in baseline, Edwin was introduced to all materials and supports available. The interventionist explained that he could use the student checklist to help him solve the problem and introduced him to the graphic organizer and counting manipulatives. During baseline, Edwin made verbal statements related to the pictures or numbers in the word problem. With emerging literacy and reading skills, Edwin attended to the word problem presented however did not attempt to read the problem or ask to have the problem read aloud. After two sessions of modeling, an immediate change in level and trend was evident, with a jump from 0 points scored throughout baseline to 9 points during the first intervention session. After being taught the steps of the student checklist and having the problem-solving procedure modeled, Edwin was able to independently use the support to successfully solve for the correct answer. After the second intervention session, Edwin made errors on non-critical steps of the student checklist which showed a decreasing trend in his performance. He was able to successfully solve two consecutive addition word problems after scoring 9 out of 10 points on the third intervention session and 8 out of 10 points on the fourth intervention session.

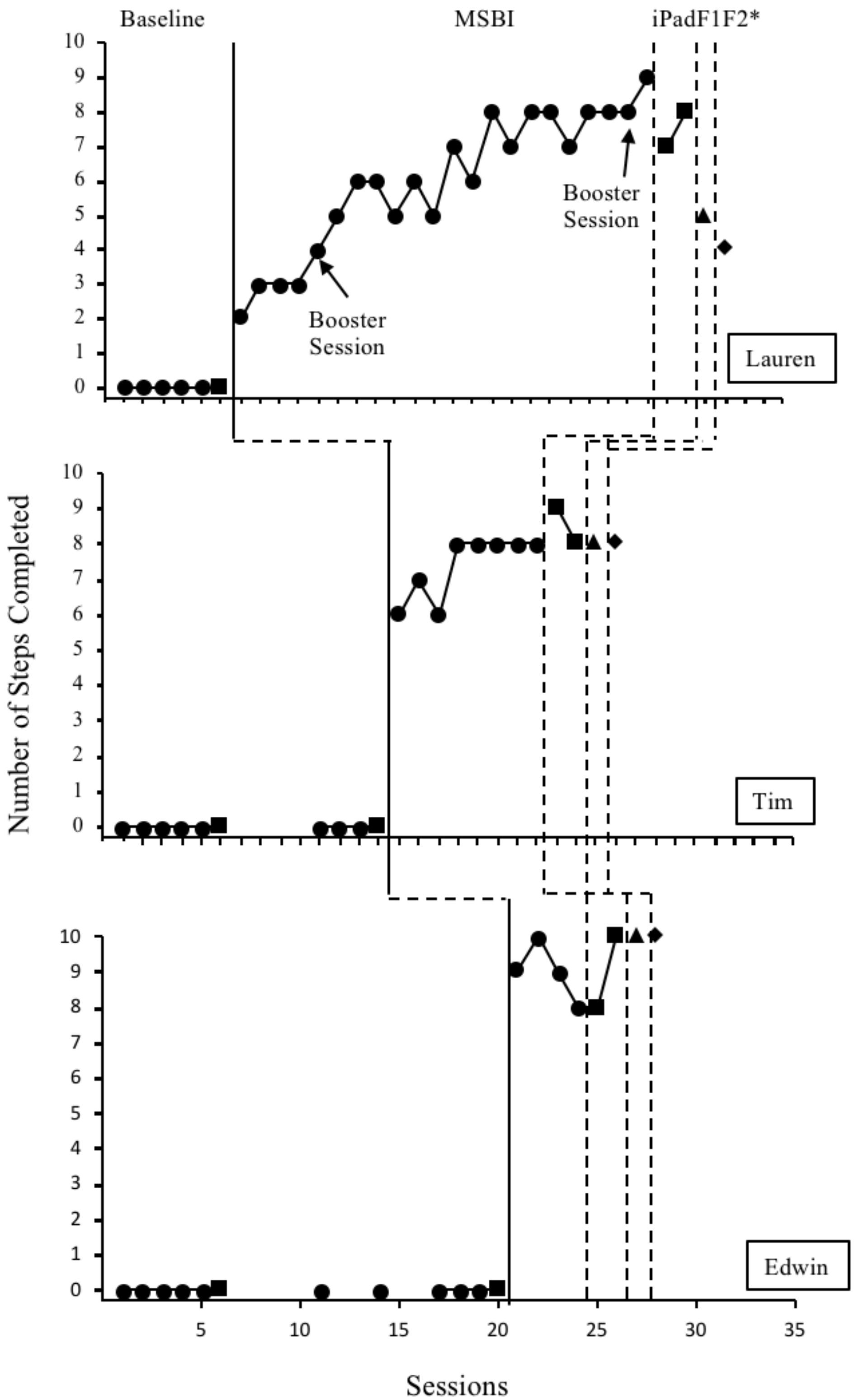


Figure 7. Graph of the number of steps performed independently correct on the task analysis. F1 indicates student performance when the task analysis was faded from the

instructional package. F2 indicates student performance when the task analysis and the graphic organizer were faded from the instructional package.

Results for Question 2: What is the effect of a multi-component instructional package (MSBI with systematic feedback in the consequent event) on non-targeted science knowledge by students with moderate/severe ID?

Figure 8 shows pre-and post-intervention data on each participants ability to answer questions related to grade-aligned science concepts. During baseline, none of the participants independently identified the targeted science concepts (i.e., identifying what a flower or plant needs to grow and what happens to ice when it melts). Following the multi-component instructional package (MSBI with systematic feedback in the consequent event), each participant was able to identify the target science concepts. The addition word problems presented throughout intervention were thematically based on the non-targeted science information.

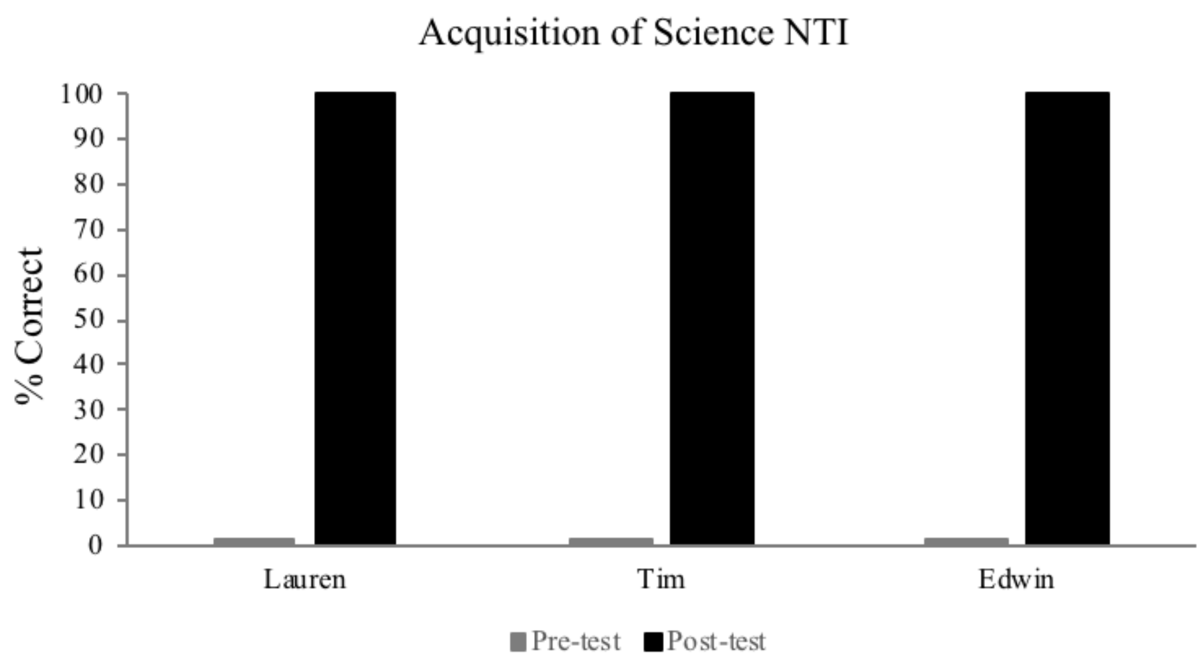


Figure 8. Non-targeted science concepts acquired by each participant.

Results for Question 3: What is the effect of a multi-component instructional package (MSBI with systematic feedback in the consequent event) on non-targeted English language arts (ELA) knowledge by students with moderate/severe ID?

Figure 9 shows pre-and post-intervention data on each participants ability to answer questions related to grade-aligned ELA concepts. During baseline, none of the participants independently identified the targeted concepts (i.e., identifying the meaning of a noun). Following the multi-component instructional package (MSBI with systematic feedback in the consequent event), 2 of the 3 participants were able to identify the target ELA concept. It is important to note the presentation of the NTI throughout intervention. The systematic feedback on non-targeted ELA concepts was consistently presented following the non-targeted science information during the intervention. The order of presentation, as well as the theme of the problems presented, could have impacted Laurens ability to acquire the non-targeted ELA information.

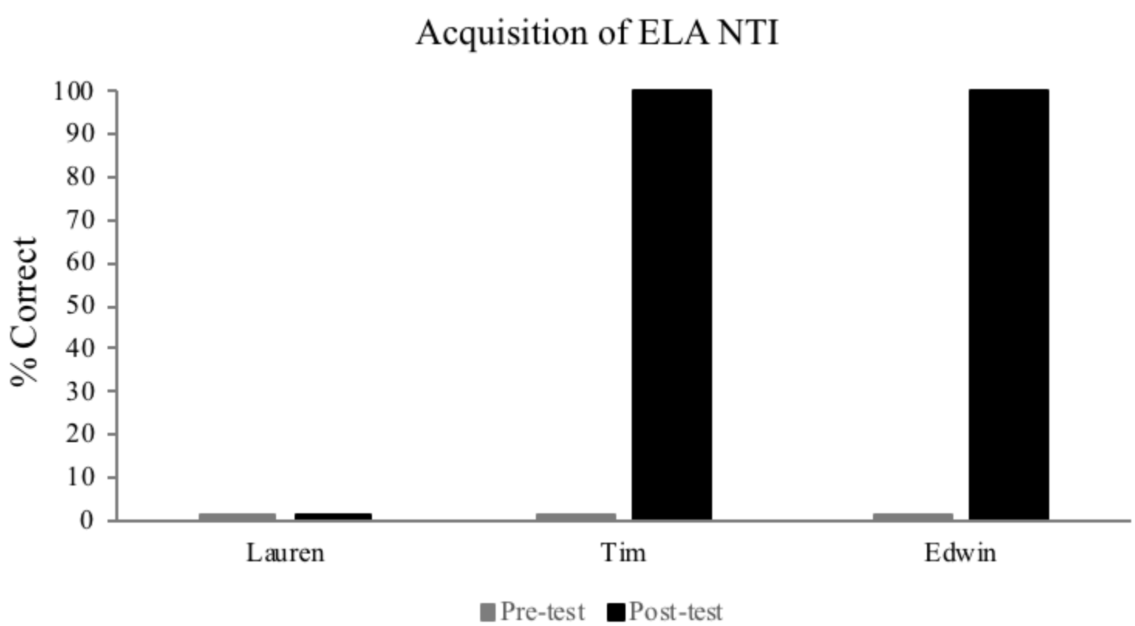


Figure 9. Non-targeted ELA concepts acquired by each participant.

Results for Question 4: What is the effect of a multi-component instructional package (MSBI with systematic feedback in the consequent event) on generalized problem-solving to an iPad by students with moderate/severe ID?

Figure 7 shows the effects of the multi-component intervention package on the acquisition of mathematical problem-solving. More specifically, the graph indicates each participants ability to generalize problem-solving to an iPad. Using SMART software (interactive platform for designing custom lessons and activities for students to access on tablet devices or interactive whiteboards) and an iPad, each participant was given all materials in an electronic format, including the use of virtual manipulatives. Each participant was given 2 generalization probes. Visual analysis of the graph indicated a functional relation between a multi-component instructional package (MSBI with systematic feedback in the consequent event) on the number of steps independently solved correct on the task analysis using an iPad for all three participants. Table 5 shows the number of points earned and problems solved during baseline generalization probes and intervention generalization probes.

Lauren. Lauren’s performance maintained during two generalization probes using the iPad. She was able to generalize problem-solving for one of the two problems presented. Scoring an average of 7.5 points on 2 generalization probes, visual analysis of the data indicate a functional relation between baseline and generalization with no overlap in the data across the baseline and generalization phase. On the first generalization session, Lauren had difficulty using the materials in electronic format and needed prompting on how to use the supports successfully (i.e., using the pointer versus the writing tool and using the virtual manipulatives).

Tim. Tim's performance maintained during two generalization probes using the iPad, indicating that he was able to generalize problem-solving skills when given materials in an electronic format. Scoring an average of 8.5 points on 2 generalization probes, a visual analysis of the data indicate a functional relation between baseline and generalization with no overlap in the data across the baseline and generalization phase. Due to motor difficulties, the electronic presentation of the generalization probes was adapted to best fit Tims physical needs. Virtual manipulatives were made larger, and each critical component (i.e., problem, student checklist, graphic organizer, number sentence) of the intervention was presented on individual pages of the software.

Edwin. Edwins performance maintained during two generalization probes using the iPad, indicating that he was able to generalize problem-solving skills when given materials in an electronic format. Scoring an average of 9 points on 2 generalization probes, a visual analysis of the data indicate a functional relation between baseline and generalization with no overlap in the data across the baseline and generalization phase.

Table 5.

Number of Points and Problems Solved in Generalization Probes

	Baseline Generalization			Intervention Generalization		
	Total Points	% Correct	# Solved	Total Points	% Correct	# Solved
Lauren	0	0%	0	15	75%	1 (50%)
Tim	0	0%	0	17	85%	2 (100%
Edwin	0	0%	0	18	90%	2 (100%)

Results for Question 5: Are students with moderate/severe ID able to maintain problem-solving skills, demonstrated by the number of steps performed independently correct and the ability to solve for the correct answer, when the student checklist is faded from the intervention package?

Figure 7 shows the effects of the multi-component intervention package on the acquisition of mathematical problem-solving. More specifically, the graph indicates each participants ability to solve addition word problems with faded supports. When presented with the graphic organizer, manipulatives and adapted supports (when necessary) and given the cue, “show me how to solve this problem,” 2 of the 3 participants were able to solve the problem independently without the student checklist. Each participant was able to recall and perform at least 50% of the steps associated with the problem-solving chain independently. One participant (Tim) performed the steps out of order, however was able to complete the critical steps necessary to solve correctly. Participants were given credit on-critical steps (circling the numbers, circling the ‘whats’, etc.) not performed if the critical steps of problem-solving were completed.

Lauren. When asked to solve the word problem without the checklist, Lauren requested the checklist and expressed concern for not having access to the support tool. Lauren was able to complete 5 out of 10 steps independently. The steps that she was able to complete independently included reading the problem (step 1), circling the ‘whats’ (step 2), circling the numbers (step 5), and filling in the number sentence to include the correct mathematical symbol (step 6). She was not able to perform the dynamic steps necessary to independently solve for the correct answer.

Tim. Tim was able to correctly solve the mathematical word problem presented without the use of the student checklist. He did complete steps out of order and combined steps for convenience; however was able to complete all critical steps associated with problem-solving. He scored 8 out of 10 points on the task analysis when the student checklist was faded.

Edwin. Edwin also was able to correctly solve the mathematical word problem presented without the use of the student checklist. Most steps were completed in order and he completed 10 out of 10 steps independently correct.

Results for Question 6: Are students with moderate/severe ID able to maintain problem-solving skills, demonstrated by the number of steps performed independently correct and the ability to solve for the correct answer, when the task analysis and the graphic organizer are faded from the intervention package?

Figure 7 shows the effects of the multi-component intervention package on the acquisition of mathematical problem-solving. More specifically, the graph indicates each participants ability to solve addition word problems when the student checklist and graphic organizer was faded from the instructional package. When presented with the problem-solving worksheet, manipulatives and adapted supports (when necessary) and given the cue, "show me how to solve this problem," 2 of the 3 participants were able to complete the problem independently. Each participant was able to recall and perform at least 40% of the steps associated with the problem-solving chain independently.

Lauren. When asked to solve the word problem without the checklist and graphic organizer, Lauren was able to complete 4 of the 10 steps correct independently. She was able to recall and perform the steps associated with reading the problem (step 1), circling the whats (step 2), circling the numbers (step 5), and identifying the rule (step 8). Without the visual supports of the student checklist and the graphic organizer, Lauren was unable to complete the steps required without prompting and support.

Tim. Tim was able to correctly solve the mathematical word problem presented without the student checklist and graphic organizer. He completed steps out of order and combined steps for convenience, however was able to complete all critical steps associated with problem-solving. He also used the manipulatives as if he had a graphic organizer, however did not draw or ask to have a graphic organizer drawn for him. He scored 8 out of 10 points on the task analysis when the student checklist and graphic organizer was faded.

Edwin. Edwin was able to correctly solve the mathematical word problem presented without the use of the student checklist and graphic organizer. Edwin created and labeled his own graphic organizer on a blank piece of paper and correctly used manipulatives to solve for the correct answer. Most steps were completed in order and he completed 10 out of 10 steps independently correct.

Results for Question 7: What are the perceptions of teachers and students on a multi-component instructional package (MSBI with systematic feedback in the consequent event) on mathematical word problem-solving and the acquisition of non-targeted science comprehension by students with moderate/severe ID?

Following the completion of the intervention, the classroom teacher and assistant completed social validity questionnaires. Table 6 shows the results of the teacher social validity questionnaires. Overall, classroom staff agreed that the participants enjoyed the intervention and made progress on all variables. Due to Laurens' limited acquisition of

NTI, the teacher reported that she agreed (score of 4 out of 5) that participants improved their ability to answer questions related to ELA.

Table 6.

Results from teacher social validity questionnaire.

	Teacher	Assistant
1. Did the participants enjoy the intervention?	5	5
2. Did the intervention improve the participants' mathematical problem-solving skills?	5	5
3. Did the intervention improve the participants' ability to identify science concepts?	5	5
4. Did the intervention improve the participants' ability to identify ELA concepts?	4	5

Following the completion of the intervention, each participant completed a social validity questionnaire. Table 7 shows the results of participant questionnaires. Overall, all participants agreed that they liked to do math with the interventionist and they would like to continue learning how to solve word problems. Participants also agreed that they liked the materials used and also liked to solve problems on the iPad. When asked if they wanted to say anything else about solving math word problems, one participant had additional comments. Tim stated, "I like solving word problems because it makes me feel motivated and makes me feel smart."

Table 7.

Results from student social validity questionnaire.

	Lauren	Tim	Edwin
1. Did you like doing math with me?	Y	Y	Y
2. Would you like to continue learning how to solve math problems?	Y	Y	Y
3. Did you like to use the graphic organizer?	Y	Y	Y
4. Did you like the rule 'small group, small group, big group'?	Y	Y	Y
5. Did you like solving word problems on the iPad?	Y	Y	Y

Chapter Five: Discussion

The purpose of this investigation was to evaluate the effects of multi-component instructional package on the addition word problem-solving skills and science and ELA knowledge of elementary school students with moderate and severe disabilities using a multiple probe across participants design. Problem-solving skills were measured using a task analysis in which the interventionist measured the participants ability to follow the steps necessary to solve the mathematics addition word problem. The acquisition of science and ELA knowledge was measured using a pre- and post-test. Following mastery on solving word problems, generalization to the iPad was measured using the same task analysis used throughout intervention. After measuring generality across materials, the ability to maintain performance with faded supports was measured using the same procedures utilized throughout the intervention. Finally, participants and their teacher were interviewed following the intervention to determine their perception of the multi-component intervention package on mathematical problem-solving and science and ELA knowledge acquisition. This chapter will explore the outcomes of the multi-component intervention package and themes derived from the outcomes of the intervention. Further, the contribution this study adds to the field of research on severe disabilities, the limitations of this study, along with recommendations for future research and implications for practice will be explored.

Solving Addition Word Problems

Prior to collecting data on student performance, each participant was introduced to the materials of the intervention package. The interventionist explained that the student checklist was a list of steps that would help solve the problem, the graphic organizer could help solve the mathematics problem, and the manipulatives could be used to solve the problem. Each participant scored zero during baseline, indicating a steady rate of responding. One participant, Edwin, commented about the pictures in the word problem and would often attempt to engage in non-related conversation with the interventionist during baseline. All participants were compliant and verbally responded to questions related to science and ELA knowledge after given the opportunity to solve the addition word problem.

Following two days of modeling and the introduction of the multi-component intervention package, visual analysis of participant data indicates a functional relation between the intervention and the ability to solve addition word problems. Data show a change in level with an increasing trend for all participants. A dramatic and immediate jump in level is evident for Tim and Edwin, while data for Lauren show a slight jump with a stable but increasing trend across time. Throughout intervention, several potential challenges related to intervention materials and participant behavior were evident. These potential challenges were the lack of previous exposure to support materials, the number of steps on the student checklist, the type and presentation of NTI at various points within a chained academic intervention package, the use of technology for students with mobility and motor challenges, and how to appropriately fade support stimuli from intervention packages.

Previous exposure to support materials. The support materials included in this multi-component intervention package included a student checklist, graphic organizer, and, if necessary, adapted response options. The student checklist served a self-monitoring tool and provided participants with written and visual representations of the steps necessary to successfully solve the addition word problem. Prior to this intervention, no participants had previous experience using a student checklist to follow a sequence of steps to complete a task or to self-monitor their behavior. Lauren and Tim required frequent prompts on how and when to use the student checklist. Additional attention to the student checklist prior to beginning intervention or during modeling could have impacted student performance.

Adapted response options (i.e., laminated check marks to Velcro on the student checklist, a number response board, adapted 3-dimensional manipulatives, picture response options) were provided for participants who required additional support completing writing, counting, and responding to materials. Lauren utilized the number response board, picture response options and adapted manipulatives throughout intervention. Due to her fine motor deficits, she used adapted materials to fill in the number sentence, identify the label in the question, label the graphic organizer, and write the answer. Additionally, she used the adapted manipulatives which were consistently presented in an organized linear array with Velcro supports to secure the manipulatives in place. While Lauren benefitted from the adapted manipulatives with structured support, she frequently became distracted removing the manipulatives from the board. Due to fine and gross motor difficulties, Tim utilized all adapted supports. Materials were also secure to a large board that could easily be place on the tray of his wheelchair and stander. The large board provided ample work space and kept materials in place. Response options that were secure with Velcro were difficult for Tim to remove. He also struggled to independently place manipulatives in the correct location on the graphic organizer, often asking the interventionist for help and point to where manipulatives should be placed.

Number of steps on the student checklist. The number of steps on the student checklist could have been problematic for Tim and Lauren. The student checklist contained 10 steps that outlined the problem-solving procedure. Tim naturally chunked steps together to accommodate his fine and gross motor deficits. For example, he would identify the numbers from the problem and fill-in the number sentence before returning to the student checklist to check off both steps. By chunking together steps that required specific behaviors related to gross motor movements related to the support materials used throughout the intervention, Tim was more efficient at manipulating materials and completing the task. A student checklist with a reduced number of steps could have positively impacted Tim's ability to independently solve addition word problems.

Like Tim, Lauren struggled with using the student checklist. Rather than keeping her on task and allowing her to monitor her own behavior, the student checklist distracted Lauren early in the intervention. Throughout intervention, Lauren required consistent prompting to follow the steps of the student checklist. As she checked off a completed step, she often became distracted and needed redirection from the interventionist. The act of checking off the step on the checklist stopped the momentum of problem-solving, which often became highly distracting. During the first booster session, the interventionist systematically reviewed the steps of the student checklist using a mass-trialed format with Lauren. While she still needed a high level of prompting throughout intervention, her ability to use the student checklist improved. If the student checklist contained less steps, Lauren might have been more efficient at using the self-monitoring tool and solving the addition word problems.

Acquiring Non-targeted Science Concepts During Mathematical Problem-solving

During baseline, participants were given science concept probes that addressed various science standards. All participants scored zero on their individual science concepts. The non-targeted science concept addressed for Lauren throughout the intervention was identifying what plants or flowers need to grow (water/sunlight). The non-targeted science concept addressed for Tim and Edwin was identifying what happened to ice after it melts. The non-targeted science concepts were presented in the consequent event following the first step of the student checklist. After reading the word problem the interventionist would make specific verbal statements related to the information presented in the problem (i.e., "This problem is about watering plants, plants need sunlight and water to grow."). The presentation of systematic feedback following the first step on the checklist did not overtly interrupt the problem-solving process for participants. Following the intervention, all participants were able to correctly identify the non-targeted science concepts. Visual analysis indicates a functional relation between the systematic presentation of information in the consequent event on non-targeted science knowledge.

Acquiring Non-targeted ELA Concepts During Mathematical Problem-solving

During baseline, participants were given ELA concept probes that addressed various ELA standards. All participants scored zero on the ELA concept, identifying the definition of a noun, during baseline. The presentation of the non-targeted ELA concept was presented in the consequent event following the second step on the student checklist. After circling or identifying the 'whats' in the problem, the interventionist would respond by re-stating the 'whats', state that the 'whats' were the nouns in the problem, and then verbally present the definition of a noun ("a noun is a person, place, or thing"). The presentation of systematic feedback following the second step on the checklist was occasionally disrupted based on student responding and the system of least prompts. For example, if an error was made on step 2, the interventionist delivered the level of prompt necessary and presented the systematic feedback following error correction or the following step solved correct. Unlike the consistent and systematic delivery of non-targeted science information presented as a consequent of step one, the delivery of non-targeted ELA information was less consistent due to the potential of participant error. Two of the three participants acquired the ELA concepts throughout intervention.

Generalization to the iPad

Prior to beginning intervention, all participants received at least one baseline probe using the iPad to solve for the correct answer. All student support materials were adapted using the SMARTNotebook™ software and presented to the student using the iPad. During baseline, all participants scored zero on problem-solving with an iPad. Visual analysis of the data indicates a functional relation between the multi-component intervention package and generalized problem-solving to the iPad. Two of the three participants (Tim and Edwin) were able to maintain mastery and independently solve for the correct answer using the iPad. The presentation of materials was adapted for Tim, placing each support tool (student checklist, graphic organizer, number sentence, etc.) on separate pages to accommodate his physical needs. Lauren maintained a high level of responding using the iPad, however was not able to independently solve for the correct answer. Lauren and Tim struggled with the use of virtual manipulatives. The ability to manipulate the virtual manipulatives was challenging with Tim's fine motor deficits, and

Lauren struggled to organize the manipulatives on the graphic organizer in a functional way. For example, Lauren did not place the virtual manipulatives in an array that she could easily distinguish the number of manipulatives present, making it difficult for her to combine the two sets and count for the final amount.

Fading the Student Checklist

After generalizing problem-solving to the iPad, the support tools were systematically faded to test for additional generalization. During the first phase of faded supports, the student checklist was removed from the intervention package. Students were given all materials used throughout intervention except the student checklist and given the prompt, “Show me how to solve this problem.” All participants verbally requested the student checklist and the interventionist prompted the participants to try to solve the problem without the checklist. All participants remembered the first step to solve the word problem (reading the problem). Lauren needed a high number of pacing prompts to keep her engaged in the problem-solving sequence and was able to recall the steps that involved gross motor behavior (i.e., circling the ‘whats’, filling in the number sentence, and the rule). Tim was able to solve for the correct response without the use of the student checklist. He completed some steps out of order (the rule and filling in the number sentence) and combined steps when possible. Edwin’s performance maintained when the student checklist was faded from the intervention package and he was able to recall all steps in the correct sequence.

Fading the Student Checklist and Graphic Organizer

The final phase that tested for generalization of faded supports involved fading the student checklist and the graphic organizer. During this phase, the student checklist and the graphic organizer was omitted from the intervention package. Lauren's performance decreased, and she was unable to identify and use the rule. For Lauren, it could be hypothesized that the graphic organizer served as a visual prompt for using the rule and mnemonic (small group, small group, big group). Both Tim and Edwin's performance maintained with the additional support tool faded. Tim utilized the manipulatives in a way that mirrored the graphic organizer (creating two small groups and combining them into one large group). Edwin requested a piece of paper, drew a graphic organizer and independently completed the required steps to solve for the correct answer.

Perceptions of Academic Outcomes

Social validity data was collected from classroom staff and participants. Overall, staff and participants reported positive perceptions and outcomes following the intervention. Participants were provided with a verbal interview with visual response options if needed. All participants agreed that they enjoyed learning to solve addition word problems, wanted to learn how to solve more problems, and liked the support tools that were used throughout the package. Following the structured questions, each participant was asked if they wanted to say anything else about learning to solve addition problems. Only one participant, Tim, made additional comments related to the intervention. He explained that he liked to solve word problems because they were hard, and it made him feel smart. He continued to say that sometimes people don't believe in him and he felt motivated after learning to solve word problems.

Classroom staff (teacher and assistant) were provided with a social validity questionnaire that consisted of a 5-point rating scale and open-ended questions. Both the teacher and classroom assistant agreed that the intervention had positive academic outcomes for all students and that students enjoyed the intervention. When rating the acquisition of non-targeted ELA information, the teacher rated the intervention slightly lower (four out of five) due to Lauren failing to acquire the non-targeted ELA concept. In a teacher interview, the teacher expressed her pleasure with the participants growth and hoped to continue to address word problem-solving in the future.

Themes Derived from Outcomes

Learning theory in intellectual disability. When analyzing participant performance across all phases of the study, slow skill acquisition and learning challenges could be a result of poor memory. The five broad categories of memory variables outlined in Ellis' theory include memory tasks, input processes, individual learner characteristics, recall processes, and remembering responses. The components of the intervention package utilized in this study specifically addressed the five categories of the multi-process memory model adopted by Ellis (1970).

To intentionally facilitate learning and memory, information was presented visually, auditory, and kinesthetically throughout the intervention. The student checklist presented a visual guide to solving addition word problems, auditory cues and systematic verbal prompts provided explicit information to participants throughout each step of the problem-solving method and a motor sequence including hand motions and a chant assisted in learning the rule. Paired association, a typical memory task that relies on mental connections between pairs (Mercer & Snell, 1977), was fostered by connecting the student checklist to specific behaviors required for problem-solving.

To foster the input variable that could impact learning and memory, environmental distractions were reduced. Instructional sessions took place in a quiet conference room where participants worked one-on-one with the interventionist. Instructional sessions occurred intentionally during typical mathematics time or during center rotations. To reduce environmental distractions, the participant and the interventionist sat at a table that faced a blank wall. The only materials present during intervention were materials necessary for solving the addition word problem. Additionally, to account for the rate of presentation, a system of least prompts was utilized. If a participant did not respond to a specific cue or task on the student checklist, a 7-10 second delay was utilized prior to administering the next successive prompt. The system of least prompts ensured that the intervention was delivered at a consistent pace. Prior to beginning instruction, the attention of the participant was gained. Participants identified what they wanted to work for, and their attention was drawn to completing the addition word problem to earn their reward.

The individual needs of each participant were considered throughout each phase of the intervention. Participant progress, individual characteristics and physical needs guided instructional decisions. All materials were specifically organized to help Lauren navigate and use the support tools independently. Tim was provided with an adapted checklist, adapted response options, 3-dimensional manipulatives, and an adapted iPad problem separating all support tools making the application easier to navigate to adjust for his physical needs. Additionally, frequent breaks were offered, and participants were given various choices throughout instructional sessions to meet their individual needs.

In an attempt to control for delay and interference between input and response, pacing and instructional prompts were used to facilitate participant recall. After a delay of 7 to 10 seconds, the interventionist would deliver the next appropriate prompt, based on student responding and the system of least prompts. Immediate delivery of specific feedback related to academic content in the consequent event following steps on the student checklist served to facilitate information recall. If a participant required multiple prompts, a delay in the presentation of NTI occurred. If a delay in the presentation of NTI occurred, making the specific verbal statement unrelated or unnatural to present, the NTI was presented following the next step on the student checklist.

The final category of variables impacting memory identified by Ellis (1970) is remembering the response. According to Ellis, the mode of presentation and the length of response impacts memory (1970). The student checklist provided support throughout the intervention for remembering the steps to solve the addition word problem. Additionally, the discrete behaviors associated with each step of the student checklist provided participants with digestible amounts of information, further supporting independent responding and reducing the length of total task response consequently reducing cognitive load. The number sentence, graphic organizer, and response options presented participants with visual supports to support independent responding. Finally, the intervention package presented instruction and supports in visual, auditory, and kinesthetic forms. The multi-modality of information presented supported student learning and information retention.

Evidence-based practices. Federal legislation mandates that all students have access to specially-designed and effective instructional practices (IDEA, 1997; NCLB, 2001, 2002; ESSA, 2015). With increased accountability and the need to provide grade-aligned academic instruction for all students, it is imperative that interventions are based on EBPs and the science of ABA. The contribution of ABA and advocacy to enhance educational opportunities for students with severe disabilities (Spooner & Browder, 2015) has made a significant impact on general curriculum access for students with moderate and severe disabilities.

This study incorporated EBPs and research-based strategies for students with severe disabilities to target multiple academic skills during one intervention package, increasing instructional efficacy. Task analytic instruction (Spooner et al., 2012), systematic instruction, graphic organizers, and manipulatives (Spooner et al., 2018) are identified as EBP for teaching academics to students with moderate and severe disabilities. While EBPs have been identified for teaching academics to students with moderate and severe disabilities, a practice for solving mathematical word problems has yet to be identified as having sufficient evidence to be considered an EBP. One strategy with an emerging base of literature for teaching individuals with moderate and severe disabilities to solve mathematical word problems is MSBI. Combined in a multi-component intervention package, these practices systematically address mathematics word problem-solving, science knowledge, and ELA content for students with moderate and severe disabilities.

Task analytic instruction is an EBP for teaching academic skills to students with moderate and severe disabilities (Spooner et al., 2012). Task analytic instruction involves breaking down a complex task into a series of discrete skills. After identifying such skills, each step of the behavior chain is systematically taught using specific chaining procedures. In the current study, the problem-solving process was broken into 10 specific skills. The task analysis was presented to participants as a student checklist and supported independent problem-solving. Throughout the study, the interventionist used a forward chaining procedure in which each step of the task analysis was taught in sequential order. Participants had an independently opportunity to complete each step of the task independently, however if the participant made an error or needed support the system of least prompts was used to facilitate the problem-solving process. The interventionist used a model-lead-test approach (Silbert, Carnine & Stein, 1981) in teaching the steps of the task analysis, combining task analytic instruction with systematic instruction.

Systematic instruction is based on the principles of ABA and involves (a) defining a discrete or chained response to measure as a demonstration of learning (i.e., identifying clear leaning objectives), (b) using specific prompting and prompt fading procedures for the acquisition of these responses, (c) reinforcement, and (d) planning for generalization and maintenance (Brown, McDonnell, & Snell, 2016; Collins, 2007; Snell & Brown, 2006; Spooner et al., 2011; Westling Fox & Carter, 2015. Systematic instruction is identified as an EBP for teaching mathematics (Browder et al., 2008), reading (Browder et al., 2006), and science (Spooner et al., 2011) for students with moderate and severe disabilities and produces effective and generalized outcomes (Wolery et al., 1988). The multi-component intervention package used in this study used a system of least prompts with an embedded time delay (i.e., if the participant did not respond to a specific cue or prompt within seven to 10 seconds, the interventionist would move to the next level of prompt) and the principles of reinforcement to systematically teach participants to follow a task analysis to independently solve mathematical word problems. Prior to beginning a session, each participant identified what they wanted to work for (i.e., a specific reward or toy, iPad time) and were provided with access to the reinforcer following completion of the session. Participants also were provided with specific verbal feedback and praise following correct responses with errors being immediately corrected by the interventionist. Following student errors, the interventionist used a model-lead-test instructional format to reinforce the desired response.

Manipulatives, an EBP for teaching mathematics to students with moderate and severe disabilities (Spooner et al., 2018), were used in the multi-component intervention package used in this study. Manipulatives are concrete or virtual objects that aid students in understanding and solving abstract mathematical concepts and problems (Bouck et al., 2014). Additionally, manipulatives can support the relationship between written numerals and cardinality. Participants in this study were taught to count and combine manipulatives to solve for the final amount in the word problem.

One component of the multi-component intervention used in this study was the use of graphic organizers. Graphic organizers show the relative position of elements and their relationship to one another to help students conceptually understand and solve problems (Ives & Hoy, 2003). Graphic organizers are identified as an EBP for teaching mathematics to students with moderate and severe disabilities (Spooner et al., 2018). The graphic organizer used in this intervention package supported the problem-solving process by allowing students to systematically count groups of manipulatives to represent specific components of the problem. After creating two small groups of manipulatives, participants combined the small groups into one large group, depicting the part-part-whole relationship and representing the operation of addition. Prior to using manipulatives on the graphic organizer, participants labeled the graphic organizer to further support comprehension of what the manipulatives represented and the connection between the different groups.

Teaching academic content within context. When teaching students with moderate and severe disabilities core and academic vocabulary, it is important to teach content within context as opposed to rote memorization to expose the student to a variety of skills applicable to a broad array of settings (Falkenstine, Collins, Schuster, & Kleinert, 2009). While teaching participants to solve addition word problems, science concepts and ELA vocabulary were embedded as systematic feedback in the consequent event of the steps associated with problem-solving. After reading the word problem, the interventionist would identify the theme of the word problem and verbally present the science concept to students prior to moving on to the next step. For example, the interventionist might say, “this problem is about flowers. Flowers need sunlight and water to grow.” The next step in the problem-solving behavior chain included identifying the meaning of the problem. After this step, the interventionist presented systematic feedback related to ELA vocabulary. For example, the interventionist might say, “this problem is about tulips and roses. Tulips and roses are flowers. Flowers are a thing. A noun is a person, place or thing.” By embedding science concepts and ELA vocabulary in story-based problem-solving, participants were given examples of where and how the skills could be applied in authentic settings.

This study utilized a constant time delay response prompt and the system of least prompts to embed NTI within MSBI. With the task analytic delivery of instruction in MSBI, embedding NTI in the consequent event using a response prompt procedure concurrently addressed multi-domain academic content in a mathematics word problem-solving intervention. One barrier to consistently presenting NTI throughout the intervention package was participant responding. For participants who required high levels of prompting or who made frequent errors, a delay in the delivery of the NTI was present. This delay often made the delivery of NTI unnatural, requiring the interventionist to deliver the NTI following the consequent step on the task analysis. If the interventionist presented the NTI following a student error or a high level of prompts, a break in the problem-solving chain occurred, interrupting the behavior momentum associated with mathematical problem-solving. Further, a high level of planning was required to embed grade-aligned content within MSBI. In an attempt to deliver natural and appropriate systematic feedback without confusing the participant or masking the target task, NTI was not presented following mathematics-related steps (i.e., completing the number sentence, making sets on the graphic organizer, combing sets to solve, etc.).

Overcoming barriers to accessing the general curriculum. While the field of special education has made significant gains on providing access to the general curriculum for students with moderate and severe disabilities, barriers still exist that inhibit access to grade-aligned academic instruction. Barriers to accessing the general curriculum include few explicit and exemplarily models (Olson, Leko, & Roberts, 2016), ambiguity and confusion (Timberlake, 2014), collaboration (Ballard & Dymond, 2017), perceived accessibility (Ballard & Dymond, 2017), and the interpretation of standards (Dukes & Darling, 2017). The current study was designed to overcome obstacles identified as barriers to general curriculum access for students with moderate and severe disabilities.

With few exemplar models available for providing access to the general curriculum for students with moderate and severe disabilities, researchers and practitioners must turn to EBPs and current research related to academic instruction. The multi-component intervention package used in this study include EBPs and practices with an emerging literature showing positive outcomes for teaching academic skills to students with moderate and severe disabilities. With few exemplar models available, the intervention package used in this study combined practices to effectively address grade-aligned academic instruction across multiple domains.

Ambiguity and confusion is often associated with providing students with moderate and severe disabilities access to general curriculum content. Perceptions, personal values, and perceived value of general curriculum content often impact student access to general curriculum content (Timberlake, 2014). The primary dependent variable in this study, mathematics problem-solving, provides access to grade-aligned, general curriculum mathematics with embedded grade-aligned science concepts and ELA vocabulary. This study provides evidence that students with moderate and severe disabilities can learn general curriculum content with minimal prerequisite skills (i.e., one-to-one correspondence, number identification 0-9) across academic domains. Dissemination of general curriculum outcomes for students with moderate and severe disabilities and the application of EBPs in the classroom setting are critical in further clarifying general curriculum access for this population.

Collaboration is often an obstacle associated with general curriculum access for students with moderate and severe disabilities. It is often found that special education teachers do not receive specialized training on general curriculum content and general education teachers do not receive specialized training on how to teach students with moderate and severe disabilities. Due to time constraints (Carter & Hughes, 2006; Coots et al., 1998; Matzen et al., 2010) and poor communication (Ballard & Dymond, 2017) planning for general curriculum access is often inhibited. When designing the intervention package, the interventionist collaborated with an expert in general education mathematics, multiple experts in general curriculum access, and general and special education teachers. The procedures of this intervention package have been validated by experts in the field, providing special education teachers with a vetted approached for teaching mathematical problem-solving with embedded science concepts and ELA vocabulary.

Identifying appropriate adaptations and modifications for students with moderate and severe disabilities is often a perceived barrier for accessing the general curriculum. When adapting and modifying the general curriculum content, it is crucial to adjust for the individual needs of each student. For example, if a student has a physical disability a mode of response might need to be modified. Students who have fine motor deficits and physical disabilities could be provided with an adapted checklist with Velcro checks to use for self-monitoring during the problem-solving procedure or with 3-dimensional manipulatives that attach to a graphic organizer. The material adaptations used in this study were based on EBPs (i.e., visual supports, task analysis, graphic organizers) and designed to meet the needs of each individual participant (i.e., structured organization, adapted student checklist, etc.). When identifying instructional practices or adapting content to meet the needs of an individual, teachers and practitioners should look to current research and implications for practice to identify the most appropriate adaptations and modifications with research to support effectiveness.

A final barrier to accessing the general curriculum is how the standards are interpreted. In connection with how the standards are interpreted, there also is a disconnect with how student progress will be measured and reported based on these standards. With a gap between academic standards and life skills for students with severe disabilities (Dukes & Darling, 2017), additional work is needed to standardize how students will best access such standards. This study targeted grade-aligned academic content within a natural application (i.e., teaching science concepts and ELA vocabulary within story-based word problems). General curriculum content should be taught within natural and applicable settings, when appropriate, to promote generalization and functional application.

Contribution to current knowledge on teaching academic skills to students with moderate and severe disability. The current study provides evidence to support the use of multi-component intervention packages to teach general curriculum content to individuals with moderate and severe disabilities. Using MSBI to teach word problem-solving with NTI embedded in the consequent event of instructional feedback to address ELA and science concepts, participants acquired grade-aligned mathematics, ELA, and science skills.

The results of this study add to existing literature supporting the use of MSBI to teach word problem-solving to students with moderate and severe disabilities (Brosh et al., 2018; Browder et al., 2017; Ley Davis, 2016; Root, 2016; Root et al., 2017; Root & Browder, 2017; Saunders, 2014). To further existing research, this study systematically faded student support tools, providing evidence that students can maintain word problem-solving performance after supports were faded from the intervention. Additionally, this study varies from existing studies (Brosh et al., 2018; Browder et al., 2017; Ley Davis, 2016; Root, 2016; Root et al., 2017; Root & Browder, 2017; Saunders, 2014) in that all materials were systematically introduced to participants prior to collecting baseline data. The interventionist explicitly identified and explained the purpose of each tool that could be used to solve the word problem (i.e., word problem, student checklist, graphic organizer, number sentence) to ensure accuracy of baseline data. Previous studies could have misrepresented baseline data due to faulty procedures and the lack of introduction to available materials prior to collecting data.

Additionally, it adds to the existing research base that supports embedding NTI in the consequent event of intervention packages to increase instructional efficacy. Previous work targeting functional skills with embedded academic NTI (Collins et al., 1995, 2010; Fetko et al., 2013; Fiscus et al., 2002) and academic skills with embedded functional NTI (Collins et al., 2007, 2011; Falkenstine et al., 2009) show the efficacy of embedding NTI in various intervention packages. This study adds to the literature to support embedding academic NTI within academic interventions to further increase access to grade-aligned academic content for students with moderate and severe disabilities.

Limitations

The current study had several limitations. First, this study included a multi-component intervention package that combined various EBPs and instructional strategies into one intervention. A component analysis, an analysis of the variables which comprise the treatment package (Cooper et al., 2007), is needed to identify the most salient features of the intervention. While participant performance was measured with some support tools faded (without the student checklist and without the student checklist and the graphic organizer), not all components of the intervention were faded.

A second limitation of the current study is the isolated problem type and the use of specially-designed materials. This study only addressed the group problem type, that targets the part-part-whole (Carpenter & Moser, 1984) relationship with addition. Other word problem types and mathematical operations were not addressed. Additionally, the word problems presented only included quantities one through nine. All word problems presented followed a very specific formula related to predetermined themes associated with academic content presented as NTI. Each word problem followed a consistent four-sentence formula with the first sentence introducing the theme of the word problem, the second and third sentences identifying the two small groups, and the last sentence presenting the question with the label. All word problems used easy-to-decode words and common names. The materials presented were systematically organized and presented to participants in a predictable and structured format. Due to these limitations, generalization of solving addition word problems could be impacted.

A third limitation is the number of embedded exposures of NTI across word problems and phases. Because participants acquired addition word problem-solving at varying rates, the number of times each participant was exposed to the NTI varied. For example, it took Lauren over 30 sessions to acquire addition word problem-solving skills while Edwin achieved mastery in just four sessions. Due to the varying acquisition rate of solving addition word problems, an exact replication of embedding NTI within the intervention is unlikely. Further, it was not investigated whether the information acquired through NTI was memorized or acquired with a level of generality to apply the information in various ways.

Finally, the current study included a complex population in which characteristics of participants varied and the setting in which intervention took place controlled for environmental distractions. Three participants diagnosed with moderate or severe intellectual disability were nominated for participation based on prerequisite skills. All sessions of the intervention took place one-on-one in a small conference room attached to the classroom during instructional time. The small sample size and individualized delivery of intervention within a controlled setting should be considered when making generalizations about the outcomes and planning for replication.

Recommendations for Future Research

The results of this study suggest several recommendations for future research in the area of general curriculum access, specifically targeting word problem-solving and multi-component intervention packages, for students with moderate and severe disabilities. This study adds to the existing body of research supporting the effectiveness of embedding NTI in the consequent event (Collins et al., 2010; Fiscus et al., 2002; Karl et al., 2013; Taylor et al., 2002; Wall & Gast, 1999) to increase instructional efficacy. While this study provides evidence that one intervention package can teach grade-aligned academic content across domains to individuals with moderate and severe disabilities, additional work should investigate embedding individual goals in multi-component instructional packages. Future research should continue to investigate how to embed NTI in chained academic and functional tasks to increase incidental learning and instructional efficacy for this population. Further, research should focus on prioritize core content with an emphasis given on functional and application-based skills to increase student independence and community participation.

While research supports that students with moderate and severe disabilities can learn academic content aligned to grade-level standards, it is important to consider how academic achievement impacts independence and functional skills (Browder et al., 2007). This study provides evidence that students with moderate and severe disabilities can learn grade-aligned academic content, however it does not investigate the generality or application of the skills addressed. Additional research is needed to investigate the impact of academic performance on long-term outcomes and the application of acquired skills for this population.

A second recommendation for future research is to expand the context of delivery. This study took place one-on-one with an interventionist in a conference room. Future research should explore implementing the intervention in a classroom setting with the classroom teacher serving as the primary interventionist. Additionally, research should explore student groupings and implementing the intervention within small and whole group settings.

The intervention package was robust and complex, requiring the interventionist to adjust the delivery of prompts and NTI based on student responding. A third recommendation for future research should explore the use of computer-aided instruction and technology supports to increase intervention efficacy, reducing the workload for teachers and interventionists. More specifically, the use of technology could increase the efficacy of the intervention package with controlled and specific prompting procedures and the delivery of NTI at predetermined and consistent points within the intervention.

A final recommendation for future research is to explore the application of word problem-solving to generalized problem situations. Solving word problems introduces students to a problem-solving method (identifying key features in a problem and following a sequence of events to identify a solution); however fails to apply to generalized situations that a student encounters across various settings. While word problems can be written to enhance generality and include situations that a student might encounter, it does not predict or guarantee a student's ability to solve problems in vivo. Future research should investigate whether or not there is a connection between mathematical word problem-solving and solving problems related to mathematics concepts (i.e., having enough of a material to share, measuring amounts when duplicating a recipe, identifying if you were given enough change from a cashier) across various settings. Further, researchers should seek to identify ways to increase opportunities for generalized problem-solving and identify ways to support problem solve across various settings and situations.

Implications for Practice

Based on the outcomes of this study, there are several practical implications related to multi-component academic intervention packages, word problem-solving, and embedding NTI within instructional feedback to increase instructional efficiency. First, practitioners should utilize EBPs and instructional strategies based on ABA (i.e., chaining, prompting procedures, principles of reinforcement) to address the academic needs of students with complex learning needs. For students diagnosed with moderate or severe disability to adequately acquire grade-aligned academic skills, such skills need to be explicitly identified with specific measurable outcomes. After identifying specific learning goals with measurable outcomes, practitioners should consider breaking the skill into a series of discrete tasks and teaching the target skill using a chaining procedure. In the current study, a forward chaining procedure was utilized to teach the progressive problem-solving sequence, building on previously mastered skills. Combined with the forward chaining procedure, a system of least prompts was utilized to systematically teach each step of the behavior chain. Simultaneously, as the system of least prompts was utilized so was specific verbal feedback in the form of verbal praise and individual systems of reinforcement were used. The results of this study show that EBPs and the strategies of ABA can be combined to teach students academic skills within the public school setting.

Further, a second implication for practice is for practitioners to utilize task analytic instruction to increase independence and self-monitoring to students with moderate and severe disabilities during academic interventions. This multi-component intervention package included a task analysis in the form of a student checklist. The student checklist listed the discrete skills in sequential order that were required to independently complete the problem-solving task. The student checklist paired a visual representation with the written description of each step to support non- and emerging readers in the problem-solving process. Practitioners should utilize chaining procedures and task analytic supports to teach chained behaviors and support student independence. When breaking a complex task into digestible and discrete skills, the process of independently completing the task is often more accessible for students with complex learning needs. Task analytic instruction also provides practitioners with crucial information about student performance, often identifying exactly where students are struggling within a chained task, which aids in making appropriate instructional and data-based decisions. When the checklist was faded from the intervention package, all participants expressed concern for not having access to the tool and verbally requested to use the checklist. Without the student checklist, Laurens performance slightly decreased, and Tim and Edwin's performance maintained. Practitioners should monitor the use of student checklists and plan to systematically fade these supports when appropriate to avoid dependency.

MSBI, a strategy with emerging evidence to support its effectiveness in teaching word problem-solving to students with moderate and severe disabilities (Root, Browder, et al., 2015), can provide students with conceptual and procedural knowledge to solve mathematics word problems (Root, 2016). A third implication for practice is to utilize MSBI to teach students how to independently solve mathematical word problems. Advancing past rote memorization and early numeracy skills, solving mathematical word problems has the potential to increase generalized problem-solving across various situations and settings for students with moderate and severe disabilities. To successfully solve mathematical word problems, one must identify key information from the problem, identify the relationships between quantities and identify which operation to use when solving. MSBI uses systematic instruction, visual supports, and a task analysis in the form of a student checklist to teach the steps of the problem-solving process. Practitioners can use this strategy to successfully teach students to independently solve mathematical word problems. Additionally, as shown in this study, materials and supports can be adapted or modified to meet the needs of each individual.

A final implication for practice is that embedding NTI in academic interventions can improve skill acquisition across a variety of academic domains. This study demonstrated that students with moderate and severe disabilities can learn grade-aligned academic content across three academic domains (i.e., mathematics, ELA, science) within one instructional package. With the increasing demands teachers face with balancing grade-aligned core instruction with meeting the individual needs of each student, teachers should consider utilizing practices that embed more than one skill within an intervention. Practitioners should identify areas of instruction in which more than one skill could be targeted within a meaningful context.

Summary

This study evaluated the effects of MSBI with embedded NTI as systematic feedback in the consequent event on solving addition word problems and the acquisition of science concepts and ELA vocabulary of elementary students with moderate and severe disabilities. MSBI with a task analysis and a graphic organizer was used to teach participants how to solve addition word problems. NTI presented as systematic feedback in the consequent event was used to present science concepts and ELA vocabulary to participants throughout intervention. A functional relation was found between MSBI and independently completing steps of the task analysis for solving word problems. Participants were able to generalize problem-solving to an iPad and performance maintained or slightly decreased when support tools (i.e., student checklist and graphic organizer) were faded from the intervention. A functional relation was found between NTI and the acquisition of science concepts. Two of the three participants acquired the ELA NTI vocabulary. Lauren, the participant who did not acquire the ELA NTI, did not actively respond to the information presented as systematic feedback (i.e., did not repeat the feedback vocally or comment on the information) following the 2nd step of the student checklist (i.e., circle the ‘whats’). With Laurens lack of response to the information and the order in which the instructive feedback was delivered, it is hypothesized that the lack of acquisition is a result of the position within the chained behavior that the instructive feedback was presented or her lack of attention to the information. The results of this study add to the evidence supporting the use of MSBI to teach mathematical word problem-solving and NTI to embed academic content within chained tasks. The findings of this study could have significant implications for designing and implementing multi-component academic intervention packages for students with moderate and severe disabilities, providing access to grade-aligned content and increasing instructional efficacy.

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APPENDIX A – PARENTAL CONSENT FORM

UNCCHARLOTTE
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 researcher named below any questions you have about this study at any time.

Investigators:

Chelsi Brosh, M.Ed, BCBA, crbrosh@uncc.esu

What is the purpose of this study?

The purpose of this study is to develop a way to teach students with moderate and severe intellectual disabilities grade-aligned academic content. The intervention will include using read alouds, a story-based lesson and a standard problem format to make the written problem accessible to nonreaders. Students will use a chart that helps them organize their answer. Additionally, we will assess non-targeted functional and daily living skills that are embedded throughout the intervention package. We will evaluate whether students can generalize across materials, technology (iPad, Smartboard), real-life activities, and instructors/settings. Your child is being considered for this study because he or she has the prerequisite skills to begin working towards solving math word problems.

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 an intellectual disability, can solve addition mathematics word problems, does not have the prerequisite skills necessary, or if you do not give your informed consent.

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, science, and literacy skills. Your child may benefit by learning to solve word problems. Additionally, your child may gain additional science vocabulary knowledge and ELA content.

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 or frustration with learning a new task. This risk will be minimized by using praise and encouragement during the instruction and by discontinuing videotaping if the child begins to act out or expresses a desire to quit.

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?

Any identifiable information collected as part of this study will remain confidential to the extent possible and will only be disclosed with your permission or as required by law.

For purposes of student evaluation and research dissemination to professional audiences, some of the intervention sessions 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 name or any personal information.

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 for your child to be in this 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, complaints, or concerns, 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 childs 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

Chelsi R. Brosh, M.Ed, BCBA__________________________________
Signature of Research Team Member Obtaining Consent   Date

Chelsi Brosh____
Printed Name of Research Team Member Obtaining Consent

Contact Information (for mailing materials)

Address:

Phone Number:

Email:

APPENDIX B – STUDENT ASSENT FORM

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

College of Education
Dept of Special Education & Child Development
Phone: 704-687-8492
Fax: 704-687-2916

Date: September XX, 2017

Student Assent Form

"My name is Chelsi Brosh. Do you want to work on solving math problems with me? When we solve math problems, we might learn other things like science concepts and how to answer questions about a story. We will work together in the back of the classroom when your classmates are in math groups. You do not have to work with me if you don't want to. It is your choice and no one will be mad at you if you do not want to with me. Would you like to learn how to solve math problems and work with me over the next few weeks?

An adult has read this to me. My choice is:

YES	NO
	

____________________________ _________________________ _______

Student Name Student Signature Date

(stamp and/or student response recorded, if unable to sign)

____

Researcher's Signature Date

This form was approved for use by the UNCC internal Review Board on ______, expires _____.

APPENDIX C – DATA COLLECTION FORM

Date:	Researcher:	Student Code:	Video: Y N
Phase:	/ 10 Steps Correct		Solved Correct Y N
IOA on Data:		IOA of Fidelity:	

Problem Theme:								
Implementation Steps of MSBI for Mathematical Problem Solving	**Impl.**	**Student Response and Prompt Level**					**Systematic Feedback and CTD - Non-Targeted Instruction**	**Impl.**
1. Give cue, “Show me how to solve this problem”		*I: Independent correct response* *RS: Restate Question* *SV: Specific Verbal* *M: Model* *EC: Error Correction*						
2. Asks, “How do we get started?”								
3. (1) Read the problem[1]		I	RS	SV	M	EC	***Science NTI*[9]**	
4. (2) Circle/finds the ‘whats’[2]		I	RS	SV	M	EC	***ELA NTI*[9]**	
5. (3) Find the label in question[3]		I	RS	SV	M	EC	***Science NTI*[9]**	
6. Labels the GO[4]		I	RS	SV	M	EC	***ELA NTI*[9]**	
7. (4) Circle the numbers[5]		I	RS	SV	M	EC		
8. (5) Fill in numbers in number sentence[8]		I	RS	SV	M	EC		
9. (6) Puts correct math symbol in number sentence[8]		I	RS	SV	M	EC		
10. (7) Makes sets[6]		I	RS	SV	M	EC		
11. (8) States the rule		I	RS	SV	M	EC		
12. (9) Combine both small groups and count (solve)[7]		I	RS	SV	M	EC		
13. (10) Write answer[8]		I	RS	SV	M	EC		
14. Student restates answer when question is asked again		I	RS	SV	M	EC		

NTI: Science	Response	
What do plants/flowers need to grow?	+	-
What happens when ice melts?	+	-
NTI: ELA	**Response**	
What is a noun?	+	-

Use of the Student Checklist (Task Analysis)			
Independent	Minimal Prompting Needed (Less than 3)	Consistent Prompting Needed (Between 3-8)	High Level of Prompting Needed (More than 8 prompts)

Notes, Questions, Comments About Student Performance:

Next Step for Upcoming Session:

[1]: S or T reads the problem: S identifies the step, asks to have the problem read, or reads I
2: Student can substitute wording ‘whats’ for ‘pictures’ or ‘nouns’. If the student does not have the motor skills to circle the ‘whats’, the response of identifying the ‘whats’ in the problem in pictures or verbally is accepted.
[3]: Underlines the label in question or finds the label in a field of response options and places the label in the number sentence appropriately.
[4]: Student labels the graphic organizer by writing the first letter of the word, writing the word, or selecting a picture or word response option from a field of 3 or 4 in the correct location on the graphic organizer. Labeling the graphic organizer does not count for or against the student score.
[5]: If the student does not have the motor skills to circle the ‘numbers’, the response of identifying the ‘numbers’ in the problem and verbally stating the numbers, picking the numbers from a response board, or having the interventionist circle the numbers is accepted.
[6]: If the student needs assistance due to mobility, student can ask for help and/or have the interventionist hold/place/move manipulatives,
[7]: If the student needs assistance due to mobility, student can ask for help and/or have the interventionist hold/place/move manipulatives.
[8]: For students who are non-writers, students may use pre-printed response options to complete task.
[9]: The presentation of NTI by the interventionist could occur during any step of the TA, however is most likely to occur between steps 1-3. Interventionist must present NTI at least once per session for both science and ELA concepts.

APPENDIX D – SAMPLE WORD PROBLEMS

Allie was buying flowers at the store.

First, she bought _____ pansies.

Next, she bought _____ mums.

How many flowers did Allie buy in all?

Lois used ice to keep her food cold.

She had _____ yogurts.

She had _____ puddings.

How many food items did Lois have in all?

Lilly bought plants at the farmer's market.

She bought _____ strawberry plants.

She planted _____ tomato plants.

How many plants did Lilly plant in all?

Taylor needed ice to keep her drinks cold.

She had _____ waters.

She had _____ juices.

How many drinks did Taylor have in all?

Chandler needed ice to keep her lunch cold.

She had _____ fruits.

She had _____ vegetables.

How many food items did Chandler have in all?

Jodi used ice to keep her drinks cold in her cooler.

She had _____ waters.

She had _____ sodas.

How many drinks did Jodi have in all?

Jeananne needed ice to keep her lunches cold.

She had _____ sandwiches.

She had _____ salads.

How many lunches did Jeananne have in all?

The fisherman used ice to keep her fish fresh.

She had _____ swordfish.

She had _____ groupers.

How many fish did the fisherman have in all?

The waitress used ice to keep the beverages cold.

She served _____ juices.

She served _____ sodas.

How many beverages did the waitress serve in all?

The butcher used ice to keep his meat fresh.

He had _____ steaks.

He had _____ chops.

How many pieces of meat did he have in all?

Anna gave her mother flowers for her birthday.

First she gave her mother _____ lilies.

Next she gave her mother _____ peonies.

How many flowers did she give her mother in all?

Nella received flowers as a gift.

She received _____ orchids.

She received _____ roses.

How many flowers did Nella receive in all?

APPENDIX E – TEACHER SOCIAL VALLIDITY QUESTIONNAIRE

Question	**(1) Strongly Disagree (3) Neutral (5) Strongly Agree**				
1. Did the participants enjoy the intervention?	1	2	3	4	5
2. Did the intervention improve the participants' mathematical problem-solving skills?	1	2	3	4	5
3. Did the intervention improve the participants' ability to identify science concepts?	1	2	3	4	5
4. Did the intervention improve the participants' ability to answer ELA comprehension questions?	1	2	3	4	5

How to you feel the participants' responded to the intervention?
Do you feel that you would continue this intervention in the future?
What would you have changed about the intervention?
Were there any challenges or difficulties associated with the intervention?
What components of the intervention were most meaningful?

APPENDIX F – STUDENT SOCIAL VALIDITY QUESTIONNAIRE

Did you like doing math with me?	 
Would you like to continue learning to solve math problems?	 
Did you like to use the graphic organizer?	 

Did you like the rule 'small group, small group, big group'?	 
Did you like solving word problems on the iPad?