Supporting Transition-Related Problem-Solving Skills for Students with Autism

Supporting Transition-Related Problem-Solving Skills for Students with Autism

by

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Abstract

Mathematics is an integral part of adult life in areas of employment, education, and independent living. Autistic students with concurrent intellectual disability (autism-ID) have significant needs in mathematics, and they exhibit lower rates of success in the post- secondary goals than students with other disabilities and their typically developing peers. Modified Schema-Based Instruction (MSBI) is a potential support for the mathematical needs of students with autism-ID in a transition-related environment. This dissertation used a nonconcurrent multiple probe across participants design (NCMPD) to evaluate the effectiveness of MSBI on transition-related mathematics skills with goal setting for three high school students with disabilities. The dependent variable was the number of task analysis items completed independently in the classroom setting and school-based work setting. Visual analysis, *Tau-U* and Design Comparable Effect Size are reported. Students showed an increase in problem solving performance in classroom and transition-related settings.

Keywords: mathematics, modified schema-based instruction, autism, intellectual disability, multiple disabilities

Supporting Transition-Related Problem-Solving Skills for Autistic Students

Chapter 1: Introduction and Literature Review

Mathematics problem-solving skills are necessary for success in post-secondary fields of employment, education, and independent living. The National Assessment of Educational Progress (NAEP, 2024) showed that students' proficiency in mathematics steadily declined as students progressed through more advanced or complex mathematics coursework (US Department of Education, 2024). Students scoring in the Proficient and Advanced ranges on the NAEP were 39% in fourth grade and 24% in eighth grade. In 2019, 24% of students scored in the Proficient and Advanced ranges in 12th grade, with an alarming 40% of 12th grade students having below basic mathematics skills. Some experts believe that a potential cause for low mathematics performance in later grades is that mathematics skills are taught in isolation instead of as integrated concepts and there is a lack of strong foundations in basic mathematics skills in earlier grades (Leyva et al., 2021).

These nationwide data are more concerning when it comes to post-secondary outcomes for students with disabilities. Although typically developing (TD) students (i.e., students without disabilities) are not scoring at the expected level of mathematics performance, students with disabilities are scoring significantly below them and have lower rates of competitive employment after high school (NAEP, 2024; Wei et al., 2013). Within disability categories, Autistic students[1]

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[1]To align with and in respect to the Autistic population's advocacy regarding person-first language, this dissertation uses a mix of person-first (i.e., student with autism-ID) and identity-first (i.e., Autistic student) to respect the diverse preferences of the community (Wooldridge, 2023). The title of this project has kept person-first language to remain consistent with university paperwork.

scored lower than students with learning disabilities on both applied problems and calculation item assessments (Wei et al., 2013). Moreover, Autistic students exhibited the third lowest mathematics performance compared to all 13 disability categories covered under the Individuals with Disabilities Education Act (IDEA), scoring only higher than students with intellectual disabilities and multiple disabilities (Wei et al., 2013). An important factor to consider is that 35.2% of Autistic students have an additional diagnosis of intellectual disability (ID) and/or multiple disability (Maenner et al., 2021).

Academic achievement predicts post-school outcomes. Using the National Longitudinal Transition Study-2 data, Nasaman and colleagues (2017) found that academic achievement was a significant predictor of overall post-school success and likelihood of enrollment in post-secondary education programs. Considering the academic and post-secondary needs of Autistic students, it is necessary to identify strategies and practices to support students to achieve independent success within the classroom and post-secondary settings such as work and community as well as the ability to manage everyday tasks they will encounter.

Mathematics Problem Solving

Mathematics problem solving skills are necessary for students to be prepared for the workplace (Saunders, 2020). As Van de Walle and colleagues (2019) described, the 21st century workplace relies less on the ability to compute problems and more about the person's ability to design solutions to the problems. This includes critical thinking, communication, collaboration, and creativity skills. Although there is no ambiguity around the importance of mathematics problem solving skills, there are numerous cognitive processes required to hone these skills. Common attributes that predict mathematics problem solving are cognitive skills such as working memory, language skills, processing speed, attention, as well as academic skills like computation and mathematics vocabulary (Decker & Roberts, 2015; Lin, 2021; Wang et al., 2016).

Working memory and language comprehension have been extensively studied in connection with mathematics problem solving (Decker & Roberts, 2015; Wang et al., 2016). Working memory allows students to hold mental representations in their mind while using other processes and is integral to the formation of mathematics problem solving skills, as it requires the student to store and manipulate multiple pieces of information all while translating text into a mathematical equation or expression as well as processing linguistic information to make connections to prior knowledge, develop inferences, and identify strategies to solve the problems (Wang et al., 2016).

Working memory and language skills are significant predictors of mathematics problem-solving skills. Wang et al. (2016) found that, for TD second grade students, working memory and language skills were significant predictors of mathematics problem solving skills along with early calculation skills. Additionally, Decker and Roberts (2015) discovered that for TD students in grades 1-4, in addition to working memory, other cognitive variables (i.e., processing speed, visual spatial reasoning, and fluid reasoning) significantly predicted students' problem-solving performance above and beyond students' computation performance. Results of a meta-analytic study also found language, working memory, attention, mathematics vocabulary, and computation to be unique predictors of mathematics problem solving skills across the 98 studies included. For older students, all of the cognitive predictors (i.e., working memory, attention, language) were still significant, but they were mediated through the academic skills of mathematics vocabulary and calculation (Lin, 2010).

Contrary to the extensive studies examining predictors of problem-solving skills of TD students, there is a dearth of research examining the cognitive skills of Autistic students in conjunction with their specific mathematics skill achievement. What is known, however, is that Autistic students show significant variability in across cognitive measures (e.g., IQ, working memory) and within academic areas (e.g., spelling and other writing tasks), and overall exhibit lower performance in abstract or inferential academic tasks, including mathematics problem solving (Kurth & Mastergeorge, 2010).

Despite a lack of direct research in the cognitive processes of Autistic students and their mathematics problem solving skills, they exhibit challenges in the cognitive domains that are related to mathematics skills (i.e., language, working memory, and attention). In a literature review of 24 studies examining working memory and Autism, Kercood et al. (2014) found that Autistic students have lower working memory scores, make more errors when solving problems, use fewer or inefficient strategies to solve mathematics problems, and perform lower on tasks that require more flexibility and planning than their TD peers and peers with attention deficit hyperactivity disorder (ADHD). Although the authors found verbal working memory of Autistic students was most comparable to students with learning disabilities (LD), their overall working memory was lower and was significantly correlated with their IQ scores. Supporting these results, Mecca and colleagues (2014) found that Brazilian children with Autism had lower performance on tasks that required flexibility and inductive reasoning.

Related to working memory, language deficits are well documented for Autistic students, as defined in diagnostic criteria. Schuh and Eigsti (2012) compared the working memory and language skills of 9–17-year-old Autistic students and TD peers. They found that working memory accounted for the variance in language skills. Similarly, research has found that attention and mathematics achievement are related for Autistic students. When comparing TD students and Autistic students, McDougal et al. (2020) found that, when controlling for IQ, Autistic students displayed a significant relationship between divided attention (i.e., the ability to attend to multiple tasks or stimuli at one time) and mathematics skills but not reading. For TD students, this relationship was not significant for mathematics or reading, despite whether the analysis controlled for IQ. Their findings suggest that divided attention may play a more significant role in mathematics achievement than IQ.

Research findings reviewed above suggest that Autistic students may experience challenges in the areas of working memory, language, and attention, which are shown to predict future mathematics achievement (Decker & Roberts, 2015; Lin, 2021; Wang et al., 2016). Therefore, cognitive characteristics of Autistic students put them at a higher risk for difficulties in developing necessary mathematics problem solving skills.

Intervention Research for Autistic Students

Research for Autistic students is extensive. However, large amounts of research focus on academic behaviors (e.g., time on task) or other defining characteristics of Autism (e.g., communication). Steinbrenner et al. (2020) conducted an extensive meta-analysis of evidence-based practices (EBPs) for Autistic students. To be included in their review, a study needed to focus on children with Autism between birth and 22 years of age, investigate the effects of a focused intervention practice, and use an experimental design to show effects on an outcome variable. They identified direct instruction (DI) as a new EBP and provided more support for the use of cognitive strategy instruction (CSI) for Autistic students. Out of the identified EBPs, DI was the third least researched after Ayres Sensory Integration and music mediated interventions. DI has mostly been used in studies targeting communication skills and only for children 0-14 years old. Out of the eight outcome measures for DI that met the inclusion criteria, only four had an academic focus and one of those was mathematics related (i.e., telling time). For CSI, 34% of included studies focused on academic outcomes and the least addressed area was mathematics performance (i.e., 3 out of 17 CSI studies). The most frequently researched academic outcome related to EBPs for Autistic students was reading (i.e., three studies on DI, and eight studies on CSI; Steinbrenner et al., 2020).

Several researchers have attempted to identify current studies and the most effective mathematics practices for the population (King & Lemons, 2016; Hart Barnett & Cleary, 2015; Root & Ingelin, 2021). Reviews of mathematics interventions for Autistic students have found that most studies focus on computational and functional (e.g., money, telling time) mathematics skills (Hart Barnett & Cleary, 2015; King & Lemons, 2016). In their review of mathematics interventions, Hart et al. (2015) found 11 studies that met inclusionary criteria of including school-aged Autistic students and using an experimental design to examine the effectiveness of an intervention on a mathematics outcome. Seven studies were academic focused with five targeting fact fluency and two targeting word problem solving; the remaining four studies targeted functional mathematics skills (e.g., next dollar strategy). Similarly, King and Lemons (2016) found 14 studies that met the What Works Clearinghouse quality standards and 78% focused on computation and functional mathematics. The reviews indicate that there is a need for the development of interventions that focus on building the problem solving or higher-level mathematics skills for Autistic students. Effective instructional strategies found were explicit instruction, systematic prompting, visual-based strategies, cognitive-based strategies, and positive behavior support (Hart Barnett & Cleary, 2015; King & Lemons, 2016).

Although older studies did not tend to focus on problem solving skills for Autistic students, they are becoming more prevalent as a more recent review by Root and Ingelin (2021) found 20 studies that targeted problem solving skills. Their review found that successful mathematics problem-solving interventions have been shown to have multiple components as opposed to one specific strategy. The following components have been successful for teaching mathematics problem solving skills to Autistic students: task analysis, system of least prompts, graphic organizers, explicit instruction, schema-based instruction, and technology-aided instruction. Out of the 20 studies, all used at least two of these components and seven used all six. These results suggest that Autistic students may benefit from a variety of strategies to make mathematical progress in more complex skills, and individualized instruction or intervention may be necessary depending on the student's unique needs. However, based on this review, there is a distinct need for problem-solving interventions for high school aged students (which were only included in 2 out of 20 studies in the review), as their educational programming shifts to focus on post-secondary transition skills.

Schema Theory and Schema-Based Instruction

Schema theory refers to the way people cognitively organize information and how new information is processed to fit into previous patterns or schemas (Axelrod, 1973). Schema theory suggests that the broader (i.e., more strategies a person knows) the schema, the more likely the person can apply familiar strategies to novel situations (Fuchs et al., 2004). The process of using schemas is called mapping. Mapping is the act of applying knowledge from one situation to another by "finding a set of one-to-one correspondences (often incomplete) between aspects of one body of information and aspects of another" (Gick & Holyoak, 1983, p. 2). At its core, schema theory relates to the generalization process and using prior knowledge to make sense of new situations or information. Schema theory plays an important role in mathematics problem solving skills for students with and without disabilities.

Word problems require students to apply existing information to new situations; therefore, if students have a narrow schema, they will struggle to generalize their skills to new tasks (Fuchs et al., 2004). Fuchs and colleagues (2004) stressed the importance of not only being cued to anticipate similarities across tasks but also being able to independently search for those connections using metacognitive skills. Therefore, instruction in schema-based strategies should include support of self-monitoring skills through the mathematics problem-solving process.

Schema-Based Instruction (SBI) is an evidence-based strategy to help teach problem-solving skills to students with learning disabilities (Cook et al., 2020). According to Jitendra (2007), SBI consists of two distinct phases. The first is the problem schema instruction phase, where the students are given story-like word problems with only known information. The purpose of this phase is to guide students' understanding of the word problem's structure that leads to the problem type. The students then map this information into given diagrams. The second phase is the problem solution phase, where students learn to solve problems with unknown quantities. In this phase, the students follow a four-step strategy checklist called FOPS: find the problem type, organize the information into the diagram, plan to solve the problem, and solve the problem. Overall, the SBI process begins with teacher-mediated instruction, followed by paired partner learning, and ending with independent learning activities, which are all supported by the heuristic FOPS.

Modified Schema-Based Instruction

Although SBI is an appropriate strategy for students with LD, it requires modifications to be effective for students with more severe disabilities such as Autism and intellectual disability (autism-ID). Spooner and colleagues (2019) instituted two major changes to SBI, making it Modified Schema Based Instruction (MSBI). First, heuristics was replaced with graphic organizers and task analysis; second, explicit instruction was adapted to use a system of prompts and modeling of think alouds. Other components added to the MSBI method were the use of hand gestures and chants to help support students' metacognitive skills.

A systematic review conducted by Clausen and colleagues (2021) investigated the overall effect of MSBI, showing that the instructional method almost meets the criteria for EBPs; however, different research teams in different geographical regions need to conduct high quality studies for MSBI to be an EBP. They identified 12 single case design studies using MSBI; 11 of which met Horner et al.'s (2005) quality standards. All studies showed that MSBI had a positive effect on mathematics performance for students with moderate disabilities. Eight of the 12 studies included participants with co-occurring Autism and ID indicating that this strategy is effective and appropriate for this population.

A meta-analysis from 2022 continued to support MSBI as an effective strategy with a strong research base meeting What Works Clearinghouse (WWC) standards with and without reservations (Yucesoy-Ozkan et al., 2022). Their review found 11 studies that met their inclusion criteria for SBI (i.e., 6 studies) and MSBI (i.e., 5 studies). All MSBI studies in their review included participants with Autism and/or ID between the ages of 10 and 14. They found that MSBI had a mean aggregated effect size of .99, indicating that the intervention provided strong effects on word-problem solving skills. Yucesoy-Ozkan and colleagues (2022) identified that MSBI research needs to be more inclusive of other geographical areas and show strong effects in high quality studies with more participants. Due to these criteria that were not met, the authors identified MSBI as an emergent EBP for students with disabilities.

Previous MSBI Studies

Five studies have examined the effect of MSBI for transition-age students with moderate or severe disabilities (i.e., Cox et al., 2024; Gilley et al., 2021; Gilley et al., 2023; Root et al., 2018; and Root et al., 2022). Root and colleagues (2018) targeted financial skills of students in middle and high school using the MSBI method. All three participants were identified as having an intellectual or developmental disability (ID; i.e., Autism, ID). More specifically, they taught students to solve percentage problems using coupons and then determined if they had enough money for the purchase. Components of the MSBI used in this study included graphic organizers, self-monitoring with visual support, and a six-step task-analysis. The intervention occurred in school, one-on-one with an interventionist. Generalization probes occurred in the same classroom and consisted of using real-world materials such as receipts and menus. In addition to MSBI, the students created goals, graphed their progress, and evaluated their goal each session. The multiple baseline design demonstrated a functional relation between MSBI and number of accurately completed problem solving steps during intervention. Generalization probes also showed improvement from baseline, although not as high as the regular word problems. Students were able to generalize and maintain the skills learned after the intervention was delivered. These results indicated that MSBI may be a useful strategy to teach and support transition-related mathematics in all domains (i.e., education, employment, and independent living) and in real-world environments.

Similarly, Gilley et al. (2021) investigated the effect of MSBI on real-world problem-solving skills of Autistic students. Three students in a post-secondary transition program were taught to use MSBI to solve multiplicative word problems with real-world contexts. Following previous MSBI research, the intervention began with three scripted lessons to model use of the strategy. Differing from Root et al. (2017), each intervention session began with students creating a goal for themselves and documenting it electronically. The steps of the MSBI were task analyzed and required the student to monitor if they were completing the step independently or with the help of the interventionist. After each session, the student self-graphed the percentage of independently and accurately completed steps and evaluated if they met their predetermined goal. The authors found that all participants made immediate and consistent improvements in their word problem solving skills.

In 2022, Root and colleagues examined the use of augmented reality (AR) through video-based instruction with MSBI to examine the effects on personal finance problem-solving skills. Four Autistic students, who were enrolled in a postsecondary transition program, participated in the study. The study looked at student skills for checking receipts for accuracy, reacting appropriately to the receipt, calculating a correct tip, and finding the final cost of the receipt. Students were provided with electronic worksheets that included a word problem, receipt, graphic organizer, and links to video-instruction. Using anchor videos (i.e., videos following the process in the community to provide context to the problem solving), social problem-solving videos (i.e., reacting to inaccurate receipts), and modeling videos (i.e., point of view video model with think aloud voice overs), the authors found a functional relationship between the intervention package and mathematics problem solving skills. The results from this study were consistent with a following replication study from Cox and colleagues (2024) in which they found that MSBI with AR video-based instruction effectively improved the mathematics problem solving skills of the high school Autistic students.

Gilley et al. (2023) examined the combination of peer-mediated intervention with MSBI to support the multiplicative comparison problem-solving skills of Autistic students. The intervention included explicit instruction, task analysis, graphic organizers, and self-monitoring. The researchers found a functional relation between the intervention package and the students' mathematics problem solving skills.

The reviewed studies examined the effect of MSBI for real-world mathematics problem solving skills for students with autism-ID and continues to be effective in combination with other EBPs. Across all studies, MSBI components shown to be effective were explicit instruction, task analysis, graphic organizers, and self-monitoring strategies. An important component for secondary students with autism-ID present in all interventions is self-determination, as the goal for postsecondary success is independence and self-advocacy (Wehmeyer, 2020). Without these skills, students with autism-ID will continue to be reliant on adults for their needs.

Self-determination refers to people acting as their own agents and has a positive relationship with quality of life for people with intellectual and developmental disabilities (Wehmeyer, 2020). One method of helping support self-determination is goal setting. Goal setting skills require students to set goals, evaluate their progress toward their goals, and adjust their plan if necessary. It has been effective in increasing motivation of students, accuracy of mathematics problems, and on-task behavior (Carr et al., 2014).

Although the reviewed MSBI studies show it is effective for high school and older students with autism-ID, there are two major gaps that future research needs to address. The first is the range of skills taught in each intervention. Most studies required the students to learn one problem-solving skill instead of having to differentiate between operations and choose the correct one based on the problem. The ability to distinguish between situations that require different operations is crucial to real-world problem solving because students will be faced with real-world mathematics problems requiring a multitude of operations, which will most likely be different in each situation. Therefore, explicitly learning to differentiate between operations is critical to problem-solving success after high school.

The second limitation in the current research base is that all instruction and generalization was limited to one setting (i.e., Root et al., 2018; Gilley et al., 2023) or continued to utilize worksheets (Gilley et al., 2021). Generalization is a major area of concern for students with autism-ID (Brown & Bebko, 2012; Hume et al., 2009; Sartini et al., 2018) and is still not widely addressed in academic research for students with ID (McDonnell et al., 2020). When generalization in different settings and situations is not addressed, it may lead to an increase in reliance on adult support systems and lower rates of independence (Hume et al., 2018). Previous research recommended that students with ID should learn to master skills prior to generalizing them to new contexts (Heward et al., 2017); although Root et al. (2022) suggests that generalization be measured multiple times throughout baseline, intervention, and after mastery in their study examining the effects of MSBI. Considering the challenges in generalization of skills for students with autism-ID (Brown & Bebko, 2012), it is imperative that academic interventions target generalization to different settings and situations to help students learn to apply the learned skill in a variety of contexts. The present study sought to extend MSBI research to natural problem-solving opportunities in the environment to further generalize the skills mastered in the classroom setting and help evaluate accessible materials that students can take with them when graduating from high school.

Purpose

The purpose of this dissertation was to replicate current research on MSBI for students with autism-ID and to extend the research to skills for transition-aged students outside of the classroom context. More specifically, this study will examine the effect of MSBI on mathematics skills for students with autism-ID in two different settings: classroom and school-based work. The goal is to help students generalize necessary mathematics skills to real-life situations with fewer supports. The research questions are as follows:

1. What is the effect of MSBI with goal setting on the word-problem solving performance for transition-aged students with autism-ID? We hypothesized that MSBI with goal setting would have a positive effect on the word-problem solving performance for transition aged students with autism-ID (Gilley et al., 2021; Root et al., 2018).
2. What is the effect of MSBI with goal setting on the mathematics-related problem-solving performance within transition related environments? We hypothesized that transition-aged students with autism-ID would be able to generalize the MSBI skills to real-world situations and/or environments (Gilley et al., 2021; Root et al., 2018).

Chapter 2: Method

Participants

Three participants were recruited to participate in this study who met the following criteria: (a) were transition-age as per Special Education Regulations in their state (i.e., 14 years old to age 22); (b) had post-secondary transition goals in education, employment, and independent living from which mathematics problems can be developed; (c) had documented autism and intellectual disability diagnosis or intelligence score below 70 as documented in evaluation reports; (d) provided informed parent consent and student assent; and (e) a satisfactory score (described below) on a researcher-made screening measure. In addition to inclusion criteria, data related to student specific transition goals and cognitive functioning (i.e., working memory, processing speed, and language skills) are reported, if they were available in student documents. IRB approval was obtained for this study.

The participants attended a licensed private school for Autistic students in a mid-Atlantic state. They received all instruction within this school and had opportunities to participate in outings into the community and inclusion events at partnering general education schools. All transition-aged students began a school-based work program when they turned 14. All baseline and intervention lessons and sessions occurred during their transition instructional period. Generalization sessions occurred in the school-based work setting during their scheduled shift. Please see Table 1 for participant demographics; all students were assigned pseudonyms.

Xavier was a 16-year-old, white male student with a diagnosis of autism, intellectual disability, and other health impairment (OHI) for attention deficit hyperactivity disorder (ADHD) and executive functioning challenges. From a review of his records, his most recent full-scale IQ (FSIQ) score was 40 and thus in the extremely low range. Xavier attended mathematics class three times per week for 45 min. During this intervention, his mathematics instruction focused on measurement data and geometry using the iReady curriculum. He was also working on adding and subtracting money up to $100. Xavier had annual mathematics goals involving solving multi-step computation problems using real-world documents (e.g., grocery receipts, menus) and a personal finance goal to manage his budget in a simulated bank account. Xavier received speech therapy, occupational therapy, and physical therapy as a part of his school program. Xavier enjoyed researching topics of interest online, playing academic games on his iPad, and animals. His post-secondary goals were to attend a college inclusion program and gain competitive employment with the support of a job coach.

Xavier scored within an acceptable range on the researcher-made screening measure with 75% accuracy. He was able to identify numbers, shapes, and use the calculator fluently, but did not complete the word problems accurately. Results of the screening measure indicated this study would be an appropriate intervention for his mathematics problem-solving skills. On the Keymath-3 subtests of Foundations of Problem Solving and Applied Problem-Solving, he scored within the < 0.1 percentile.

David was a 16-year-old, African American male student who received special education services under IDEA with the primary classification of Intellectual Disability. His secondary disability category is Multiple Disabilities, which includes autism, speech or language impairment (SLI), vision impairment, and OHI for ADHD and executive functioning challenges. His most recent intelligence tests indicated that his FSIQ is 64 and a classification of very delayed. David attended mathematics class five times per week for 45 min. His mathematics instruction focused on telling time to the nearest quarter hour and identifying total amounts of money from a set of three bills provided. These topics were also his IEP goals with the additional goal of managing his personal budget using a simulated bank account. David received speech therapy, occupational therapy, and physical therapy as a part of his school program. David enjoyed playing video games, listening to music, and public transportation systems. His post-secondary goals were to attend a college inclusion program and gain competitive employment with the support of a job coach.

David scored within an acceptable range on the researcher-made screening measure with 75% accuracy. He was able to identify numbers, shapes, and use the calculator fluently, but did not complete the word problems accurately. Results of the screening measure indicated this study would be an appropriate intervention for his mathematics problem-solving skills. His KeyMath-3 scores also showed an elevated need for additional mathematics intervention. He scored within the < 0.1 percentile on the Foundations of Problem Solving and Applied Problem-Solving subtests.

Adam was a 16-year-old, male student. School records indicated that he was of Hispanic or Latino ethnicity and multi-racial. He received special education under the classifications of intellectual disability, autism, emotional disturbance, SLI, and OHI for ADHD. His most recent FSIQ score was 49 and described as very poor. Adam's mathematics instruction during the intervention focused on money skills (e.g., using bills to purchase items, determining if he had enough money to purchase items) and personal finance; these topics also aligned with his IEP goals. He attended mathematics class five times per week for 45 min. Adam received speech therapy, occupational therapy, and music therapy as a part of his school program and services. Adam enjoyed telling jokes, talking with peers, playing music, and learning about different countries. He had post-secondary goals were to participate in on-the-job training and obtain competitive employment with the support of a job coach.

Adam scored within the acceptable range on the researcher-made screening measure with a score of 67% accuracy. Adam was able to identify numbers, shapes, and input number sentences into a calculator independently. At times, he needed a reminder to press the buttons with more pressure and to press the equal sign. He did not attempt to solve any word problems on his screening measure. Adam's KeyMath-3 scores placed him within the < 0.1 percentile on the Foundations of Problem Solving and Applied Problem-Solving subtests.

Settings

Classroom

The intervention sessions took place in the students' classroom during their Life and Career class. All classroom spaces in the school were large (approximately 400 square feet) and had a mix of student desks, tables for small group work, and a teacher desk. Room dividers were available to help reduce distractions for when students were working in small groups or one-on-one with staff. There was a maximum of eight students and seven staff members in each room. Intervention sessions occurred in the classroom in a location or seating arrangement of the student's choosing, such as a desk, standing table, or floor. All classroom intervention sessions took place one-on-one with the interventionist.

School-Based Work

After the participant met mastery criteria in the classroom setting, generalization sessions took place in the school-based work setting. At the school site, transition-aged students participated in 2-hour transition instructional periods three to five times per week. Xavier received Life and Career instruction three times per week for 6 hours; David and Adam received Life and Career instruction five times per week for 4 hours. These blocks included direct instruction in transition and daily living skills as well as scheduled in-school work shifts. These work shifts included jobs around the school, such as filling school store orders, taking inventory, custodial tasks, and administrative tasks. Generalization sessions took place during the participants' scheduled transition class.

Interventionist and Data Scorers

The interventionist was a certified special education teacher for grades 7-12, had 10 years of experience in the classroom, and served as a senior administrator at the school site during this intervention. The interventionist conducted all assessments, lessons, and data collection sessions for each participant. The interventionist trained graduate students to be research assistants (RAs) to support data scoring for the data collection sessions. Training sessions were conducted in a virtual meeting for approximately 30-45 minutes. In the training session, an overview of the measure was presented and the interventionist modeling how to score the videos. After the initial session, the data scorers were given a practice video and were required to meet a 100% agreement with the interventionist on training materials. The data scorers scored most MSBI probes for baseline, intervention, and generalization sessions from video recordings. Due to time constraints, the interventionist had to score all of Adam's sessions and David's generalization sessions. All interventionist scored sessions for David were double scored for agreement by RAs.

Materials

All instructional materials (i.e., probes, task analysis, word problems) for this study were researcher-made based on previous MSBI studies (e.g., Browder et al., 2018; Root et al., 2017; Root et al., 2018). During baseline, student materials included (a) an iPad with the calculator and Worksheets Go application and (b) electronic worksheet with the problem. When students entered the intervention phase, they had the same materials as baseline with the addition of the MSBI self-monitoring checklist, graphic organizer, and the session's goal setting sheet and social validity questions. For generalization, student materials included a post it with the necessary information written for the problem, a calculator, an iPad with the Worksheets Go application, and a graphic organizer. All materials with the exception of the goal setting and social validity sheet were on the iPad in the Worksheets Go application.

Each problem contained three sentences. The first sentence contained the starting amount; the second sentence contained the amount of change; and the last sentence was the question. Any additional supports listed in the student's specially designed instruction were provided as outlined in their IEP (e.g., visual supports for reading). Example problems, graphic organizer, and task analysis checklist can be found in Appendix A.

Design and Measurement

The study used a nonconcurrent multiple probe across participants design (NCMPD) to evaluate the effectiveness of MSBI on the independent problem-solving performance for students with autism-ID.

Design

A NCMPD across participants design was used to answer the research questions for this study. A NCMPD was chosen because of its feasibility of implementation in the school setting and schedule. By demonstrating similar effects at different points in time, NCMPD enhanced the external validity of the study (Kratochwill et al., 2022; Morin et al., 2023; Slocum et al., 2022). Keeping with best practice, this study used start-point randomization for the order of participants (Morin et al., 2023). The study was implemented over three phases (i.e., baseline, intervention, generalization). Each phase contained a minimum of five data points.

Measures

Screening Tool. As in previous MSBI studies (e.g., Browder et al., 2018; Root & Browder, 2018; Root et al., 2018), a screening tool was developed by the researcher to determine the participant's ability to complete the following items: (a) identify numbers up to three digits, (b) identify shapes, (c) transfer numbers to a calculator, (d) solve multi-digit addition and subtraction problems with an iPad calculator, and (e) solve multi-digit addition and subtraction word problems with an iPad calculator. The purpose of the screening tool items was to determine (1) if the participant had the essential skills and prerequisite skills needed to benefit from intervention (items 1-5), (2) verify that the participant had not already mastered the target skill (items 9-12), and (3) assess the current level of calculation ability (items 7-12). One hundred percent accuracy on pre-requisite skill items (items 1-5), and < 25% accuracy on target skill items (items 9-12) indicated satisfactory performance on the screening tool. If the student required prompting to complete the calculator items, they were counted as correct since a pre-unit lesson was given to support calculator skills on the iPad. See Appendix B for the screening tool.

MSBI Intervention Probes. The primary dependent variable for this study was the percentage of MSBI steps solved independently and correctly in the classroom on a researcher-created test based on previous research (Gilley et al., 2021; Root et al., 2018). All MSBI intervention probe sessions were videotaped for scoring. An expert panel of two reviewers was assembled to determine if the probes were appropriate to measure the targeted skills. One expert reviewer has extensively published in the MSBI field, and the second reviewer had experience researching academic skills for the target population for this study. As described in the procedures, if the student completed a step with no additional help beyond the Level 1 prompt (described below), the step was counted as independent. Each step of the task analysis was operationally defined in Table 2. The student was considered to have met mastery criteria when they solved 16 out of 20 steps independently on one data collection session (Root et al., 2017). Students were moved from intervention into generalization when they met mastery criteria or had at least five data points. Each MSBI probe included one addition problem and one subtraction problem. The order of presentation of the problems was randomized for each probe in baseline and intervention. Students completed the same baseline probe problems; intervention probes were individualized to fit students' interests related to employment, post-secondary education, and independent living goals when appropriate, but the numbers of the word problems were consistent across participants. The difficulty level of the problem itself remained consistent across probes, and the only difference in the intervention probes was the individualization of the problem scenarios for the interests. Some problem scenarios in the intervention probes were the same for students if their goals and interests aligned. Example MSBI baseline probes and an intervention probe example for each participant can be found in Appendix C. The MSBI probes were identical for the maintenance data collection of the study.

MSBI Generalization Probes. In generalization sessions, the MSBI checklist consisted of six steps, as opposed to 10 required for intervention sessions. The steps eliminated were those associated with a written word problem and those not usual to solving real-world mathematics problems such as reading the problem, circling the starting amount, and underlining the change amount. The MSBI generalization probe included one problem related to the work they were performing that day at their in-school job. Four data points were collected in baseline, and six generalization data points were collected after mastery was met in intervention. Half of the generalization problems were addition and half were subtraction. The order of the problem operations was randomized for each participant prior to their start in the study. See Table 3 for the randomized order of problem operations and Table 4 for the task analysis of generalization steps.

Social Validity. Previous MSBI researchers were contacted to use their social validity scale for this dissertation. They recommended consistent and repeated social validity measures for the duration of the intervention conducted by the interventionist.

After each data collection session in the intervention phase, the interventionist asked the students three questions on the following topics: (1) how they felt about their problem-solving; (2) how they felt about the word problems; and (3) which components of the session they did or did not enjoy that day: setting their goal, checking off their steps as they worked, using the organizer, and using the calculator. For the first two questions, the student circled an emoji face from five options ranging from a frowning emoji to a smiling emoji with heart eyes. These questions were scored from 1 to 5, with five indicating the most positive feeling. Students' answers were averaged across all intervention sessions. For the third question, the student was presented with four components of the intervention and were prompted to select if they liked (i.e., checkmark) or disliked (i.e., red x) each component. They were also told that they did not have to put either on the component. Frequency of choice for each component was calculated, and the total frequency that the student chose the component was divided by the total number of intervention sessions and multiplied by 100 to obtain a percentage. See Appendix D for the repeated social validity measure.

As a repeated measure, the consistency over time may have helped eliminate any potential influence of student answers that the interventionist administration of the measure may have caused. The researchers consulted for social validity also suggested that the interventionist should be the administrator of this social validity because they are able to directly observe the student's behavior during the session. For example, a student may have spent the session putting their head down a lot and refusing to complete some components and then circle the happiest face during how they felt about the problems. The interventionist would be able to ask follow-up questions for answers that didn't align with their behaviors during the sessions. The procedural fidelity for social validity focused on allowable statements and unallowable statements the interventionist could make during the sessions (see Appendix E). A trained graduate student research assistant conducted fidelity for 40% of randomly selected social validity sessions.

Interscorer Agreement

RAs conducted interscorer agreement (ISA) for > 30% of randomly selected sessions for every phase of the study from video recordings of the sessions. ISA was calculated using a point-by-point agreement (i.e., total number of steps agreed upon divided by the total number of steps observed multiplied by 100). One hundred percent of interventionist-scored sessions were included in ISA analysis for David and 96% were scored for Adam. Only one video was unable to be scored for Adam's ISA due to technical difficulties.

Treatment Fidelity

Treatment fidelity was assessed for baseline sessions, the intervention lessons, and data collection sessions for the intervention, generalization, and maintenance phases. See Appendix E for all fidelity documents. The intervention lessons were video recorded, and a trained graduate student research assistant conducted fidelity from the video recordings using a checklist. Treatment fidelity was collected for 50% of intervention lessons and > 30% of data collection sessions in the intervention phase, two generalization sessions, and one maintenance session for each participant. Interobserver agreement (IOA) was conducted for $\geq$ 30% of randomly selected fidelity sessions by RAs.

Procedural Fidelity

Procedural fidelity was conducted for ≥ 30% of each student's baseline sessions and for 100% of all social validity sessions (i.e., session check-ins) for each student. RAs conducted procedural fidelity. Procedural fidelity checklists can be found in Appendix F.

Data Analysis

Visual analysis was used to evaluate if there was a functional relationship between the MSBI procedures and the student's problem-solving skills across problem types. Visual analysis examined the trend, stability, immediacy, level, and overlap. Tau-U was calculated to account for any undesirable baseline trend and provide an effect size (Parker et al., 2011). Effect sizes were interpreted as follows: .65 is questionable; between .66 and .92 is effective; and .93 is very effective (Rakap, 2015).

Additionally, a Between-Case Standardized Mean Difference effect size (BC-SMD) was calculated as proposed by Pustejovsky et al. (2014) to provide a more conservative effect size than Tau-U. BC-SMD involves modeling the nested structure of the single-case research design (SCRD) data with a hierarchical linear model that captures variation in the outcomes both within and across participants. The BC-SMD estimate was calculated using the *scdhlm* app, a web-based ES calculator for SCRD studies (Pustejovsky et al., 2022). The model used in this study used a Restricted Maximum Likelihood estimation method with time trends and accounted for changes in linear trend based on author recommendations. BC-SMD compares data from between- and within-group means to produce an effect size similar to group design Cohen's *d* (Valentine et al., 2016). According to Chen et al. (2023), BC-SMD can be interpreted the same way as the standardized mean difference in a group design study. Therefore, effect sizes were interpreted as follows: 0.2 is a small effect size; 0.5 is a medium effect size, 0.8 is a large effect size (Cohen, 1977).

Procedures

Throughout all phases of the study, the student continued to receive mathematics instruction from their special education teacher. As a part of the school's policies, weekly communication logs were sent home to each participant's families outlining what they are completing in their classes. The researcher reviewed these logs to assess if any students received instruction in the intervention components in the classroom. David and Adam's instruction during the intervention focused on telling time and using bills and coins to make purchases. Xavier's instruction focused on finding the total cost of items from a menu and calculating decimals up to the hundredths place with a calculator. Toward the end of his intervention phase, Xavier's mathematics class worked on word problems using key words; however, no components of the intervention were used in the word problem instruction. Problem solving instruction he received in his typical mathematics class was after he had already received his intervention lessons and began intervention. During the intervention, Xavier had one mathematics teacher, and David and Adam had 3 different mathematics teachers due to turnover at the school site.

Each student had a positive behavior support plan and received school money for engaging in desired behaviors throughout the school building. The school's procedures for following expectations were followed. Any additional behavior supports listed in the student's IEP were used, such as "first…then…" charts or visual schedules. All baseline sessions, intervention lessons, intervention sessions, and generalization sessions were video recorded without the student's face to assess fidelity.

Pre-Unit Lesson

Prior to baseline and intervention, the participant participated in one pre-unit lesson with the interventionist. As suggested by Root et al. (2018), a pre-unit lesson may help lessen the cognitive load for the students during intervention. The pre-unit lesson for this intervention included entering numbers into the calculator, solving one- to three-digit addition and subtraction problems using the calculator, navigating the electronic worksheet application, and transferring the answer from the calculator to the electronic worksheet. A direct instruction model was used for the pre-unit lesson (i.e., modeling, guided practice, and independent practice). Error correction was a system of least prompts beginning with verbal questions and ending with modeling prompts. See Appendix G for the pre-unit lesson.

Baseline

No instruction in the MSBI method was provided during the baseline phase. The students continued to receive their scheduled mathematics instruction. No other mathematics instruction was administered. All teachers were asked not to teach word problems or use any MSBI components during the intervention.

In baseline sessions, students were given an iPad with two electronic worksheets on it, an Apple Pencil, and a calculator. The interventionist gave the instructional cue to "show me how you solve this problem." The student was provided with verbal praise for remaining on-task. No instructional feedback was given. Once the participant completed at least five data points and had a stable baseline, they entered into the intervention phase.

Intervention

The intervention phase included introductory lessons, data collection sessions, and goal-setting components.

Lessons. After baseline data were collected, the interventionist provided two introductory lessons (e.g., Browder et al., 2018; Root et al., 2018). Scripted lesson plans were used and can be found in Appendix H. The first lesson taught the students about change problem types and how to use the change problem rule (i.e., "one thing–[unit] *holds hand at chest height with palm facing down*; [if addition] add to and change *moves palm upwards*; [if subtraction] take away and change *moves palm down*). The second lesson taught the student how to use the goal-setting sheet and how to use the checklist and organizer to solve the problems. Each lesson included statements or activities about the importance of mathematics problem-solving skills after high school. An expert who has extensively studied and published MSBI research reviewed the lessons and provided feedback.

Data Collection Sessions. Data collection sessions occurred one to five times per week depending on the student's schedule for approximately 10 to 15 min per session. The sessions began with the student completing the goal setting sheet and reviewing their progress from the previous session. The interventionist reviewed the number of steps they completed independently in their previous session and marked it on the number line. The student was prompted to choose a goal that was greater than or equal to their previous score or to the right of their previous score on the number line. After the student set their goal, they were provided the iPad with electronic worksheets, Apple Pencil, and calculator and prompted to follow the checklist and begin the first problem.

Two word problems were solved during each data collection session. Each problem was related to the student's individual goals in post-secondary education, employment, and independent living. Because mathematics problem solving requires that steps be completed correctly to reach an accurate answer, a system of least prompts from previous MSBI research was used to ensure opportunities for accuracy in each step of the task analysis and also served as scaffolding (Browder et al., 2018; Root et al., 2018). The system of prompting included four levels with at least a five sec delay. Level 1 provided a verbal redirection prompt if a student does not begin the next step of the MSBI task analysis in 5 s or longer after the stimulus was presented or after the previous step was complete. If the student required a Level 1 prompt to attend to the task (e.g., "Let's focus," "What step are you on?" "How do you complete that step?"), this step was still marked as independent, as it was believed that distractions occurred and did not reflect the student's ability to perform the step.

Level 2 included general verbal with gesture prompts was the interventionist stating the step they are on and pointing to the step on the checklist (e.g., "Your next step is to circle and label your starting amount" and *point to next step on checklist*). Level 3 provided specific verbal and gesture prompts that told the student more specifically how to complete the step (e.g., "Your starting amount will always been in the first sentence. Circle your starting amount and write it in your organizer" and *point to first sentence*). Level 4 provided direct guidance on how to complete the step (e.g., "The starting amount is in the first sentence: You worked 12 hours yesterday *and point to first sentence*. Your starting amount is 12 *and point to 12*. Circle 12 *and point to 12* and write 12 in your organizer *and point to section of organizer*). Any prompting beyond a Level 1 prompt was counted as an incorrect response toward the dependent variable.

When a student made an error in problem solving, prompts were used without a 5 s delay to ensure they could complete the rest of the steps accurately. At times, participants would complete the steps correctly, but out of the intended order. If the student was able to complete the problem accurately, their work was still counted as independent. The interventionist would provide correction when they observed the student to make an error that would impact their ability to solve the problem accurately. For example, the student may have written the correct starting and change amounts in the graphic organizer before circling or underlining them in the problem. The student was only redirected or provided prompting (e.g., “remember to circle your starting amount in the problem”) if they omitted the step altogether.

After the student completed all problems, the interventionist reviewed their goal sheet with them and stated their previous score and the goal they chose at the beginning of the session. The interventionist then prompted the student to count the checkmarks in their independent column on their self-monitoring sheet and wrote their score in the designated space. The interventionist asked if their score was greater than (to the right of their goal), less than (to the left of their goal), or equal to (in the same place as their goal) their goal and prompted them to circle if they met their goal or not.

After the student checked if they met their goal, they were guided to review the session check-in sheet (i.e., social validity). For the first two questions, the interventionist would read the question aloud and instruct them to circle the emoji face that represented how they felt (e.g, “Which emoji face shows how you felt about your problem solving today?”). For the second section, the interventionist instructed the student to put a checkmark on components they liked or an “x” on components they did not like using that day.

Data collection sessions happened three to five times per week. The duration for Xavier’s sessions ranged from 5 min 10 s to 8 min 5 s; David’s was 5 min 10 s to 6 min 56 s; and Adam’s was 13 min 11 s to 19 min 14 s. Xavier’s intervention including baseline, lessons, maintenance, and generalization occurred over a span of 8 months; David’s lasted for 10 months; and Adam’s for 6 months. It is important to note that the school site for this intervention included a summer program that students attended, as David’s intervention lasted over the summer into the next school year. Although he moved into a new grade, his placement within a high school classroom that spanned multiple grades remained the same. The length of intervention time was due to scheduling conflicts with the interventionist and is addressed in the limitations section.

Generalization

The generalization probes were modified to occur more naturally than the classroom intervention sessions. There were two main differences in generalization probes from the classroom intervention probes. First, questions were verbally stated because they were dependent on the task the student was completing at the moment and because real-world mathematics problems are not typically written as structured word problems. The numbers and labels were written on a piece of scrap paper (i.e., post it note) to which the students could refer and to help ensure any errors were due to not using the strategy correctly and not working memory challenges. For example, the student's job task in the work program changed daily, so questions were centered around their completion of the task (e.g., "You have 10 orders to fill. You just finished filling the 4 orders. How many orders do you have left to fill?"). In baseline, the student was provided with a calculator after the question was asked. When they were moved into the generalization phase after mastery of the intervention, they were provided with the iPad that contained the electronic worksheet with the graphic organizer and a calculator. Checklist was not provided to students during the generalization phase.

Although the students did not have the checklist in the generalization phase, the modified problem-solving task analysis included six steps instead of ten to account for there not being a written word problem: label starting amount, label change amount, label what you are solving for, plus or minus, solve problem, and write answer. The task analysis was modified to better represent real-world problem-solving steps to assist in generalization.

The percentage of independently completed steps was documented as their generalization data point. The system of least prompts from the classroom intervention procedures was used during generalization. Four generalization data points were collected in the baseline phase, and six generalization data points were collected in the generalization phase.

Maintenance

Maintenance data points were collected approximately 1 week and 3 weeks after the student completed the intervention phase. The procedures and setting were identical to the intervention data collection procedures with the exception of not using the goal setting sheet in the maintenance phase. Two questions with the checklist and organizer were presented to the student for each maintenance data point. Adam was not able to complete his second maintenance data point due to time constraints on this project.

Chapter 3: Results

All participants showed improvement in mathematics problem solving performance from the baseline phase to intervention, generalization, and maintenance phases. See Figure 1 for the NCMPD graph.

Intervention Effects

Baseline

Xavier had an average baseline score of 10.6% accuracy in solving his math problem solving. His first baseline score was 15% accuracy due to reading the problem aloud. On all other baseline sessions, he did not read the problem and added for all problems presented of which he would get the addition problems correct but not the subtraction problems. His baseline range was 10%-15% accuracy with a stable trend. David displayed a similar steady baseline trend to Xavier with an average baseline of 20% accuracy and a range of 10%-25%. David read the problems aloud and added each problem that was presented. Adam's baseline data averaged at 7.9% accuracy and ranged from 5%-10% accuracy. He would read some of the problems aloud and did not attempt to solve them. When he used the calculator in baseline, he would enter one number from the problem and say he was done.

Intervention

Upon entering the intervention phase, Xavier's accuracy in problem solving immediately increased to 75% accuracy with a steady upward trend. He often completed the steps out of order, which would cause him to omit steps that he did not need to reach the correct answer. For example, Xavier filled in his graphic organizer with the correct numbers and completed the problem before identifying the numbers in the word problem itself (i.e., circling the starting amount, underlining the change amount). Xavier met mastery criteria after the second intervention session and maintained high scores with a range of 75%-100% accuracy and an average of 85% accuracy in word problem solving. Overlap between his baseline and intervention scores was 0%.

David showed an immediate increase in his problem-solving performance from baseline to intervention, from 25% accuracy to 75% accuracy. His average intervention performance was 81% accuracy. David met mastery criteria on his second intervention session. His performance was maintained throughout the remainder of his intervention sessions with a range of 75%-85% accuracy. David's most consistent errors during the intervention phase was not explicitly using the change problem rule or hand gesture to identify if the problem required addition or subtraction and inconsistently identified the starting and change amounts in the word problem itself. He had no overlap between his baseline and intervention data points with little variability.

Adam's problem-solving performance immediately increased from 10% accuracy to 50% accuracy. His intervention scores showed more variability in his performance with a range of 50%-80% accuracy, and he showed a steady increasing trend throughout all intervention sessions. Adam met mastery on the fifth intervention session and had an average of 63% accuracy. His most consistent errors were on the following steps: find and label what you are solving for, identify the starting amount in the word problem, and identify the change amount in the word problem. He needed additional support in transferring the number sentence from the graphic organizer to the calculator but was able to independently do so after his third intervention session. After his first intervention session, he used the change problem rule or hand gesture and correctly identified the operation of the problem consistently through the remainder of his intervention sessions. Adam showed no overlap between his baseline and intervention sessions.

Tau-U scores were calculated to determine an effect size for the intervention. All participants had a Tau-U of 1 with a weighted average score of 1. Tau-U metrics indicate that the intervention was highly effective.

BC-SMD was calculated to determine an effect size for the results of this study. The model used in this study used a Restricted Maximum Likelihood estimation method with time trends and accounted for changes in linear trend. According to the BC-SMD online calculator, the effect size was 1.7 at 95% confidence interval. This can be interpreted as large effect size (Cohen, 1977).

Maintenance

Xavier maintained his intervention scores with 95% and 100% accuracy, which were in the same range as his intervention accuracy scores. David also maintained mastery with his maintenance sessions with 80% and 80% accuracy. Due to time constraints, only one maintenance data point was collected for Adam. Adam's maintenance data point was 65% accuracy, which did not meet mastery criteria. Items that Adam missed in his maintenance session were related to circling and underlining the numbers in the word problem. He was able to maintain his ability to use his rule, identify if he was adding or subtracting, and solve the problem.

Generalization Effects

Baseline

Xavier had an average generalization baseline score of 16.5% accuracy in natural problem-solving situations. He added all problems presented in the generalization baseline with a range of 0%-33% accuracy. David's average generalization baseline score was 16.5% accuracy with a range of 0%-33% accuracy. He also added each problem presented. Adam's average generalization baseline was 0% on all sessions. During these sessions, he would shrug his shoulders or respond, “I don’t know” when presented with the question.

Generalization

Upon entering the generalization phase, Xavier continued to maintain high levels of accuracy in problem solving with an average of 92% accuracy and a range of 67%-100% accuracy. He required higher levels prompting during the first generalization session to help fill in the graphic organizer instead of immediately solving the problem. During his first generalization probe, Xavier completed the problem accurately without filling in the graphic organizer, which resulted in a lower score from not completing the task analysis steps.

In the generalization phase, David’s first score was 67% accuracy as he did not fill in the graphic organizer completely without prompting from the interventionist. After his first generalization session, he scored 100% accuracy in his problem-solving skills. His range during generalization was 67%-100% with an average of 92% accuracy.

Upon entering generalization, Adam scored 67% accuracy with natural problem-solving opportunities. When beginning generalization, Adam struggled to fully complete the graphic organizer and transfer the number sentence to the calculator. His average generalization score was 80.5% accuracy with a range of 50%-100% accuracy. When provided with prompts in his first generalization sessions, Adam showed the ability to maintain those skills throughout the remainder of data collection. He scored 100% on his final two generalization sessions.

All participants had an upward or high and stable trend in their generalization performance.

Social Validity

Xavier completed all social validity measures after intervention sessions. His average rating of his problem-solving skills and the problems presented was 5. He chose the happiest option each session. When asked which components of the intervention he liked using the most, he rated that he liked checking off his steps as he worked for 57% of sessions, setting his goal for 43% of sessions, and using the calculator and graphic organizer for 29% of the sessions. He indicated that he disliked setting his goal and checking off his steps after the first session. After the first session he did not place an "X" or indicate explicit dislike of any of the components.

David completed four social validity measures during intervention sessions. A fifth was unable to be collected due to his time with the interventionist needing to be shorter than usual for a class activity that he did not want to miss. David's average rating of his feelings about his problem-solving skills was 3.25 and ranged from 3-5; his average for his feelings about the word problems he solved was 4. He indicated in 75% of social validity sessions that he enjoyed checking off his steps as he worked, and he liked using the calculator for 25% of sessions. David did not choose setting his goal or using the graphic organizer as a component of the intervention that he liked. He did not put an "X" on any component of the social validity measure.

Adam completed all social validity measures. He rated his feelings about problem solving and the word problems he had as a 5 for each session. Adam indicated that he enjoyed checking off his steps for 100% of the sessions and did not choose any other component or place an "X" on any component.

Fidelity and Interscorer Agreement

Procedural Fidelity

Procedural fidelity assessments were conducted for all baseline, intervention, generalization baseline, generalization, and maintenance phases as well as the repeated social validity measure. Trained scorers conducted fidelity assessments for 37.5% of Xavier's baseline, 40% of David's baseline, and 42.8% of Adam's baseline. All students had 40% of intervention sessions and 50% of maintenance sessions scored for procedural fidelity. Fidelity was 100% for Xavier, 100% for David, and 100% for Adam. Fidelity was also conducted for 50% of baseline generalization sessions and 33% of generalization sessions for all participants with the following results: 100% for Xavier, 100% for David, and 100% for Adam. Graduate students also scored interobserver agreement (IOA) for ≥ 30% of sessions scored for fidelity. IOA for all fidelity checks was 100%.

Forty percent of repeated social validity measures were assessed for fidelity to ensure that student answers were not guided or influenced by the interventionist. When planning for this social validity measure, the interventionist was prepared to ask follow-up questions for answers that didn't align with their behaviors during the sessions; however, this situation did not arise during the study. Social validity fidelity for Xavier was 88.5%, 100% for David, and 100% for Adam. During Xavier's first social validity questions, the interventionist did not indicate to the student that they should answer honestly or tell them to put a check or X over components that they liked or did not like. Xavier immediately began circling every option, so the interventionist stated each question separately and read each component out loud. The scorer indicated that the interventionist did not influence the student's answers during this session. The scorers for social validity fidelity rated that they believed the student's answered honestly and that the interventionist did not influence their answer. Social validity fidelity was also examined by additional graduate students for IOA. IOA for social validity fidelity was 100%.

Treatment Fidelity

Treatment fidelity was assessed for 50% of the intervention lessons administered for Xavier and Adam. David's intervention lessons were unable to be assessed for fidelity due to technical difficulties with the recording equipment. Fidelity for the lessons was 100% for Xavier and 100% for Adam. Graduate students also conducted IOA for lesson fidelity. IOA was 100%.

Interscorer Agreement

Interscorer Agreement (ISA) was conducted for the same percentage of baseline, intervention, generalization baseline, generalization, and maintenance phases as the fidelity checks. Average ISA for Xavier's baseline, intervention, and maintenance session was 99% with a range of 95%-100%; David's ISA average was 89% with a range of 80%-100%; and Adam's ISA average was 96.25% with a range of 80%-100%. ISA was also conducted for generalization sessions. ISA for generalization 33% of Xavier, 96% of Adam's sessions, and 100% of David's sessions. One video was not included in ISA for Adam due to a technical issue in which the device did not record properly. Xavier's average ISA for generalization was 89% with a range of 67%-100%; David's was 94% with a range of 83%-100%; and Adam's was 98.3% with a range of 83-100%. The researcher resolved that Xavier's 67% ISA score was due to him labeling his starting amount and change amounts in the opposite spots on the graphic organizer. The problem was an addition problem, so the error did not impact his ability to correctly solve the problem. One scorer scored these steps as incorrect, and another labeled them as correct. The researcher determined that they should be labeled as incorrect, as the student mislabeled the starting and change amounts and would not have reached the correct answer if the problem involved subtraction.

Chapter 4: Discussion

All participants showed improved mathematics problem-solving performance in this study. The results from this study support the hypothesis that MSBI with goal setting had a positive effect on the word-problem solving performance for transition aged students with autism-ID (Gilley et al., 2021; Root et al., 2018). It also supported the additional hypothesis that the participants were able to generalize the MSBI skills to real-world situations and/or environments (Gilley et al., 2021; Root et al., 2018). The purpose of this study was to replicate and extend the MSBI research base with a specific focus on solving naturally occurring mathematics problems in a real-world context. The results found were consistent with previous MSBI research.

Identification of Critical Problem-Solving Skills

As in previous MSBI research, transition-aged participants in this study showed little to no problem-solving skills during their baseline phase (Gilley, et al., 2023; Root et al., 2022). Both Xavier and David used addition in every problem presented. Xavier often did not read the problem and immediately added the numbers together in the calculator. David read the problems but continued to only use addition. This behavior could be indicative of several things. The students could have had a conceptual misunderstanding of change problems, or a lack of instructional time spent on problems other than addition. Also, the behavior could be the result of habit, indicating that they are used to only using addition in any current math contexts.

Adam also showed low performance in mathematics problem-solving skills, but he would not attempt to solve any problems in baseline. Similar to David and Xavier, this could be due to a lack of instructional time spent on problem solving and a conceptual misunderstanding of how to solve word problems. Additionally, Adam showed low confidence in his problem-solving skills in baseline. He often hovered his finger over the calculator and looked at the interventionist for reassurance that it was the correct answer. During these moments, the interventionist reassured him to try his best. This suggests that Adam was reliant on adult prompts to complete academic work. Similar to David and Xavier, this could be due to a lack of instructional time spent on problem solving and a conceptual misunderstanding of how to solve word problems.

Regardless of reasoning, the baseline performance of participants in this study showed a continued need for intensive problem-solving intervention for the participants in the study who were older students with autism-ID. For these students, it is imperative that these skills are addressed quickly due to the limited number of years they have left to receive school services through IDEA. Additionally, their mathematics problem solving skills are necessary for their success after high school as workplace skills rely less on computation and more on problem-solving (Saunders, 2020; Van de Walle et al., 2019).

Fortunately, intervention packages such as MSBI can provide effective results in little time. As shown by numerous researchers, MSBI can lead to immediate improvements in problem-solving performance in a short period of time (Cox et al., 2024; Gilley et al., 2021; Gilley et al., 2023; Root et al., 2018; and Root et al., 2022). Supporting previous research, this study also showed immediate and high levels of improvement upon beginning the intervention. Two of three participants reached mastery within two intervention sessions and the third reached mastery after five. The results of this study continue to support the use of MSBI to quickly address problem-solving needs of older students with autism-ID. Consistent with the research base (Gilley et al., 2023; Root et al., 2018; Root et al., 2022), students were able to maintain high percentages in maintenance and in generalization sessions, showing that the effects of the intervention can be maintained in different settings and situations.

A critical observation from this study is the order in which students completed the problem-solving steps. All participants attempted to solve the problem following the steps in a different order, such as filling in the graphic organizer but not identifying the numbers in the word problem itself. While the interventionist intervened when students made an error, they allowed the students to complete the steps in the order of their choosing as long as it did not impact their ability to reach the correct answer. For example, both David and Xavier often read the problem and immediately began filling in the graphic organizer. Students were able to achieve the correct answer consistently without completing certain steps of the task analysis (e.g., circle the starting amount). Similarly, Adam struggled to identify the numbers in the problem and the "what" or unit of the problem itself. However, he correctly used the change problem rule and identified the correct operation of the problem for all intervention probes. If only critical steps were measured, Adam would have met mastery after his third intervention session instead of his fifth.

This suggests that not all steps assessed in this problem-solving intervention were critical to the completion of the problem and future task analyses should measure progress based on the completion of critical problem-solving steps in the process instead of all steps (Gilley et al., 2023). Only measuring progress with critical problem-solving steps could accelerate student time to mastery criteria and allow interventionists and practitioners to begin the generalization process sooner.

Natural Problem-Solving Opportunities and Support for Generalization

The goal of interventions, whether behavioral or academic, is to support the student's generalization of the skills to different environments or settings in the hope that they can use the skills to be successful in real-world settings and situations (Burt & Whitney, 2018).

Generalization has been a consistent area of need in MSBI research (Root et al., 2022). One significant contribution of the current study was to extend and strengthen support for generalization measures in MSBI research. All participants showed improvement from generalization baseline to the generalization phase after mastery of the intervention was reached.

An important component of generalization in this study was to minimize materials needed and use naturally occurring problem-solving opportunities in transition-related environments. Additionally, the interventionist continued to support students using a system of least prompts during generalization to help them self-correct and identify any errors made. Generalization did not include a checklist or word problem, yet participants were able to complete the graphic organizer and accurately solve the problems correctly with numbers written down on a post it note. This decision was to ensure that the generalization mirrored realistic problem-solving procedures that naturally occur throughout one's day.

MSBI offers a multi-component intervention package, which includes explicit instruction and repeated practice along with a number of other evidence-based strategies for students with disabilities (Hart & Cleary, 2015). Results from this study support the use of MSBI to teach real-world problem-solving skills that students will be able to generalize. The author believes that these skills were generalizable with the support of a system of least prompts, as with few reminders all participants were able to reach 100% accuracy in their generalization scores by the end of the sessions. Anecdotally, the interventionist observed higher engagement in generalization lessons, which could be due to the relevance to the task they were completing, the shorter sessions with a single problem, or the removal of the checklist, which could have been overwhelming for them to follow.

All students became more independent problem solvers in generalization sessions, which may impact their ability to solve everyday mathematics problems in the real world. This has the potential to impact their postsecondary outcomes by increasing their independence in task completion, time management, financial skills, and general daily executive functioning tasks (e.g., planning to go to the store, getting ready for work). Additionally, increased generalization of problem-solving skills has the potential to influence the student's ability to self-manage their day and routines without direct adult support.

Limitations and Suggestions for Future Research

Although the current MSBI study showed effective results in problem solving for students with autism-ID, there are a few limitations to address. First, this study used a NCMPD. Due to the timing of delivery of nonconcurrent designs, replications of effects are not shown for the same time period. For example, Xavier's intervention took place in the Fall and Spring of 2024, David's in the Spring and Fall of 2024; and Adam's in the Winter of 2025. There is not a way to vertically analyze the effects of this intervention, as replications did not happen concurrently. Therefore, validity threats such as history and maturation are potential influences on the results. However, despite critiques of nonconcurrent designs not establishing as much rigor as concurrent, some researchers believe that NCMPD can enhance the external validity of the study as it shows the effectiveness of the intervention at different points in time (Kratochwill et al., 2022; Morin et al., 2023; Slocum et al., 2022). Future research should continue to validate the reliability and rigor of nonconcurrent single case designs.

Another limitation of this study was that the researcher was the interventionist. This limitation has two prongs to address. The first is that the intervention was not conducted by classroom staff, meaning that we do not know if the same level of effectiveness would have been achieved if instruction was provided by the student's teacher. Therefore, we are unable to determine if this intervention is feasible in the classroom setting delivered by classroom staff. Second, due to the responsibilities of the interventionist, there would be periods of time from one week to four weeks where intervention was unable to occur. Although the participants still made adequate progress, future researchers should identify the necessary duration and length of an effective MSBI intervention to help with classroom and transition planning.

Additionally, the use of a repeated social validity measure administered by the interventionist was a limitation. Outside scorers conducted additional fidelity assessments to ensure that the interventionist did not display any behaviors to influence the outcomes of the measure. For this study, the participants had good rapport with the interventionist as they have worked together in different situations over the past three years, and the target population for this project requires extensive time to build relationships and create a safe environment where students feel they can be honest. Although additional measures were taken, there is still a chance that the participants felt they needed to answer in a specific way regardless of assurance from the interventionist. Another limitation regarding social validity is that it is unknown to the researchers if the students understood the meaning of emoji scale. Future intervention research for students with extensive support needs should consider how to best embed social validity measures that will accurately capture the acceptability of the intervention for the participants as well as gauge their understanding of the measure itself.

Although generalization of target skills was successful in the maintenance component of this study, the interventionist developed all generalization questions based on the task, activity, or situation they were engaged in at the time of the session. We were unable to measure whether the students could have developed the questions for themselves or recognize potential mathematics problems that are a part of their daily routines. Future research should focus on developing interventions that assist students with autism-ID in identifying potential problem-solving situations in their daily lives. This may assist them in further generalizing the skills learned in MSBI as well as help students initiate their problem-solving skills independently.

Also, treatment fidelity for this study was 100% and ISA was more variable. This difference is most likely due to the potential subjectivity in the assessment scoring. Although the researcher provided guidelines and operational definitions for each step for the scorers, the MSBI scoring was based on the system of prompts used, which makes the scoring more vulnerable to subjectivity. Future MSBI research should include additional scoring procedures that focus on accuracy as well as independence in problem solving. It is important to note that there was no disagreement in ISA on the accuracy of the solved problems in this study; most disagreements were for steps that were not critical to correctly solving the problem (i.e., "identify your starting amount") and all ISA was above 80% with the exception of one score of Xavier's that was 67% and addressed by the researcher..

Lastly, MSBI is a multi-component intervention using explicit instruction, graphic organizers, task analysis, repeated practice, and system of prompts. Due to the use of multiple components, it is unclear if any one component would be effective in improving student problem solving performance. Similarly, the addition of student interests in the intervention probes as a part of the intervention package pose a confound to the results, as personalized problems and academic work that includes student interests has been shown to increase accuracy and engagement (Ku et al., 2007). However, students increased their completion of each step in the MSBI checklist and performance in generalization. Also, generalization problems were not interest-based, suggesting that other intervention components in conjunction with including their interests in the problems are responsible for the change in their MSBI performance. Students showed improvements in natural problem-solving opportunities with only the use of the graphic organizer and system of prompts. Future researchers should continue to identify the critical elements necessary to increase problem solving performance as well as identify the least intrusive and stigmatizing ways that students can use these elements in the community and real-world settings.

Implications for Practitioners

The results of this study replicate the effectiveness of MSBI in classroom and transition-related environments. There are several implications for educators and administrators in schools that can be gleaned from the results. First, students with autism-ID continue to need direct instruction in mathematics problem solving skills and MSBI continues to be an effective intervention with the potential to show immediate results. When evaluating curricula for adoption, administrators should ensure that problem solving skills are included in functional mathematics curricula for older students. To support implementation of these curricula, administrators should also build professional development includes building teacher competency in understanding how to best support Autistic students' problem-solving skills. Second, teachers should find explicit ways to practice generalization for academic skills. This will help provide repeated practice in real-life scenarios that mathematics problem solving occurs. Lastly, practitioners should continue to explore how technology can fade direct adult prompting to support independence.

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Table 1

Participant Demographics

Participant	Age	Gender	Race/Ethnicity	Disability	Full Scale IQ
Xavier	16	Male	White	Autism, ID, OHI	40
David	16	Male	African American	ID, Autism, SLI, OHI	58
Adam	16	Male	Hispanic, Multi-Racial	Autism, ED, ID, SLI, OHI	58

Notes ID=Intellectual Disability; OHI=Other Health Impairment; SLI=Speech and Language Impairment; ED=Emotional Disturbance

Table 2

Intervention Task Analysis Definitions

Step	Scoring Definition
Read or listen the problem	Read the problem aloud, ask for it to be read vocally or through gestures, or use the read aloud feature on the electronic worksheet app. This step was measured using video data.
Find and label what you are solving for	Write or type the label in the appropriate space of the organizer. This step was measured using video data and permanent products.
Circle the starting amount	Draw a circle around the starting amount in the word problem. This step was measured using video data and permanent products.
Label the starting amount	Writing the starting amount in the starting amount space on the graphic organizer. This step was measured using video data and permanent products.
Underline the change amount	Underline the second number/the change amount. This step was measured using video data and permanent products.
Label the change amount	Write the underlined number in the change spot on the graphic organizer. This step was measured using video data and permanent products.
Use my rule	Verbally state or make the hand gesture for the change problem rule (e.g., “one thing–[unit] *holds hand at chest height with palm facing down*; [if addition] add to and change *moves palm upwards*; [if subtraction] take away and change *moves palm down*). This step was measured using video data.
Plus or minus?	State the correct operation OR circle the correct symbol (i.e., plus sign or minus sign) on the graphic organizer. This step was measured using video data and permanent products.
Solve problem on the calculator	Enter the correct number sentence into the calculator. This step was measured using video data.
Write the answer	Write the correct answer on the graphic organizer. This step was measured using video data and permanent products.

Table 3

Generalization Problem Operations Randomization

Generalization probe	Participant 1	Participant 2	Participant 3
Baseline 1	addition	subtraction	subtraction
Baseline 2	addition	subtraction	addition
Baseline 3	subtraction	addition	addition
Baseline 4	subtraction	addition	subtraction
1	subtraction	subtraction	addition
2	addition	addition	subtraction
3	subtraction	subtraction	addition
4	addition	subtraction	subtraction
5	addition	addition	subtraction
6	subtraction	addition	addition

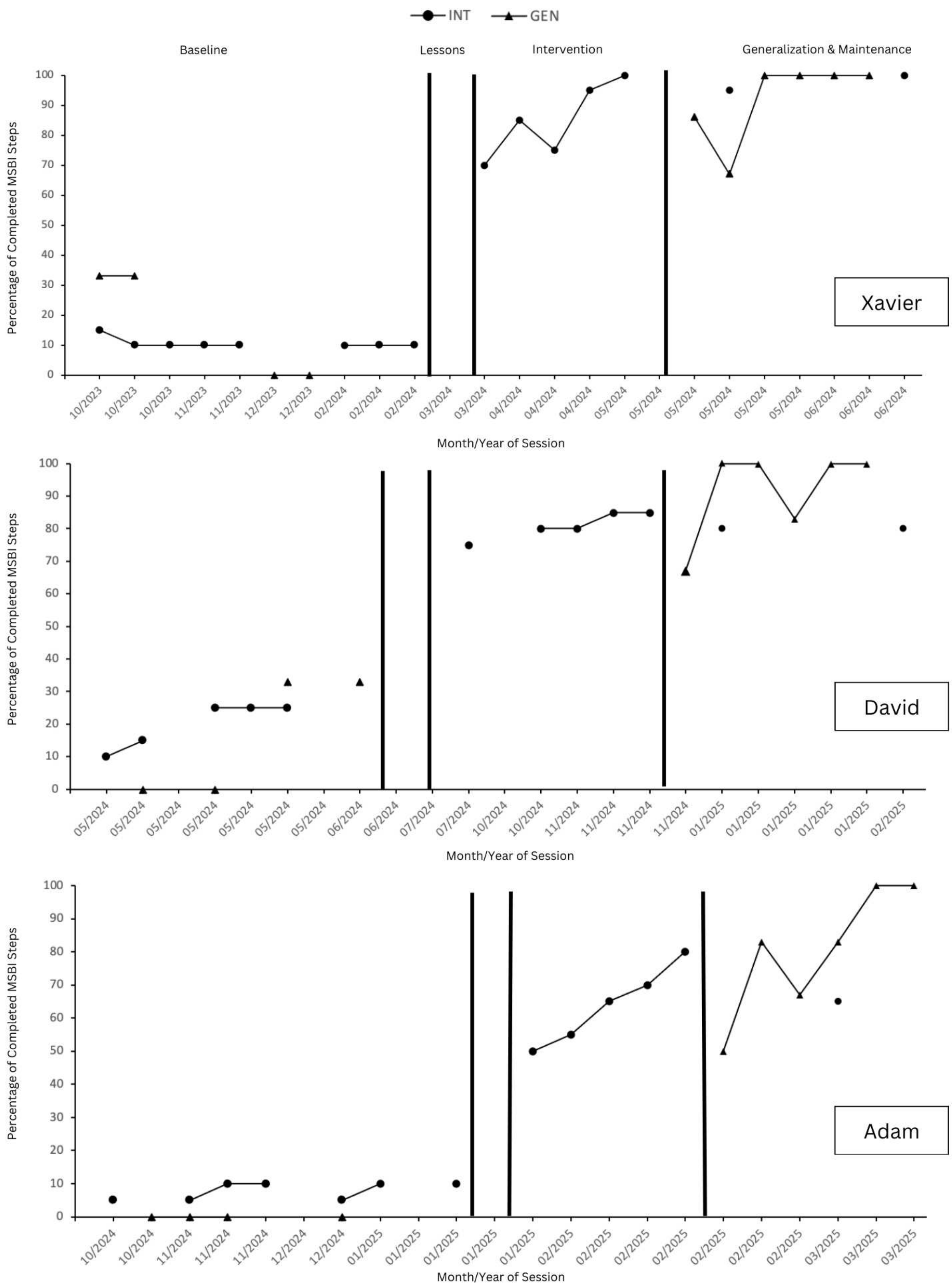
Table 4

Generalization Task Analysis Definitions

Step	Scoring Definition
Find and label what you are solving for	Write or type the label in the appropriate space of the organizer. This step was measured using video data and permanent products.
Label the starting amount	Writing the starting amount in the starting amount space on the graphic organizer. This step was measured using video data and permanent products.
Label the change amount	Write the underlined number in the change spot on the graphic organizer. This step was measured using video data and permanent products.
Plus or minus?	Circle the correct symbol (i.e., plus sign or minus sign) on the graphic organizer OR state the correct operation of the problem. This step was measured using video data and permanent products.
Solve problem on the calculator	Enter the correct number sentence into the calculator. This step was measured using video data.
Write the answer	Write the correct answer on the graphic organizer. This step was measured using video data and permanent products.

Figure 1

MSBI Results



Appendix A

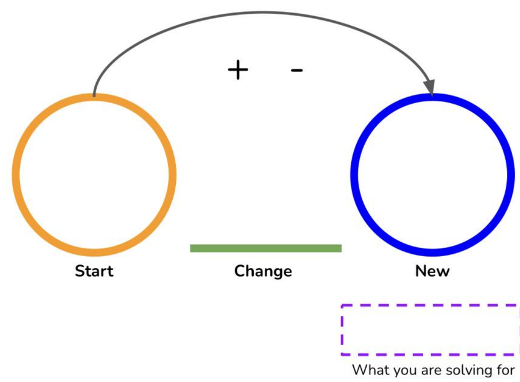
Worksheet and Task Analysis Example

Problem-Solving Steps	With help	By myself
Read or listen the problem		
Find and label what you are solving for		
Circle and label starting amount		
Underline and label change amount		
Use my rule.		
+ or -		
Solve the problem on a calculator.		
Write the new amount.		

You ride the bus for 30 minutes to get to work.

From the bus stop, you walk another 15 minutes.

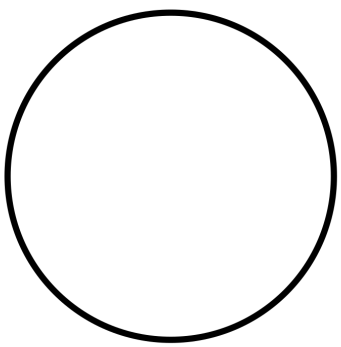
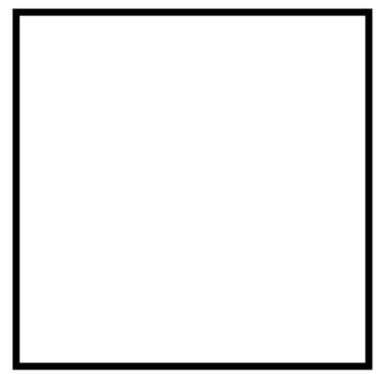
How many minutes does it take you to get to work in total?



Adapted from Gilley et al. (2021)

Appendix B

Researcher-made Screening Tool

<table>
<tr><td colspan="3"><u>Screening Tool: Student Sheet</u></td></tr>
<tr><td>8</td><td>43</td><td>256</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>$8 + 3 =$</td><td>$34 - 29 =$</td><td>$104 + 62 =$</td></tr>
<tr><td colspan="3">Amanda made 36 chocolate chip cookies for a birthday party. She dropped 15 cookies on the floor. How many cookies remain for her to take to the birthday party?</td></tr>
<tr><td colspan="3">James made 15 cups of lemonade. He sold 4 cups. How many cups of lemonade does he have left to sell?</td></tr>
</table>

Andrew is sorting receipts at work. He sorted 150 receipts for office supplies and 53 for cleaning materials. How many receipts did he sort altogether at work?
Sara drives 28 miles to work. Today, Sarah has driven 13 miles when she hits a stop light. How many more miles does she have to go until she gets to work?

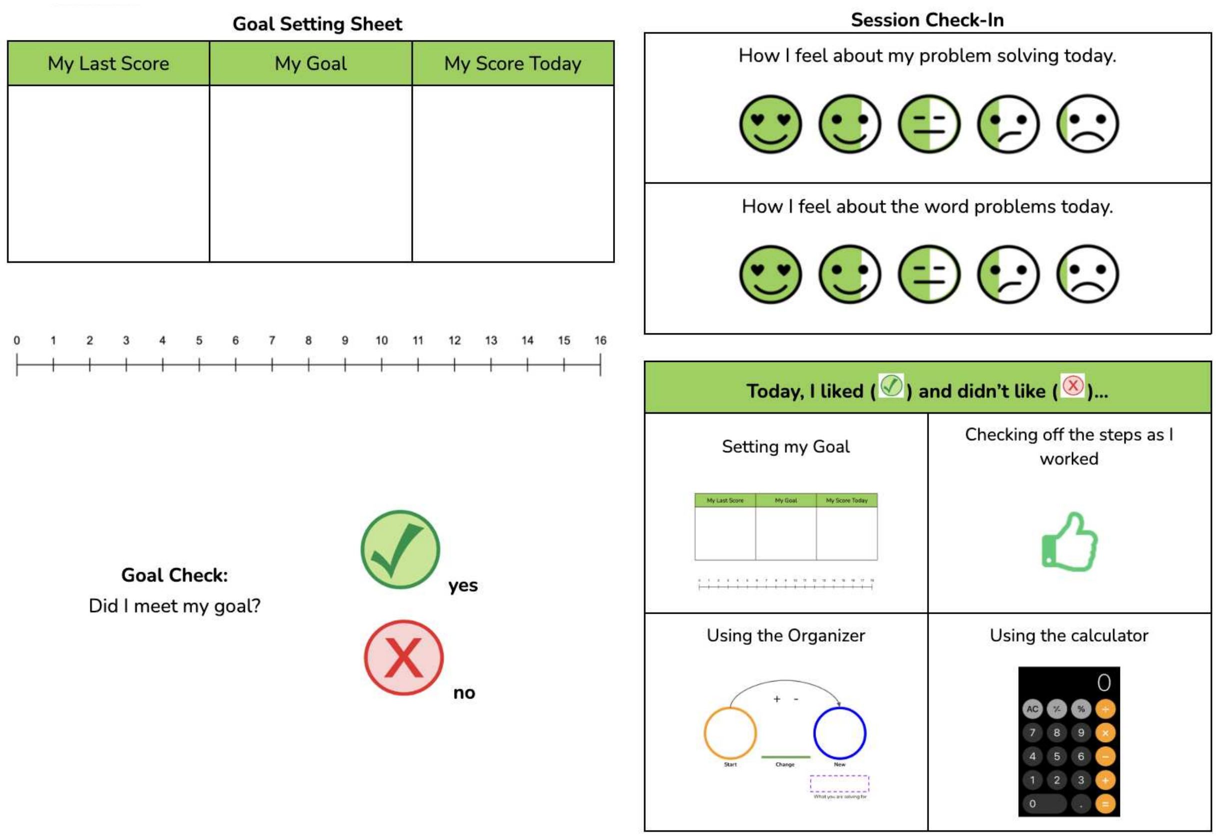
Appendix C

Baseline and Intervention Probe Examples

Baseline Problem You invited 15 people to your birthday party. Your mom invited 9 more people. How many people in total were invited?	You bought 100 post-its for your college class. You used 64 post-its. How many post-its do you have left?
Xavier Intervention Problem You need to buy 19 art supplies for a project to do with your mom. Your mom asks you to buy 15 more art supplies. How many art supplies do you need to buy?	You are filling an order for 64 cookies at the bakery you work at. You bake 24 cookies. How many cookies do you have left to bake to fill the order?
David Intervention Problem You have ridden past 19 bus stops on your Septa shift. Your ride past another 16 bus stops before you are done. How many bus stops will you pass on your shift?	You are filling a grocery order for 64 items You find 24 items. How many items do you have left to find to fill the order?
Adam Intervention Problem You have plant 19 seeds at your job on the farm. Your boss gives you 16 more seeds to plant. How many seeds will you plant at work?	You are filling a grocery order for 64 items You find 24 items. How many items do you have left to find to fill the order?

Appendix D

Goal Setting and Repeated Social Validity Measure



Adapted from Root et al. (2022)

Appendix E

Social Validity Fidelity Checklist

Procedural Fidelity Checklist (Session Check-in)	
Y=was followed; N=not followed; N/A=not applicable	
1. Daily session check-in questions were asked after the student completed their problems and checked if they met their daily goal.	
2. The interventionist prompted the student to answer the question honestly, that they would not get in trouble if they did not like something, and that they want to know how they feel so they can make the sessions better for them. *Mark NA if other than the first intervention data point.*	
3. The first question was read aloud to the student and the student was prompted to circle the emoji that represented how they felt. Mark Y if the student answered the question without it being read aloud	
4. If the student circled an emoji that was different from their behavior, the interventionist asked a clarifying question (e.g., “I noticed you smiling and saying you were proud of yourself for the work you did today, but you circled the sad face. Is that how you feel?”). *N/A if a clarifying question was not asked.*	
5. If a clarifying question was asked, the interventionist did NOT tell them to change to their answer. (e.g., “Is that how you feel?” versus “Erase that and circle the happy emoji”). *N/A if a clarifying question was not asked.*	
6. The second question was read aloud to the student and the student was prompted to circle the emoji that represented how they felt.	
7. If the student circled an emoji that was different than their behavior, the interventionist asked a clarifying question (e.g., “I noticed you smiling and saying you were proud of yourself for the work you did today, but you circled the sad face. Is that how you feel?”) *N/A if a clarifying question was not asked.*	
8. If a clarifying question was asked, the interventionist did NOT tell them to change to their answer. (e.g., “Is that how you feel?” versus “Erase that and circle the happy emoji”). *N/A if a clarifying question was not asked.*	
9. The interventionist asked the student to place a check mark or an x on the components that they enjoyed or didn’t enjoy during the session. If the student marked only one thing, the interventionist did not ask anything beyond, “Anything else you liked or did not like using today?”	

10. The interventionist did not tell the student that they had to put an x or check on any item.	
11. The interventionist did not ask any leading questions (e.g., “How much did you like the problems today?”) or guide the student to answer the question in any specific way.	
12. Do you believe the student answered the questions honestly?	
13. Do you believe the interventionist’s statements influenced the student’s responses in any way?	
Total Ys	
Total Possible Ys	
Percentage	

Appendix F

Instructional Fidelity Checklists

Baseline Procedural Fidelity Form

Problem	1	2
The student was presented with the problem and asked to solve it.		
No prompts were provided for how to solve the problem.		
Total +:		
Total Possible +:		
Percentage:		
(+)=completed; (-)=not completed; n/a=not applicable		

Lesson Procedural Fidelity Form

Lesson component	Y/N/NA	Comments
Review		
Was the content from the previous lesson reviewed?		
Was the student given opportunities to respond?		
Was error correction provided?		
Warm-up		
Was a warm-up provided as outlined in the lesson?		
Was the student given opportunities to respond?		

Was error correction provided?		
Modeling		
Did the teacher model the content according to the lesson?		
Was the student given opportunities to respond?		
Was error correction provided?		
Guided Practice		
Was guided practice implemented according to the lesson?		
Was the student given opportunities to respond?		
Was error correction provided?		
Independent Practice		
Did the student complete independent practice?		
Was the student given opportunities to respond?		
Was error correction provided?		
Scoring		
Total number of Ys		
Total number of possible Ys		

Total number of Ys divided by total number of possible Ys multiplied by 100%		

Data Collection Session Fidelity Form

Session:		
Student completes goal setting sheet.		
Problem	1	2
Student is prompted to solve the problem and/or begin at the first step of the checklist.		
A 5-second or greater delay was used prior to prompts, except in the case of an error when a 0s delay was used.		
Prompts follow the system of least prompts for errors: verbal + gesture, specific verbal + gesture, and modeling.		
Student completed goal setting sheet and checked if they met their goal.		
Total +:		
Total Possible +:		
Percentage:		
(+)=completed; (-)=not completed; N/A=not applicable		

Appendix G

Pre-Unit Lesson Plan

Topic: Using the Calculator and Electronic Worksheet

Objective:

1. Given an iPad, the student will navigate to the calculator with 100% accuracy as measured by interventionist observation
2. Given 3, one- to three-digit addition and subtraction problems and an iPad, the student will enter the problems correctly into the iPad calculator and write down the answer with 100% accuracy as measured by interventionist observation.

Materials Needed:

- iPad calculator
- Electronic worksheet and Apple Pencil

Procedures

Guiding Script	Expected Response
<u>Recall Prior Knowledge</u>	
1. Review behavior expectations	
2. Today, we are going to practice solving mathematics problems on the iPad	
3. Let's start by identifying numbers you already know:	
4. *Show the numbers on the first page of the electronic worksheet. Point to 13.* What number is this?	Thirteen
5. *Repeat Step 4 with the numbers 9, 25, 184, and 67*	
6. Awesome work! Let's read some mathematics problems.	Thirteen plus eighteen
7. Tap this green button in the bottom right-hand corner of the screen to turn to the next page.	
8. *Point to 13 + 18 on the worksheet*. What does this problem say?	
9. *Repeat steps 7-8 with 20-8, 125 + 81, and 64 + 79*.	

<u>Model</u>	
10. Now, we are going to solve some problems. Can you go to the next page of the worksheet?	
11. Let's use our calculator to solve this problem. *13+4=*	
12. What does this problem say?	Thirteen plus four
13. Good. Now, I'm going to enter the problem into the iPad calculator. Watch me enter the problem.	
14. *Point to 13 and say,* First I tap 13 into the calculator.	
15. *Point to the + sign*. Next, I tap the plus sign because I'm adding.	
16. *Point to 4*. Then, I tap 4 into the iPad calculator.	
17. Do I have any more numbers to put into the calculator?	No
18. Right! I don't have any more numbers. All that's left is the equal sign. *Point to the equal sign*. So I tap the equal sign on the calculator.	
19. What number does the iPad calculator say?	17
20. Great. So our answer is 17. I'm going to write my answer on the other side of my equal sign.	
21. To write using our electronic worksheet, I'm going to tap the pencil icon at the top of the page and use my Apple Pencil to write the answer like I would on paper. *Write 17 as answer*.	Thirteen plus four equals seventeen AC or points to AC
22. Our problem now says 13+4=17. What does our problem say now?	
23. The last thing I need to do is clear my iPad calculator; I need to tap the AC button to clear the iPad calculator. What button do you tap to clear the iPad calculator?	
24. To get to our next problem, you will need to unselect the pencil icon you tapped to type.	
25. Awesome work! Let's try one more like this.	
26. *Repeat steps 10-23 with the following problem: 134-58=*	

<u>Guided Practice</u>	
27. Go to the next page.	
28. *Point to 34-8=*	Thirty-four minus eight
29. What does this problem say?	
30. Very good. It says 34 - 8 =. What's the first number you enter into the iPad calculator? Good. Enter it.	34 or enters 34
31. What comes next? Perfect. Tap the - sign.	
32. What do you do next? Awesome. Enter 8.	Minus sign or enters minus sign
33. Do you have any more numbers to enter?	Eight or enters eight
34. Great. How do we get our answer?	No
35. Awesome job, now where do we write our answer?	Equal sign or taps equal sign
36. Good work! What is the last thing we need to do? Awesome, go ahead and clear the calculator.	Points to after the equal sign or write it after the equal sign
37. *Repeat steps 28-36 with the following problem: 231-76=*	Clears the calculator
<u>Independent Practice</u> 38. Great job with those problems. There are 3 more problems on this worksheet. 39. Can you do those on your own? 40. *One problem will be on each page to give students the opportunity to practice selecting the pencil icon and turning to the next page independently.* 41. *Students complete problems independently.* <u>Error Correction</u> ● 0-s to 3-s time delay procedure will be used with a system of least prompts.	

Independent Worksheet

Participant Initials: _____________ Pre-Unit Worksheet

$$51 + 78 = \_\_\_\_\_\_\_\_$$

$$349 - 26 = \_\_\_\_\_\_\_\_$$

$$92 - 5 = \_\_\_\_\_\_\_\_$$

Appendix H

Lesson Plans

<table>
<tr><th colspan="2">MSBI Lesson 1</th></tr>
<tr><td colspan="2">Topic: Change Problem Type Introduction</td></tr>
<tr><td colspan="2">Objective: Given a 2 change word problems on an electronic worksheet and an Apple Pencil, the student will identify the problem type by vocalizing the rule for change problems and/or use the hand gesture and circling the correct operation symbol with 75% accuracy (3 out of 4 points) as measured by interventionist observation and researcher-made worksheet.</td></tr>
<tr><td colspan="2">Materials:
● Transition math sorting chart and pictures
● Whiteboard with dry erase marker
● iPad with GoWorksheets installed
● Apple Pencil</td></tr>
<tr><th colspan="2">Procedures</th></tr>
<tr><td>Guiding Script</td><td>Expected Response</td></tr>
<tr><td><u>Anticipatory Set:</u>
• Today, we are going to learn about when you may have to use math after high school.
• First, let’s talk about the different areas you may experience after school.
• The first might be more school. After high school, you may go to a different school to help you learn things for your job. You may have to take math classes or figure out how many hours of training you need.
• This picture shows someone doing math homework for school after high school. Point to picture.
• What does this picture show someone doing math for? (possible modification to provide options if no response)
• Right! This one shows someone doing math homework for school after high school. Let’s put that in the school column.
• The next area you have after high school is work. Work is what we complete to earn money. At work, you may have to do math tasks such as counting items for inventory or figuring out if you made enough money to meet your sales goal.
• This picture shows someone counting items at work for their inventory. Point to picture.</td><td>School

Work</td></tr>
</table>

• What does this picture show someone doing math for? (*possible modification to provide options if no response)* • Awesome work! This picture shows someone doing math for their work after high school. Let's place it in the work column. • The last area is independent living or at home. That refers to where you live and the activities you need to do to be able to keep up your home. Some math you may do for home could be grocery shopping or budgeting your money. • This picture shows someone counting money to pay at the grocery store. Points to picture. • What does this picture show someone doing math for? (*possible modification to provide options if no response)* • Great work. This picture does show someone doing math for their home life or independent living after high school. Let's put that in the home column. • Now, I'm going to give you three pictures to sort on your own.	Home *Student sorts pictures into correct columns*
<u>Modeling</u> • Great work looking at those examples of using math after high school. • Today, we are going to learn about a specific type of math problem you may encounter after high school. • It is called a change problem. *Write change on the whiteboard.* • What is the problem called? • The rule for a change problem is one thing that we are adding to or taking away from to change the number. So for change problems, the operation we use will be addition or subtraction. *Write + and - on the whiteboard.* What are the operations we will use in a change problem? • *Write on the whiteboard: one thing–same, add to it or take away and change.* • Your turn. What's the rule for change problems? • We can also show that we know the rule for change problems by using a hand gesture. One thing–same *[holds one hand flat with palm facing down]*, add to it or take away *[hand moves up or right hand moves down]* and change • Your turn. Show me the gesture. *Do the gesture alongside the student.* • Great work. Let's look at an example of how we can use the rule to help us figure out if we are adding or subtracting. *Show Problem 1 on the electronic worksheet.* • When we have a problem on our iPad like this, we can read the problem out loud or have the worksheet read it for us. Which would you like to do? • Great. *Read the problem in the format the student chooses.*	Change Add and subtract One thing–same, add to it or take away and change *Does the gesture* *Student chooses to read or has the iPad read*

You buy a new pack of 12 pencils for school. *You give 5 pencils to your friend.* *How many pencils do you have left?* • *Place 12 pencils on the desk.* Our starting amount is 12 pencils, so our one thing is pencils. *Holds hand with palm facing down.* By giving away pencils, they are getting taken away from that starting amount. Watch: *remove 5 pencils from the table.* Is the number of pencils we started with getting bigger or smaller? • If you give 5 pencils to your friend, will the number of pencils you have be added to or taken away from? • We will take away from the starting amount [*move hand down or lower than starting height],* which means we will subtract. *Circle the subtraction sign.* • Let's use the rule together. One thing–pencils [*holds palm facing down*], take away, and change [*move palm down*]. To know how many pencils are left, we would subtract. • Great work! Let's look at another problem. You choose to read it or have the iPad read it to you. *You have a line of 10 customers waiting for food at the dining hall.* *11 more customers get in line.* *How many customers are in line altogether?* • *Place 10 customer pictures on table*. We have 10 customers as our starting amount–our amount of customers is changing. One thing–customers. [*Hold out hand*.] 11 more customers get in line. *Add 11 more customers to the table.* • Are the number of customers getting bigger or smaller? • Will we add to or take away from our starting number of customers? • Yes, we will add to it *[move hand up]*. This means that we will be adding. *Circle the addition sign.* • Let's use our rule together. One thing– customers [*holds palm flat]*. Add to and change [*move hand up*]. To know the new amount of customers, we would add.	Less Taken away *Says rule or does gesture with interventionist* Add to *Says rule or does gesture with interventionist*
Guided Practice • We are going to do one more problem together and then I'll have you try 2 on your own.	*Student chooses how to read the problem.*

• Here's the next problem. Read it how you choose. *You have 95 copies of a report to make for your boss.* *You complete 32 copies.* *How many copies do you have left to make?* • What is your starting amount? • Good. Your starting amount is 95 copies. Your one thing is copies. *[holds out hand]*. • Will you add to or take away from your starting amount of copies? • Good work. 32 copies are completed so you will take away from the starting amount. *[moves hand down]* • Would you add or subtract to solve this problem? • Great work. Can you use your rule to talk me through that problem one more time? • *Do the hand gesture alongside the student.*	95 copies *[holds out hand]* Take away [*moves hand down*] Subtract. *Circles minus sign.* *One thing–copies [holds palm facing down]*. Take away and change *[moves palm down]*.
Independent Practice • Great work on using your rule to figure out how to solve that problem. • Now, I'm going to give you two more to try on your own. Remember to read the problem how you choose, use your rule for change problems, and circle the addition or subtraction sign. • Present the student with the following problems. 1. *You spend 25 dollars on food for your birthday party.* *You spend another 14 dollars on decorations.* *How many dollars did you spend in total?* 2. *You have 135 dollars in your bank account.* *You spend 38 dollars on a birthday present for your mom.* *How many dollars are left in your bank account?*	*The student will read the problem how they choose, use the rule for change problems, and circle the correct operation sign for each problem.* One thing–problems, add to and change. One thing–dollars, take away and change.
Closure: • Today, we learned about change word problems and using our rule to figure out if we are adding or subtracting. • Can you tell me what operations we use in change problems?	Add or subtract

• Awesome work today; next time, we will go through the steps to solve the problems.	

Error Correction Procedures:

Level 1	5s time delay for no response	Restate the rule or the prompt and gesture to the appropriate area on the material. (e.g., "You are taking away from your starting amount." *[move hand down]*).
Level 2	5s time delay for no response Modeling the full problem	Restate the rule and provide the answer and gesture to answer on the materials. (e.g., "You are taking away from your starting amount." *[move hand down]. Use the whiteboard to draw representative items*. If "If we start with 12 pencils and give 5 away, is the number of pencils we started with getting bigger or smaller? When you are taking away, you subtract. Circle subtract"). Model the full problem alongside student

MSBI Lesson 2	
Topic: Change Problem Type with Checklist and Organizer	
Objective: Given a 2 change word problems on an electronic worksheet, a 9-step problem-solving checklist, a graphic organizer, and an Apple Pencil, the student will complete each step of the checklist for each problem with help from the interventionist with 100% accuracy as measured by interventionist observation and researcher-made worksheet.	
Materials: • Independence vs with help sorting chart and cards • Copy of goal setting sheet • iPad with GoWorksheets installed • Apple Pencil	
Procedures	
Guiding Script	Expected Response
<u>Warm-up</u> • Today, we are going to follow a checklist to help us solve the change problems that we learned last time. • Can you remind me what the rule is for change problems?	*One thing, add to or take away and change*

<u>Anticipatory Set (independent vs with help)</u> • Great work. Before we learn the checklist, I want to talk about the importance of being independent after high school. When you graduate, you are going to have to do a lot of things on your own. • First, we are going to sort some pictures of people doing things by themselves or with help • Let's start with this picture. The person is doing laundry alone, meaning that they are doing it independently or by themselves. *Show the picture and put it in the "by myself" column.* • What about this person? Are they doing their homework by themselves or with help? • Good work. They are doing homework with help because there is someone there helping them, so we will put that in the "with help" column. It's okay to need help sometimes and to ask for it when you need it, especially if it is something new you are learning. ○ Try sorting the rest of the pictures.	With help *Sorts remaining pictures.*
<u>Modeling</u> • Before we start counting steps toward your goal, I'm going to teach you how to use the problem-solving checklist and organizer for change problems. • *Bring up the checklist and worksheet on the iPad.* • To solve change problems, we can follow this eight-step checklist. Each item on the checklist is able to be read to you, if you choose. You will see that our checklist is split into two columns: with help and by myself. When you complete a step with my help, we will put the thumbs up icon in the "with help" column and when you complete it by yourself, you will put it in the "by myself" column. • Because this is the first problem you are doing, we are going to put all the icons in the "with help" column. • You will also see your word problem in the top right of the worksheet. This looks exactly like the problem we worked with in our last lesson. • Below that is our graphic organizer. This will help us organize the information in our problem in order to solve it. In this graphic organizer, we will write our starting amount, how much it is changing, decide if we are adding or taking away, and then writing what the changed amount is. We will also include the label of what we are solving for. • Let's work through the checklist together. • The first step is to read or listen to the problem. Just like our last lesson, you can choose to read it out loud or to have the iPad read it for you. Which would you like to do? Okay, go ahead.	*Chooses method for reading*

You ride the bus for 30 minutes to get to work. *From the bus stop, you walk another 15 minutes.* *How many minutes does it take you to get to work in total?*	
• Now that we have finished that step, we are going to put a thumbs up symbol next to it. *Drag icon to column.*	
• Your turn. Place the thumbs up next to that step.	
• The next step is to find and label what you are solving for. For this step, we need to identify what is the one thing we are solving for or that is changing in our problem. *Hold hand with palm facing down.*	*Drags icon*
• In this problem, the minutes are changing, so we are solving for minutes. We will type minutes in the purple dashed box of the graphic organizer. This helps us remember what we are solving for while working on the problem. *Erase what the interventionist typed.*	*Types minutes*
• Your turn. Type what we are solving for into the organizer.	
• The next step is to circle and label your starting amount.	
• Our starting amount for this problem is 30 minutes. It's the first number in our problem and will be what our change is happening to.	
• I'm going to draw a circle around 30 minutes and then write 30 in the first orange circle of the graphic organizer because it is what I am starting with. *Erase what interventionist wrote.*	
• Your turn. Circle 30 and write it in the starting amount spot on the organizer.	*Circles and writes 30*
• Great work following that step. Now, let's put a thumb icon next to it to know it is complete. *Drag thumbs up icon to step*. Your turn. Drag the thumbs up icon to that spot.	*Drags icon*
• The next step is to underline and label our change amount. The change amount will tell you how much is being added to or taken away from the starting amount.	
• The change amount for this problem is 15 minutes. We underline 15 in the problem and then write it on the green line of the organizer because that is the amount we are changing our starting number by. *Erase what the interventionist wrote*.	
• Your turn. Underline 15 and write in the correct spot on the graphic organizer.	*Underlines and writes 15*
• Great work. Let's mark that we completed that step. *Drag icon*. Your turn. Drag the icon to the step you just completed.	
• The next step is "use my rule." For this step, you can tell me what the rule for change problems is or you can use the hand gesture. This is what we worked on in our last lesson. We will use our rule	

to help us figure out if we are adding or subtracting. We start with one thing–minutes. Will we be adding to or taking away from our starting number of minutes? • Good. So our rule is one thing–minutes, add to and change • Your turn. Use your rule for change problems. Let's do it together. One thing–minutes [*hold hand palm facing down*]; Add to [*move hand up*] and change. • Great work. Let's mark that we completed that step. *Drag icon*. Your turn. Drag the icon to the step you just completed. • Our next step is plus or minus, where we will circle the operation we will be using. Using our rule helped me figure out that we are adding to our starting amount, so I'm going to be adding for this problem. I'm going to circle the plus sign on the organizer. *Erase what the interventionist wrote*. • Your turn. Will we be adding or subtracting in this problem? Circle the plus sign. • Let's mark that we completed that step. *Drag icon*. Your turn. Drag the icon to the step you just completed. • Almost done! The next step is to solve the problem. We will use the calculator to do this. When we look at our organizer, it will also give us the structure of our number sentence. For this problem, we have 30 minutes as our starting amount, which we add 15 to. Our number sentence that we type into the calculator will be 30 + 15 =. • Your turn. Type the number sentence into the calculator. • Let's mark that we completed that step. *Drag icon*. Your turn. Drag the icon to the step you just completed. • Our final step is to write down our answer or new number. We take the number from the calculator and put it in the blue organizer circle that says "new ." I'm going to write 45 in the box. *Erase what the interventionist wrote.* • Your turn. Write answer in the new amount box. • Let's mark that we completed that step. *Drag icon*. Your turn. Drag the icon to the step you just completed. • We have no more steps left, which means that we are done with our problem. • Let's talk through the problem with the organizer. Our problem was "you ride the bus for 30 minutes to get to work. From the bus stop, you walk another 15 minutes. How many minutes does it take you to get to work in total?" ● *Use gestures while talking through the organizer*. The amount of minutes we started with was 30. Then we added another 15	Add to *Vocalizes and/or uses gesture with interventionist.* *Drags icon* Adding; *circles plus sign* *Drags icon* *Types number sentence* *Drags icon* *Writes 45 in the new amount box.* *Drags icon*

minutes of walking from the bus stop, which changed our total to 45 minutes to get to work.	
<u>Guided Practice</u> • Now, I want to try one without me modeling it for you. Again, we will put all the thumbs up icons in the “with help” column because we are still learning it. • Here is our problem. Let’s start with the first step: Read or listen to the problem. *You have 55 letters to label and send for work.* *You label and send 13.* *How many letters do you have left to label and send?* • *Guide the student through each step of the problem similar to the modeling portion of the lesson, except without the interventionist completing the tasks prior to the student and prompting the student to answer prior to providing answer.*	*See modeling for expected responses.*
<u>Independent Practice</u> • Great work on that problem. *Goal Setting* • As we work together, I want you to be able to solve the math problems independently or by yourself. • So to help motivate you, you are going to set a goal to do a certain amount of steps by yourself. When we are done with the problems, we will check to see if you met your goal. • This is your math success packet. When we meet, you will see your last score in this first box. Your last score was 0 because you haven’t learned the steps yet. • Today, you can get a total of 16 steps independently. • You are just learning how to solve these problems, so you don’t want your goal to be 16, you want something a little higher than your last score that you think you can meet. • Look at the numberline. What is a goal you want to set for yourself this lesson? o *If the student chooses a number greater than 10, prompt them to choose a lower number and reiterate that they are just learning the problems, so we do not expect perfection when we are starting out.* • Now, you will have the chance to see how many steps you can do independently to reach your goal. *Refer to student goal sheet.*	*Expected response is to follow checklist with prompts from interventionist.*

Remember you are starting with 0 total points and made the goal of X points independently for today. So when you complete a step without my help, you will put the thumbs up icon in the "by myself" column. • Ready? Here is your first problem–start at the top of your checklist. *You begin working your 8-hour shift at the Dining Hall.* *You work for 6 hours.* *How many hours do you have left to work?* • *Use system of least prompts for both problems as needed.* • Awesome job trying all the steps independently. You have one more problem to try and then we will check if you met your goal. • Here is your last problem. Start at the beginning of your checklist. You spend 25 dollars on food for your birthday party. You spend another 14 dollars on decorations. How many dollars did you spend in total? • *Use system of least prompts for both problems as needed.*	
<u>Closure:</u> • Great work trying both of those problems independently. Let's count how many steps you did by yourself today. • *Count number of thumbs up icons in the "by myself" column of the checklist for both problems.* • Write your total score in Today's Score box on your goal setting sheet. • *Use the number line to prompt the student to determine if they met their goal or not and have them circle yes or no.* • Great work today. Before we go, we are going to fill out your session check-in. We will do this so I can get to know what parts of problem-solving you like or don't like. I want you to be honest. If you don't like something, that's okay; I want to know. • *Guide student through the session checkout.* • Next time we meet, you will be able to try to beat today's score.	*Counts total icons in "by myself" columns* *Identifies if goal was met with assistance of interventionist.* *Student completes check-in*

Error Correction Procedures: The same system of prompts was used from the procedures of the study.

Appendix I

Replication Study Comparison

	Previous MSBI Research (Cox et al., 2024; Gilley et al., 2021; Gilley et al., 2023; Root et al., 2018; Root et al., 2022)	Current Study
Primary Outcome Measures	● Percentage of MSBI Steps (i.e., behaviors) completed independently	● Percentage of MSBI Steps (i.e., behaviors) completed independently
Interventionist(s)	● Research assistants ● Post-doctoral fellow ● Peer Mentors	● Primary researcher
Setting(s)	● Post-secondary transition program ● Public high school ● Private school for students with disabilities	● Private school for students with disabilities
Geographic Region	● Southeastern United States	● Northeastern United States
MSBI Components	● Task Analysis ● Graphic Organizer ● Goal Setting ● Video Modeling ● System of Prompts ● Peer mentoring ● Hand Gesture/Chant	● Task Analysis ● Graphic Organizer ● Hand Gesture/Chant ● Goal Setting ● System of Prompts
Target Skill(s)	● Money Skills ○ Calculating tip ○ Percentage off coupons ● Multiplicative comparison problems	● Change word problems in a variety of contexts
Generalization Setting	● Classroom ● On-campus coffee shop ● Community Mall	● School-based work
Study Design	● Concurrent Multiple Probe Across Participants	● Nonconcurrent Multiple Probe Across Participants
Data Analysis	● Visual Analysis ● BC-SMD	● Visual Analysis ● BC-SMD & Tau-U

Curriculum Vita

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PROFESSIONAL EXPERIENCE

Head of Service *Private School*	July 2024-Present
Director of Research, Development, and Transition *Private School*	May 2022-June 2023
School Psychologist *Colonial Academy, Colonial IU 20, Wind Gap, PA*	November 2021- May 2022
Emotional Support Teacher *Colonial Academy, Colonial IU 20, Wind Gap, PA*	August 2019- November 2021
Graduate Research Assistant *Lehigh University, Bethlehem, PA*	August 2017- July 2019
Teacher Associate *Centennial School of Lehigh University, Bethlehem, PA*	August 2015- May 2017
Adjunct Instructor *Community College of Allegheny County, Pittsburgh, PA*	August 2012- December 2013

EDUCATION

Ph.D.	Special Education, Lehigh University, 2025
M.Ed.	Secondary Education, Lehigh University, 2017
M.A.	Literary and Cultural Studies, Carnegie Mellon University, 2012
B.A.	English and Professional Communications, Chatham University, 2011

UNIVERSITY TEACHING EXPERIENCE

2022	Lead Instructor: Introduction to Inclusion and Special Education Lehigh University
2022	Co-Instructor: Intensive Intervention in Mathematics and Content Area

	Literacy Dr. Emily Sharp, Lehigh University
2021	Co-Instructor: Assessment in Special Education Dr. Minyi Dennis, Lehigh University
2019	Co-Instructor: Student Teaching Seminar Dr. Linda Bambara, Lehigh University
2018	Co-Instructor: Introduction to Inclusion and Special Education Dr. Minyi Dennis, Lehigh University

PUBLICATIONS

Lindström, E. R., **Fisher, E**., Cook, M., Perrella, M., McFadden, K. A., Chen, R., & Fallah, M. B. (2023). An observation study of mathematics instruction for students with IDD in grades K-2. Research in developmental disabilities, 141. https://doi.org/10.1016/j.ridd.2023.104591

Fisher, E. & Dennis, M (2023). Using the Number Line and Self-Explanation to Support the Fraction Magnitude Understanding of Middle School Students with Emotional and Behavioral Challenges. Journal of Emotional and Behavioral Disorders.

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Dennis, M., & **Gratton-Fisher, E.** (2020). Use data-based individualization to improve high school students' mathematics computation and mathematics concept and application performance. Learning Disabilities Research and Practice, 35(3), 126-138.

Gratton-Fisher, E., & Zirkel, P.A. (2020). Ten Legal Lessons for Special Educators. Exceptionality, 29(1), 41-46, DOI: 10.1080/09362835.2020.1727341

PRESENTATIONS

Fisher, E. & Winn, J. (2025, January). Nice is Not Enough: An In-Depth Analysis of One School's Compassionate ABA Practices. Division on Autism and Developmental Disabilities, Clearwater, FL.

Fisher, E. & Winn, J. (2024, January). Bridging the Research-to-Practice Gap at A Step Up Academy. Division on Autism and Developmental Disabilities, Honolulu, HI.

Fisher, E. & Stefankiewicz, E. (2023, March). A Data-Based Decision-Making Framework for Post-Secondary Transition Programming for Students with Autism. Council for Exceptional Children Conference, Louisville, KY.

Fisher, E. & Dennis, M (2023, March). Using the Number Line and Self-Explanation to Support the Fraction Magnitude Understanding of Middle School Students with Emotional and Behavioral Challenges. Council for Exceptional Children Conference, Louisville, KY.

Winn, J. & **Fisher, E.** (2023, January). Bridging the Research-to-Practice Gap: A Descriptive

Case Study. Pacific Coast Research Conference, San Diego, CA.

Fisher, E. (2021, November). IEP Meetings. Guest Lecture for Student Teaching Seminar, Lehigh University, Bethlehem, PA

Fisher, E. (2020, April). IEP Meetings. Guest Lecture for Student Teaching Seminar, Lehigh University, Bethlehem, PA

Fisher, E. (2019, November). IEP Meetings. Guest Lecture for Student Teaching Seminar, Lehigh University, Bethlehem, PA

Dennis, M., & **Gratton-Fisher, E.** (2019, October). Use data-based individualization to improve high school students' mathematics computation and mathematics concept and application performance. Panel presented at the Council for Learning Disabilities Conference, San Antonio, TX.

Gratton-Fisher, E. (2019, October). Meta-Analysis of the Relations Between Engagement, Achievement, and Motivation. Roundtable presentation at the Council for Learning Disabilities Conference, San Antonio, TX.

Lindström, E., **Gratton-Fisher, E.,** & Nielsen, C. (2019, October). Effects of behavior interventions on reading outcomes: A synthesis. Poster presented at the Council for Learning Disabilities Conference, San Antonio, TX.

Lindström, E., & **Gratton-Fisher, E.** (2019, February). Effects of behavior interventions on reading outcomes: A synthesis. Poster presented at the Pacific Coast Research Conference, San Diego, CA.

CERTIFICATIONS

Instructional I, Teacher, English, Grades 7-12, Commonwealth of Pennsylvania

Instructional I, Teacher, Special Education, Grades 7-12, Commonwealth of Pennsylvania

Instructional II, Teacher, English, Grades 7-12, Commonwealth of Pennsylvania

Instructional II, Teacher, Special Education, Grades 7-12, Commonwealth of Pennsylvania