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Embedding Literacy in Mathematics Problem Solving Instruction for Learners With Intellectual and Developmental Disability

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Abstract

Although solving word problems involves both literacy and mathematics skills, research to date has only targeted mathematical learning. This study sought to increase teaching efficiency by embedding literacy instruction within mathematical word problem solving instruction for three elementary students with intellectual and developmental disabilities. A multiple probe across participants design showed a functional relation between modified schema-based instruction (MSBI) and mathematical word problem solving. All participants increased knowledge of nontargeted literacy skills using instructive feedback, and two participants demonstrated a further increase following the use of constant-time delay (CTD). The results highlight several implications for practice regarding the feasibility of MSBI with instructive feedback to simultaneously address multiple academic domains or skills. Limitations and suggestions for future research are discussed.

Key Words: *mathematics; intellectual disability; access to the general curriculum; universal design for learning*

The education of students with intellectual and developmental disabilities (IDD) has maintained a rapid evolution over the course of the past decade as the field of special education has reconciled the seemingly competing demands of general curriculum access and "functional" skills (Shurr & Bouck, 2013). Although the years immediately following initial accountability mandates such as the No Child Left Behind Act of 2001(2006) launched debates regarding the merit of academic instruction for students with IDD (e.g., Ayres, Lowry, Douglas, & Sievers, 2011; 2012; Courtade, Spooner, Browder, & Jimenez, 2012), recent discussions have pivoted to how to teach personally relevant academic skills (Root, Knight, & Mims, 2017; Thoma et al., 2015; Trela & Jimenez, 2013).

The push for raised expectations for the academic learning of students with IDD has been maintained by the positive outcomes of students themselves. Students with IDD are learning to decode text (Ahlgrim-Delzell et al., 2016), answer comprehension questions about grade-aligned content (Wood, Browder, & Flynn, 2015), solve algebraic equations (Root & Browder, 2017), and develop and evaluate predictions about the natural world through the inquiry process (Jimenez, Lo, & Saunders, 2014). Browder and Spooner (2011) point out that we do not yet know the impact of standards-based education on the long-term outcomes for students with IDD. Yet it is logical to conclude that, if individuals with IDD are provided with academic instruction that increases their autonomy within and across their community, fosters relationships with others, and increases their capacity for future learning, positive postschool outcomes will follow (Taber-Doughty, 2015).

Mathematics is an academic content area that has the potential to produce meaningful effects on the long-term outcomes for students with IDD. According to the social cognitive career theory

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(Lent, Brown, & Hackett, 1994), positive mathematics learning experiences can enhance career decisions. Students with IDD who have positive mathematics learning experiences may not only gain knowledge and skills in these areas, but also have a broader understanding of how content knowledge is used in real-world settings. However, it is unlikely that students with IDD will be able to apply mathematical learning in real-world settings if their instruction has been limited to a focus on early numeracy skills and has not included training on how and when to apply these skills to everyday contexts (Saunders, Root, & Jimenez, 2018). Problem solving has been hailed as the cornerstone of mathematical learning by the National Council of Teachers of Mathematics (NCTM, 2000), and it is critical that students with IDD are able to generalize their skills in order for mathematical learning to be truly meaningful.

The emphasis of mathematics research for students with IDD is beginning to reflect the importance of problem solving, as this is the basis for being able to solve real-world problems (Van de Walle, 2004). A recent review of the literature on teaching mathematics to students with moderate to severe level of disability by Spooner, Root, Saunders, and Browder (2018) shows an increasing focus on problem-solving skills for students with IDD in research conducted between 2005–2016. These findings reflect a change in trend from a prior review by Browder, Spooner, Ahlgrim-Delzell, Harris, and Wakeman (2008) that indicated an overwhelming emphasis on basic skills such as time and money in the research conducted from 1975–2005. Treatment packages that combine multiple evidence-based practices, such as systematic instruction, explicit instruction, graphic organizer training, and manipulatives, are being used to create universally designed supports that provide students with access to instruction on grade-aligned problem-solving skills, such as solving algebraic word problems (e.g., Root & Browder, 2017) and using the Pythagorean theorem (e.g., Creech-Galloway, Collins, Knight, & Bausch, 2013). What has not changed over the two reviews is the context where mathematical interventions were being conducted, with both reviews finding very few studies being conducted in inclusive settings. Although the expectations of mathematical learning are increasing to promote higher-level thinking skills such as problem solving, there continues to be a need for expanding the research into inclusive settings.

One treatment package with an emerging record of success in teaching problem solving to students with IDD is modified schema-based instruction (MSBI; Spooner, Saunders, Root, & Brosh, 2017), which adds supports to schema-based instruction (SBI), an established evidence-based practice for teaching problem solving to students with high-incidence disabilities (Jitendra et al., 2015). The key features of traditional SBI include: (a) visual diagrams known as schemas to show the relationship between quantities in word problems, (b) a heuristic to remember the problem-solving process, (c) the use of explicit instruction to teach the problem-solving process, and (d) metacognitive strategy instruction (Powell, 2011). MSBI supplements SBI with additional universally designed supports to increase the physical and cognitive accessibility of problem-solving tasks and instruction, including (a) a student-friendly task analysis to serve as both a heuristic and to facilitate self-monitoring, (b) enhanced visual supports on graphic organizers, and (c) incorporation of systematic instruction along with explicit instruction (Spooner, Saunders, et al., 2017).

These key features of MSBI align with the universal design for learning (UDL) framework and promote self-determination. The MSBI conceptual model promotes multiple means of representation, action and expression, and engagement, and offers options for differentiating these individual supports based on student needs, as described by Spooner et al. (2017). For students with IDD who have emerging literacy skills and are not yet independent readers, incorporating pictorial-self instruction through the use of a student-friendly task analysis not only provides multiple means of representation, action and engagement, and expression, but has also been effective in teaching the self-determination skill of self-management. The use of pictorial self-instruction within MSBI is an innovative application of a well-established instructional strategy, reflecting a response to the call of Wehmeyer (2015) and Thoma et al. (2015) for effective universally designed strategies that teach individuals with IDD academic content.

Empirical evaluations of the efficacy and feasibility of MSBI for teaching problem solving to students with IDD have made an important contribution to the evidence base for UDL, an area that is surprisingly sparse (Rao, Smith, & Lowrey, 2017). Effective mathematical interven-

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tions that employ principles of UDL are imperative for the call to expand research for teaching mathematics to individuals with IDD in inclusive settings. Browder et al. (2017) evaluated the effects of MSBI taught by classroom special education teachers on mathematical problem solving of eight elementary and middle school students with a moderate level of intellectual disability. Students learned to solve and discriminate between three types of additive problems (group, change, and compare; Carpenter & Moser, 1984). After students demonstrated mastery using paper-based materials, researchers assessed generalization to computer-based word problems and video problems. Results of the multiple probe across dyads design showed a functional relation between MSBI and mathematical problem solving, as all students who completed the study were able to solve and discriminate between the three problem types in both paper-based and computer-based formats. Some students were also able to demonstrate some generalization to video-based problems.

In related evaluations of MSBI, researchers have found it an effective strategy for teaching middle school students with IDD to solve word problems related to personal finance (Root, Saunders, Spooner, & Brosh, 2017) and algebraic word problems (Root & Browder, 2017), and also that it is feasible for peers to implement MSBI with fidelity (Ley Davis, 2016). Although these initial investigations pioneered an effective strategy for teaching the pivotal skill of problem solving to students with IDD, researchers only measured mathematical learning outcomes. Effectiveness of instruction should not be the only goal of researchers or practitioners. Instructional efficiency is also important, as it reflects how quickly a learner is able to acquire new information in relation to the amount of time spent receiving instruction (Wolery, Ault, & Doyle, 1992).

One way to increase instructional efficiency is to target multiple skills within single instructional sessions through the use of instructive feedback on nontargeted information (NTI; "non-target stimuli"; Wolery, Schuster, & Collins, 2000). According to Collins (2007), instructive feedback can be used to systematically provide information on additional skills during learning trials. There is an extensive research base on the effectiveness of this strategy for addressing a variety of skills, including functional and core content (e.g., Collins, Hager, & Galloway, 2011; Jameson, McDonnell, Johnson, Riesen, & Polychronis, 2007), leisure skills and core content (e.g., Fetko, Collins, Hager, & Spriggs, 2013), and multiple academic skills (e.g., Wolery et al., 2000). Given the presence of written text in word problem solving instruction, there is a natural opportunity also to address literacy-related skills as nontargeted information through instructive feedback. For example, when affirming a correct response for a student, the teacher can state additional information about the parts of speech (e.g., nouns or verbs) in the problem.

As the standards-based instruction era has raised expectations for students with IDD, teachers need evidence-based instructional methods for supporting students in acquiring meaningful academic skills. A series of research studies support the use of MSBI to teach mathematical problem solving to elementary and middle school students with IDD (Browder et al., 2017; Ley Davis, 2016; Root, Saunders, et al., 2017; Spooner et al., 2017), but they have not yet attempted to capitalize on the opportunities to address literacy skills within the context of mathematical word problem solving instruction. Instructive feedback on nontargeted information increases instructional efficiency by allowing multiple instructional priorities to be addressed within single instructional sessions (Collins, 2012). It also provides the opportunity to address academic skills, individualized education plan (IEP) goals, and functional skills within the same lesson (Falkenstine, Collins, Schuster, & Kleinert, 2009). Given the increased expectations for what special education teachers are supposed to teach and the finite amount of instructional time in a day, NTI addresses the need for efficiency of instruction and truly maximizing instructional time (Collins et al., 2011). If found effective, this also holds promise for building practices that have potential to work in inclusive general education mathematics settings for people with IDD that address a variety of learning needs. The purpose of the current study was to increase teaching efficiency by embedding instructive feedback specifically related to literacy skills within mathematical word problem solving tasks for elementary students with IDD. The following research questions were addressed:

1. What is the effect of MSBI on mathematical word problem solving by elementary students with IDD?
2. What is the effect of instructive feedback during mathematical problem-solving instruc-

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tion on acquisition of literacy skills by elementary students with IDD?

Method

Participants

Three elementary students diagnosed with IDD participated in this study. Students were nominated to participate by their mathematics teacher based on meeting the following criteria: (a) participation in a special education program under the eligibility category of intellectual disability (IQ of less than 70), and (b) participation in alternate assessment aligned with alternate achievement standards (AA-AAS). Additionally, participants were required to possess the following prerequisite skills: (a) identification of numbers 0–9 when presented in random order; (b) making sets up to 9; and (c) the ability to maintain attention and participate appropriately in small group instruction for at least 5 min, as observed by researchers during regular classroom instruction.

Ashley was a 10-year-old White female student diagnosed with a moderate level of intellectual disability in the fourth grade. She had a full-scale IQ score of 50 (Wechsler Intelligence Scale; Wechsler, 2003). She received all academic instruction in a self-contained classroom for students with moderate levels of disabilities. According to her IEP, Ashley was able to identify written numerals and make sets; however, she was not able to independently add and subtract to solve equations. Ashley enjoyed being the teachers' helper, working with her classmates on various assignments, and aimed to please others. She particularly liked to work on the computer or tablet and enjoyed completing various art activities.

Micah was a 10-year-old African American male student diagnosed with a mild level of intellectual disability in the fourth grade. He had a full-scale IQ score of 60 (Wechsler Intelligence Scale; Wechsler, 2003). He received all academic instruction in a self-contained classroom for students with moderate levels of disabilities; however, he did participate in inclusive opportunities with his same-age peers during nonacademic time throughout the day such as lunch, nonacademic classes, and recess. According to his IEP, Micah was able to identify written numerals up to 20, count with one-to-one correspondence, and was able to tell time with 80% accuracy. Micah worked well one-on-one with others and thrived given social praise. He enjoyed telling stories to others and liked to receive attention from others.

Joe was an 11-year-old White male student diagnosed with a mild level of intellectual disability in the fifth grade. He had a full-scale IQ score of 56 (Wechsler Intelligence Scale; Wechsler, 2003). He received all academic instruction in a self-contained classroom for students with moderate levels of disabilities. According to his IEP, Joe was able to identify two-digit written numerals, count with one-to-one correspondence, and could solve one-digit addition equations with support. Joe had a strong interest in sports and games and enjoyed talking about these topics with others. He worked best given one-on-one attention and aimed to please others.

Setting

This study took place in a public elementary school in a large metropolitan area in the southeast United States. The school is comprised of 814 students in kindergarten through grade 5. The school contains a diverse student population with the racial composition being approximately 66% White, 9.5% African American, 18.2% Hispanic, 3.9% Asian, and 2.0% other. Approximately 30% of students qualify for free or reduced-price lunch. Participants received all daily academic instruction from a special education teacher who had 3 years of teaching experience and has worked with people with disabilities for over 10 years. Intervention sessions were conducted one-on-one in the students' classroom during time allocated for mathematical instruction. Sessions lasted approximately 20 min and took place three to four times per week. The interventionist was a special education doctoral student who was a board-certified behavior analyst (BCBA) and former special education teacher.

Targeted and Nontargeted Skills

To increase inclusive academic opportunities for students with IDD, it is important to align instruction with the academic standards addressed in general education settings, moving beyond number sense to higher-level thinking skills, such as problem solving. Mathematical problem solving involving addition and subtraction align with early elementary standards. The targeted skill for participants in this study was solving mathematical problems of the group problem type, which

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Table 1
Task Analysis and Corresponding Expected Student Responses

Step	Expected Student Response
1. Read the Problem	Asked for problem to be read aloud
2. Circle the Nouns	Circled two referent nouns in lines 2 and 3
3. Find Label in Question	Found label in question (e.g., How many animals did Ava see?), and then inserted label into line on number sentence template
4. Use My Rule	Said the rule for group problems, "Small group plus Small group combined into a big group," repeat the rule using the nouns from the problem, such as "crabs plus fish combined into animals"
5. Fill-In GO	Wrote the numbers and labels from the problem onto the corresponding areas of the graphic organizer (e.g., "crabs" in the first small group, "fish" in the second small group, "animals" in the big group)
6. Circle the Numbers	Circled numerals in word problem
7. Fill-In Number Sentence	Filled in numbers in boxes on number sentence
8. Plus or Minus	Determined whether problem was addition or subtraction and inserted symbol into number sentence
9. Make Sets	Used concrete manipulatives to make sets on graphic organizer corresponding to quantities in the problem (e.g., set of 5 in the first small group and set of 3 in the second small group)
10. Solve and Write Answer	Solved problem by moving all manipulatives into the big group, counting the total number of manipulatives, and writing the answer in the number sentence template

depicts a part-part-whole relationship (Carpenter & Moser, 1984).

Solving mathematical word problems involves various literacy skills, including reading a problem, understanding the language used, identifying key information, and conceptually organizing the information presented prior to solving. Because of the overlap between mathematics and literacy skills needed to solve word problems, the NTI addressed in this study focused on grade-aligned literacy skills. To align with early elementary ELA standards, the nontargeted literacy skills of identifying nouns and verbs within the context of the word problems were identified as nontargeted because of their discrete and definitive definitions (i.e., a noun is a person, place, or thing and a verb is an action word) and the importance of these parts of speech to the problem-solving process. For example, as participants worked through the steps of the self-monitoring checklist, they were asked to identify the nouns in the problem. Participants were taught to identify the nouns and the label in the word problem. The nouns and the label add context to mathematical problem solving by teaching the relationship of part-part-whole equations (i.e., If Jose bought 2 carrots and 3 onions, then he has 5 vegetables altogether). With embedded instructive feedback, participants gained exposure to discrete literacy skills and a generalized application of the skill (i.e., identifying a noun or verb from the problem). Although nouns are the emphasis in the group problem type, preteaching verbs will aid in solving other problem types, such as change problems, where the verb is used to determine the operation for solving. By focusing on identifying nouns and verbs as nontargeted information, participants in this study received additional grade-aligned academic content, further increasing potential inclusive academic opportunities for students with IDD.

Materials

Materials and procedures utilized throughout the intervention were developed as a part of a federally funded, multiyear research grant The Solutions Project (Grant No. R324A130001; see Browder et al., 2017). The modified schema-based instruction (MSBI) intervention package and instructional materials, including scripted lesson plans, graphic

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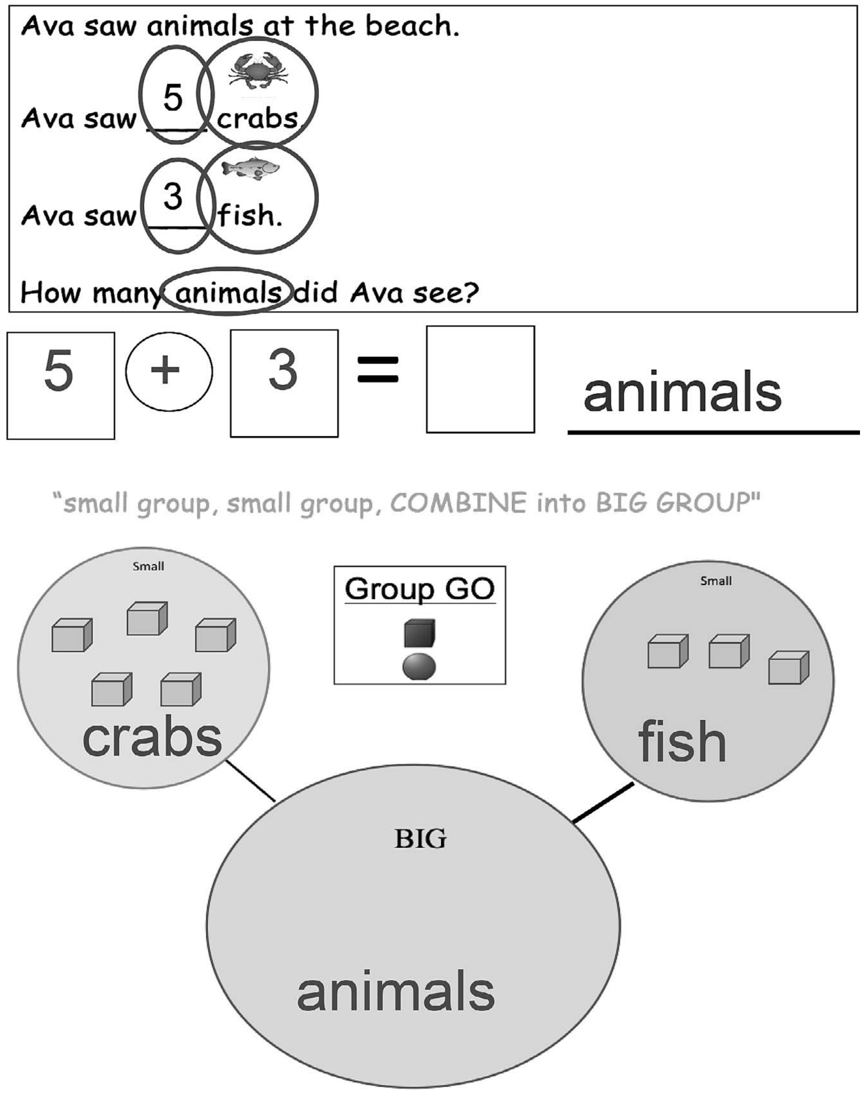

Figure 1. Example student materials, including word problem, number sentence template, graphic organizer, and manipulatives, demonstrating completion of task analysis through step 9.

organizer, rule, and word problems, were adapted from those developed by Saunders, Root, & Browder (2017). In each session, students were presented with a laminated self-monitoring checklist, laminated equation template, laminated and color-coded graphic organizer, two word problems, and manipulatives.

Participants were given a task analysis in the form of a self-monitoring checklist during each session that consisted of 10 steps and systematically advanced participants through the steps of solving the word problems. Each step of the task analysis was paired with visual cues to provide additional support to emerging readers. Table 1 lists the steps of the task analysis and expected student responses for each step. Students were provided a dry erase marker to check off steps as they were completed to promote self-monitoring (see Table 1).

The graphic organizer (Figure 1) utilized in this study was approved by experts in the field of SBI and elementary mathematics for content validity. The graphic organizer was color coded to provide further visual supports for distinguishing between the two small groups (parts) and one big group (whole), and groups were connected with lines to show the action of combining the two parts into one whole. Students were taught a

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rule to represent the problem type, "small group, small group, BIG group," and the rule was paired with hand motions that mimicked the structure of the graphic organizer (see Figure 1).

All word problems used in this study came from the bank of those developed by (Saunders et al., 2017) and followed a consistent formula. Each problem consisted of four sentences, with the first sentence "anchoring" the problem by providing the real-world context for the problem, such as passing out equipment in PE class, observing animals at the zoo, or winning prizes at a fair. The second and third sentences identified the first and second nouns, or "small groups." The last sentence contained the label of what the students were solving for, or the "big group." Word problems only depicted quantities less than 10 to facilitate use of manipulatives. An example problem can be seen in Figure 1. For a full description of the guidelines used to develop problems, see Spooner et al. (2017). Students were provided with counting chips for manipulatives.

Experimental Design

This study used a multiple probe across participants design (Gast & Ledford, 2014; Horner & Baer, 1978). This study consisted of three phases: (a) baseline, (b) intervention, and (c) maintenance. All three participants entered baseline together. The first participant was selected to enter intervention due to the teacher reporting the likelihood of the participant exhibiting testing satiation and refusal with repeating testing without feedback on correctness. After a minimum of five data points, the first participant entered intervention. Once the first participant showed a stable upward trend in the primary dependent variable upon entering, the second participant entered intervention after three consecutive baseline probes were administered. This systematic process continued until all participants entered intervention. A minimum of five data points on the primary dependent variable were collected in the intervention phase for each participant. Maintenance data points were taken at least once per participant at 5-day intervals postintervention.

Dependent variables. A total of three dependent variables were measured throughout the study. The first and primary dependent variable measured was the percent of steps independently completed on a 10-step task analysis. Criterion for mastery and changing intervention phases was achieving a score of at least 80% of the steps across two problems, which must include an independent correct response for step 10 (solve and write answer) for two out of three consecutive sessions. The second dependent variable was the total number of mathematical word problems solved correctly on both word problems presented during a session, measured by independent correct responding to step 10 (solve and write answer) on the word problems.

The third dependent variable was the percent of literacy questions answered correctly. In each session, participants were asked four literacy questions, which included (a) defining noun, (b) identifying a noun a problem, (c) defining verb, and (d) identifying the verb a problem.

Interobserver agreement and procedural fidelity. The primary interventionist trained a second observer on data collection procedures. The second observer observed a minimum of 30% of baseline and intervention sessions for each participant via video recordings. To ensure reliability, the second observer used the same data collection instrument as the primary interventionist and collected data on all dependent variables for each session. Interobserver agreement (IOA) was conducted for at least 30% of baseline and intervention sessions for each participant. IOA for Ashley was taken for 40% of baseline sessions, with a mean agreement of 90%, and for 33% of intervention sessions, with a mean agreement of 100%. IOA for Micah was taken for 33% of baseline sessions, with a mean agreement of 90%, and for 43% of intervention sessions, with a mean agreement of 95%. IOA for Joe was taken for 29% of baseline sessions, with a mean agreement of 90% and for 38% of intervention sessions, with a mean agreement of 96%.

From the same video recordings, the second observer used a procedural fidelity checklist to measure the degree to which the intervention was implemented as intended, including the presentation of nontargeted information presented as systematic feedback in the consequent event and the level of prompting utilized throughout implementation. Procedural fidelity was calculated for a minimum of 30% of the baseline and intervention sessions. Procedural fidelity for Ashley was collected for 40% of baseline sessions, with a mean agreement of 100%, and for 33% of intervention sessions, with a mean agreement of 100%. IOA for Micah was taken for 33% of baseline sessions, with a mean agreement of 90%, and for 43% of intervention sessions, with a mean

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agreement of 100%. IOA for Joe was taken for 29% of baseline sessions, with a mean agreement of 100%, and for 38% of intervention sessions, with a mean agreement of 100%.

Procedures

Each session, whether in baseline, intervention, or maintenance condition, followed the same general procedures. The student was presented with materials that included word problems, self-instruction checklist (task analysis), graphic organizer, manipulatives, and a dry erase marker. Participants were given two word problems to solve in each session. Participants were asked two literacy questions after each problem about either nouns or verbs, with the order of which skill came first randomized by session. A total of four literacy questions were asked in each session, including: (a) what is a noun, (b) what was a noun in the problem, (c) what is a verb, and (d) what was a verb in the problem.

Baseline. The interventionist presented the directions, "show me how to solve this problem," to the participant. If requested by the participant, the interventionist read the problem aloud. No prompting, feedback, or error correction was provided.

Intervention. The intervention was broken into several phases: modeling, MSBI plus instructive feedback, MSBI plus CTD for more explicit and systematic teaching of the parts of speech, and maintenance. Intervention sessions were conducted daily for 8 weeks and lasted approximately 20 min each.

Modeling. For the first 2 days of intervention, the interventionist explicitly modeled and taught each step of solving the problem and how to use the self-monitoring checklist and the materials provided (e.g., graphic organizer, manipulatives, equation template). During modeling, no data were collected because participants were not asked to make independent responses. Table 1 lists expected participant responses for each step of the self-monitoring checklist.

Following two sessions of modeling, the interventionist gave participants the opportunity to attempt each step prior to using a system of least prompts and began using instructive feedback to address the nontargeted literacy skill. The interventionist provided the participant with instructional materials and said, "Show me how to solve the problem." If the participant did not respond to a specific step on the student checklist within 10 s of the instructional cue, the interventionist followed a least intrusive prompting hierarchy: (a) generic verbal prompt (e.g., "What's next?), (b) specific verbal prompt reading both the step to the participant and providing information on how to perform that step, and (c) a model and retest so the participant elicited the correct response before moving to the next step. If the participant responded incorrectly, an error correction procedure was utilized, which involved a model of the correct response followed by an immediate representation of the step. For example, if the student made an error in step and made a set incorrectly, the interventionist would say, "Watch me first, 5 crabs… (place manipulatives on set and count aloud) 1, 2, 3, 4, 5." Then the interventionist would remove the set just made and say "Your turn. Make your sets."

MSBI + instructive feedback. Instructive feedback was used to address the nontargeted literacy skills to promote understanding of the text of the word problem (Fiscus, Schuster, Morse, & Collins, 2002). After the participant finished circling the nouns in step 2, the instructor would review what the problem was about by either identifying the nouns in the problem and giving the definition of a noun or identifying the verbs in the problem and giving the definition of a verb. For example, "This problem is about crabs and fish. Crabs and fish are nouns. A noun is a person, place, or thing." This procedure was repeated after the student completed step 5 ("fill-in graphic organizer").

MSBI + CTD phase. Because participants were not meeting mastery of NTI with instructive feedback only, an additional phase was added to explicitly and systematically teach participants to identify the parts of speech—noun and verb—within the problem. Once participants demonstrated mastery on the primary learning target (word problem solving), a CTD procedure was used to explicitly teach each of the literacy skills at the same time points on the task analysis. After the participant finished step 2 and step 5, the instructor would first use a 0 s delay round, followed by 4 s delay round. Participants actively responded to the embedded feedback provided by the interventionist after steps 2 and 5 using CTD. This procedure was used to draw the participants' attention to the embedded feedback and NTI presented.

Maintenance. After participants met mastery criteria, they moved into maintenance.

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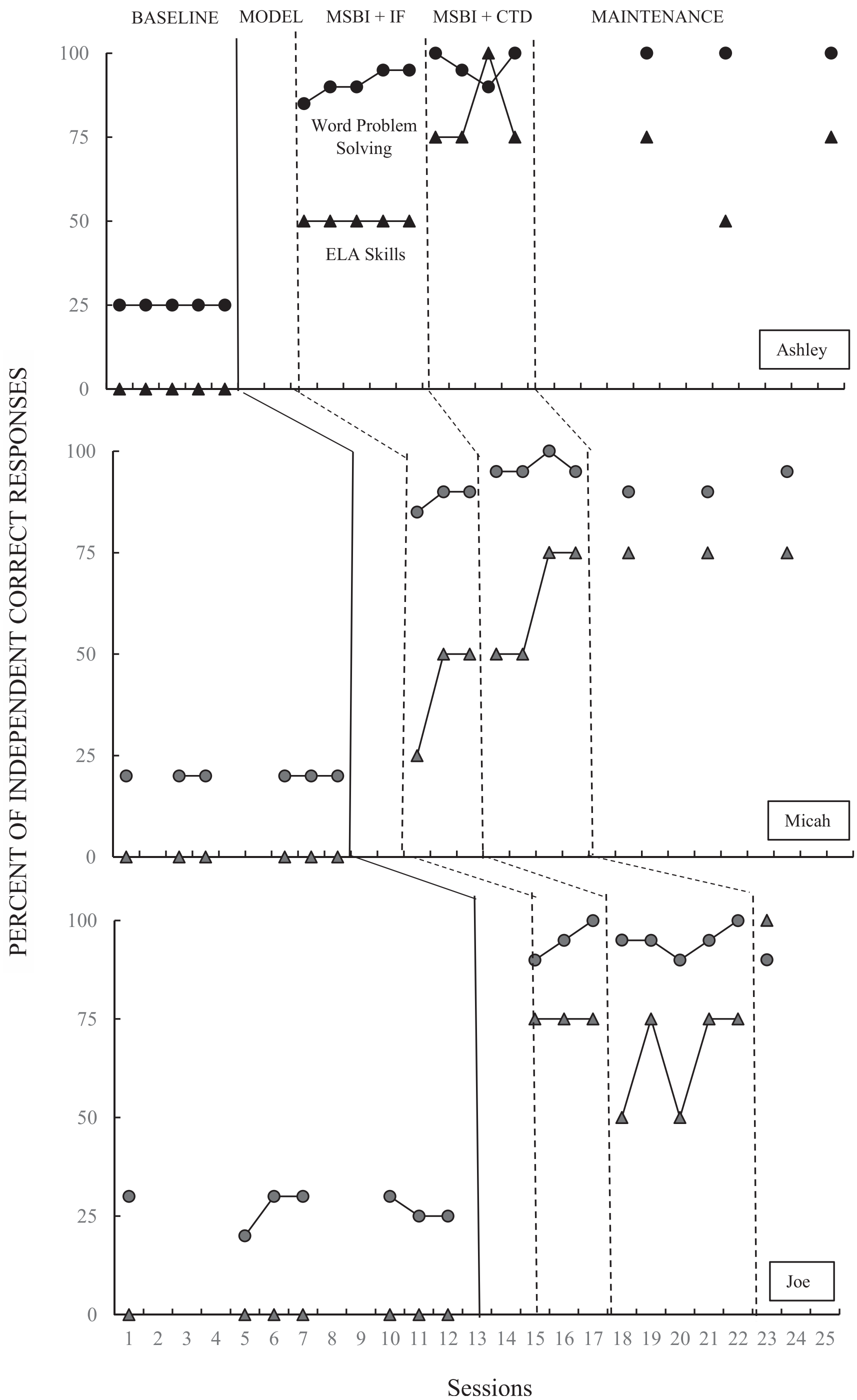

Figure 2. Graph of percent of independent correct responses on steps of task analysis (circles) and literacy questions (triangles) by phase across participants. MSBI = modified schema-based instruction; IF = instructive feedback; CTD = constant time delay; ELA = English Language Arts.

Maintenance probes were conducted approximately every five sessions. In maintenance probes, each participant was given two word problems with the materials presented during intervention to solve. No prompting or instructive feedback was provided to participants during maintenance probes on either mathematics or literacy skills.

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Results

Figure 2 represents the percent of independent correct responses to both steps of the task analysis and literacy questions. During baseline, all participants demonstrated a stable pattern of responding for mathematical problem solving and answering literacy questions. Upon entering intervention, each participant demonstrated an immediate jump in level or increasing trend for word problem solving, with no overlapping data with baseline performance for mathematical problem solving for answering literacy questions. Visual analysis of the graph shows a functional relation between MSBI and the percent of independent steps of solving a word problem. In addition, there was an increase level of literacy questions answered correctly upon entering intervention for all three participants. Two out of three participants demonstrated a change in level (Ashley) or trend (Micah) following the addition of a CTD procedure (see Figure 2).

During baseline, Ashley was able to independently complete 25% of the steps of the task analysis correctly in each session across the two mathematical word problems, but was unable to correctly solve any of the word problems. In each baseline session, she read the problem (step 1), filled in the number sentence (step 7), and inconsistently selected the appropriate operation (step 8). Ashley reached mastery of problem solving after five sessions. She was able to solve a total of 10 problems across the nine intervention sessions. Ashley was unable to answer any of the literacy questions correctly during baseline. Once intervention began on the nontargeted literacy skills using instructive feedback, she demonstrated an immediate increase in level to 50% correct responses (two questions answered correctly), which typically included defining and giving examples of nouns in the problem. Once she demonstrated mastery on the primary dependent variable (problem solving), a CTD procedure was used to directly teach the nontargeted literacy skills. Following four sessions using CTD, Ashley further increased correct responding to literacy questions to an average of 81% (range 3–4 questions answered correctly). She was able to maintain problem-solving performance of 100% correct responding after termination of intervention, solving a total of five additional problems, and answer an average of 66% of the literacy questions (range 2–3 questions answered correctly).

During baseline, Micah was able to independently complete 20% of the steps of the task analysis correctly in each session across the two mathematical word problems, but was unable to correctly solve any of the word problems. Similar to Ashley, he read the problem (step 1) and filled in the number sentence (step 7) in each baseline session. Micah reached mastery of problem solving after four sessions. He was able to solve a total of six problems across the six intervention sessions. Micah did not answer any literacy questions correctly during baseline. Once intervention began on the nontargeted literacy skills using instructive feedback, he increased his level of independent responding to an average of 42% correct responses (range 1–2 questions answered correctly), which typically included defining and giving examples of nouns in the problem. Once he reached mastery on the primary dependent variable (problem solving), a CTD procedure was used to directly teach the nontargeted literacy skills. Following four sessions using CTD, Micah further increased correct responding to literacy questions to an average of 62.5% correct (range 2–3 questions). Micah maintained performance on both mathematical problem solving and answering literacy questions once intervention was terminated, as demonstrated by an average of 92% (range 90–95%) of the steps of the task analysis solved correctly, six additional problems solved, and answering 75% of the literacy questions correctly (3 questions).

During baseline, Joe was able to independently complete an average of 22.8% (range 20–30%) of the steps of the task analysis correctly in each session across the two mathematical word problems, but was unable to correctly solve any of the word problems. Similar to Ashley and Micah, he read the problem (step 1) and filled in the number sentence (step 7) in each baseline session. Sometimes Micah filled in the correct operation (step 8) and attempted to solve the problem (step 10) using mental strategies. Although he was able to calculate the correct numerical answer for a few problems if he had memorized the mathematics fact (e.g., $2 + 2 = 4$), he never used the label in his response (e.g., four snacks), a necessary component for solving the problem (see Table 1). Joe reached mastery of problem solving after three sessions and was able to solve a total of 12 problems across the seven intervention sessions.

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Just like Ashley and Micah, Joe did not answer any literacy questions correctly during baseline. Once intervention began on the nontargeted literacy skills using instructive feedback, he increased his level of independent responding to an average of 75% correct responses (3 questions), which included giving the definition for nouns and verbs and an example of nouns in the problem. Once he reached mastery on the primary dependent variable (problem solving), a CTD procedure was used to directly teach the nontargeted literacy skills to follow the same phase order used for prior participants, although it did not increase his average correct responding to literacy skills (average 65%, range 2–3 questions answered; see Figure 2). Due to the end of the school year, only one maintenance data point was collected for Joe, but he was able to demonstrate maintenance of mathematical problem solving with 100% of the steps solved independently correct, solving two additional problems and answering 100% of the literacy questions correctly.

Social validity. After completing the intervention, social validity was collected by directly interviewing each participant. Each participant reported they enjoyed the intervention and wanted to continue solving word problems. Additionally, participants reported that they liked to solve the word problems with the student checklist and the graphic organizer.

Discussion

This study aimed to increase instructional efficiency for students with IDD by addressing both mathematics and literacy skills within single instructional sessions. By using instructive feedback related to nouns and verbs found within word problems, students had the opportunity to learn nontargeted skills during mathematics problem solving tasks. All three students were able to master solving the mathematical word problems following introduction of MSBI and were able to maintain responding. In addition, all three students demonstrated an increase in level of correct responding to literacy questions following the use of instructive feedback during MSBI. For two out of three participants, the addition of CTD procedure to MSBI further increased their correct responding to literacy questions, and all participants were able to maintain skills following intervention at relatively the same levels as intervention.

Students with IDD have demonstrated that they are capable of learning much more than what was once thought possible or worthwhile if given instruction using evidence-based practices and universally designed supports. A particular area that is expanding is mathematical problem solving, whereas, prior to 2008, only one published study had attempted to teach an individual with IDD to solve mathematical word problems, the basis for solving real-world problems (Neef, Nelles, Iwata, & Page, 2003; Van de Walle, 2004). Recent research is showing students with IDD can learn to solve mathematical word problems and that MSBI is an effective strategy that combines evidence-based practices for students with IDD with tenants of UDL (e.g., Browder et al., 2017; Spooner et al., 2017). The current study makes an important contribution to this expanding literature base, as it demonstrates a method for addressing multiple instructional targets, thereby increasing instructional efficiency. It also supports the need to maintain high expectations for students with IDD.

Contrary to the findings by Collins et al. (2011) and Falkenstine et al. (2009), which showed students with IDD could acquire NTI to mastery in chained academic tasks, participants in this study were not able to acquire the NTI to mastery levels. Although participants did not acquire NTI to mastery, is important to note that all participants did show gains associated with the nontargeted literacy skills addressed by the embedded systematic feedback. There are a few possibilities for why this occurred.

First, prior to this study, participants had never been exposed to parts of speech, including both nouns and verbs, so there was no conceptual understanding basis. For the targeted skill of mathematical word problem solving, participants had been exposed to prerequisite numeracy skills and had some exposure to solving addition and subtraction equations. Because the nontargeted literacy skills had never been addressed prior to this study, the embedded instructive feedback could have been disregarded by participants due to confusion or lack of prior exposure.

Also, in both Collins et al. (2011) and Falkenstine et al. (2009), both studies measured NTI at the conclusion of the study once participants had met mastery on the primary dependent variable, whereas, in this study, NTI

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was measured along the duration of the entire intervention. Perhaps those participants had more practice to mastery with feedback prior to being assessed.

Finally, most participants had difficulty identifying the verb in the problem. The nouns are critical components of a group problem type because these compose the two parts that are combined into the whole group (i.e., label), and participants had to directly identify these nouns in the problems and label the graphic organizer (steps 2, 3, and 5). It is logical that participants acquired this component through NTI because of the attention to this part of speech in the problem-solving process. The verb, on the other hand, was not as critical for solving because it was not directly linked to the operation (+ or –). In group problems sets are combined, so addition is the operation used when solving for missing final quantities; whereas, in other problem types, like the *change* problem type, the action verb tells the student whether to add or subtract and may have shown a greater change because this would have been a critical step in the chained task. Thus, it is logical that participants needed additional instruction to acquire this skill, and CTD was used. Even with CTD, results were variable and not to mastery. This may be attributed to what was considered a "discrete" skill in this study. Falkenstine et al. (2009) used discrete skills such as stating times on a clock or reciting state capitals, both of which are quick recall skills. Whereas, in this study, identifying nouns and verbs, even with the definition provided, may have been a higher-level thinking skill that needed discrimination training paired with multiple exemplar training to establish concept understanding (Cooper, Heron, & Heward, 2007). This may have shown more positive results. Although the results associated with embedding nontargeted literacy skills in mathematical problem solving are variable and inconclusive, it is important to recognize that all participants did gain some literacy skills through instructive feedback and CTD throughout the intervention package. This shows promise for designing and implementing intervention packages that address more than one skill.

Implications for Inclusive Practices

Enhanced quality of life is frequently articulated as a valued outcome of education of students with IDD (Browder et al., 2009). While the impact of standards-based instruction is unknown, the impact of inclusive learning on school and post-school outcomes and quality of life is known (Kurth, Lyon, & Shogren, 2015; Kurth, Morningstar, & Kozleski, 2014). Inclusive opportunities and supporting students with IDD in accessing the general curriculum alongside their typically developing peers promotes a culture of belonging, builds professional collaboration, and increases engagement (Kurth et al., 2015).

MSBI has several benefits that would make it conducive to being utilized in a general education setting, especially given that many features align with the UDL framework. The graphic organizers for each problem type may benefit all learners in the classroom and can be faded depending on each student's proficiency with problem solving. Another benefit is the focus on self-monitoring and self-management through a chained academic task using the student-friendly task analysis, thus increasing students' independence and decreasing reliance on a teacher to provide prompting or support to complete problem-solving tasks. The task analysis could be differentiated based on students' needs. For example, readers could use a words-only task analysis or an acronym for the problem-solving steps, whereas emerging or non-readers could have pictorial support. In classrooms using multi-tiered systems of support, MSBI could be used potentially as a Tier 2 intervention in lower elementary grades. Incorporating MSBI as a UDL approach to teaching problem solving could potentially address the barrier of misalignment between the content students with IDD and their typically developing peers are learning in general education mathematics settings (Spooner et al., 2017).

In addition, NTI could be used to increase instructional efficiency for all learners in a general education setting, serving as a review of interdisciplinary grade-level skills, such as the literacy skills in this study. For individuals with IDD participating in a general education setting, the special education teacher or support personnel would need to take instructional data to make decisions regarding progress, such as moving from instructive feedback only to employing more explicit, systematic instruction like the CTD procedure as was done in this study. Another option would be to explicitly preteach the skill prior to using it as NTI, thus establishing acquisition of the skill, and then use peers to

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provide NTI instruction to increase opportunities for practice by embedding trials during natural opportunities throughout the lesson.

Limitations and Future Research

The researchers were not able to collect final maintenance data for the third participant because the school year ended. One consideration would be to measure NTI at the conclusion of the study once participants had mastered the primary dependent variable like Collins et al. (2011) and Falkenstine et al. (2009). In addition, the setting and delivery models are limitations. The study was conducted one-on-one by a researcher in a self-contained classroom. Prior work in this area has shown that systematic instruction techniques such as system of least prompts, time delay, and task analysis can be embedded within general education mathematics instruction (Browder et al., 2012). Future research should examine the feasibility of the intervention within inclusive settings with naturalistic instructors (i.e., paraeducator or peer). Finally, this study had limited findings with participants acquiring literacy skills as NTI to mastery, but this may have been attributed to the nature of the content requiring concept discrimination versus a true discrete recall skill. Future researchers should examine embedding other discrete academic tasks into NTI or using NTI to increase the number of opportunities for practice of previously learned material.

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