Hammill Institute on Disabilities

Remedial and Special Education
2018, Vol. 39(1) 53–64

DOI: 10.1177/0741932517717042
rase.sagepub.com
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Using Video Prompting to Teach Mathematical Problem Solving of Real-World Video-Simulation Problems

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Abstract

Mathematical problem solving is necessary in many facets of everyday life, yet little research exists on how to teach students with more severe disabilities higher order mathematics like problem solving. Using a multiple probe across participants design, three middle school students with moderate intellectual disability (ID) were taught to solve video-simulation real-world mathematical problems by finger counting using video prompting (VP) in conjunction with systematic instruction (e.g., least intrusive prompting) with error correction and feedback. The simulated videos covered a variety of thematic units (i.e., pet store, grocery store, household chores, sporting goods store, outside chores, and thrift store) students may encounter in their everyday lives. The results of this study demonstrated a functional relation between VP and participants' mathematical problem-solving skills. Findings from this study provide several implications for practice and research for using video-based interventions to teach mathematical problem solving to students with moderate ID.

Keywords

mathematics, moderate intellectual disability, video-based interventions, video prompting, computer-assisted instruction, self-monitoring

Applying mathematical concepts and problem solving are an integral part of everyday life and are required for being able to navigate the world. This includes things such as making purchases, creating budgets, utilizing calendars for planning purposes, calculating wages, determining distances, determining temperatures, and understanding time. According to the National Council of Teachers of Mathematics (NCTM, 2000), problem solving is the cornerstone of mathematical learning and without it, an individual's ability to solve future mathematical problems is severely limited. Competence in mathematics is critical for students with disabilities as it may help lead to better lifelong opportunities in the areas of independent living, socialization, and employment. Yet, many students with severe disabilities often lack fundamental mathematics skills (e.g., counting, creating number sets, measurement, extending patterns, and using calendars for future planning) and mathematical problem-solving skills, and need to be taught using explicit and systematic strategies (Browder et al., 2012).

Systematic instruction has strong empirical support for teaching mathematics to students with severe disabilities. Browder, Spooner, Ahlgrim-Delzell, Harris, and Wakeman (2008) conducted a meta-analysis to determine effective practices for teaching mathematics to students with moderate/severe intellectual disability (ID) and found systematic instruction with prompting and feedback (e.g., system of least prompts) to be an evidence-based practice (EBP). Many of the skills targeted in this meta-analysis were discrete mathematics skills, including several of the foundational skills, with few studies focusing on more complex, chained mathematics skills such as problem solving. Browder et al. suggested additional practices should be investigated to teach more complex skills.

Almost a decade later, much of the nation has transitioned to the Common Core State Standards (National Governors Association, 2010) and more emphasis has been placed on higher level thinking mathematics, such as problem solving, for all students, including those with severe disabilities. In a recent review of the literature for teaching mathematics to students with moderate/severe ID by Spooner, Saunders, Root, and Brosh (2017), explicit instruction was added as an EBP. Explicit instruction is defined as

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a series of supports and scaffolds where students are guided through the learning process in a step-by-step manner with clear explanations and demonstrations of the targeted skill and provided with practice with feedback until mastery is achieved (Archer & Hughes, 2011). The nature of this practice lends itself to teaching more complex mathematics skills such as problem solving.

When considering mathematics instruction for students with severe disabilities, the need to continue to build these foundational skills does not disappear, but rather moves toward building foundational skills and higher level thinking mathematical skills simultaneously, especially as students move to advanced grade levels. The field also should consider the generality of these skills to real-world scenarios if the ultimate goal is for them to be problem solvers in their everyday lives. Students with severe disabilities experience difficulty in generalizing the mathematical skills they do possess to real-world scenarios (Westling, Fox, & Carter, 2015). Community-based instruction (CBI) can provide students with rich, real-world, hands-on experiences in natural community environments. The constraints of diminishing school budgets, adequate supports, and the amount of time educators can dedicate to providing CBI often prevents them from providing these opportunities (Mechling & O'Brien, 2010). To remedy these constraints, researchers have investigated feasible options that replicate natural settings and situations outside of classroom environments (Mechling & O'Brien, 2010). The researchers in this article propose a twofold approach. First, build foundational mathematics skills using explicit strategies, and second, practice using these skills in simulations of real-world mathematical problems to better enhance generalization to real-world situations.

Build Foundational Mathematics Skills

When students with disabilities lack automatic fact recall, remedial strategies need to be introduced. Finger counting is a natural component of the development of mathematical skills in children and can lead to more efficient numerical comprehension (Stegemann & Grünke, 2014). Although experts in mathematics education discourage the use of finger counting beyond early elementary, neurocognitive experts find it is important for processing numerical information, even in older children (Berteletti & Booth, 2015). Finger counting alleviates working memory demands and provides visual cues, both of which are important for students with severe disabilities, but no research exists on its use for this population. According to Stegemann and Grünke (2014), our hands can represent numbers as a sum or a multiple of 10 and can facilitate the understanding of the 10-base numerical system. When finger counting is taught in an explicit and systematic manner, it can provide a permanent visual representation to assist in reducing the working memory load when performing numerical calculations. One advantage of finger counting as it pertains to the ability to generalize to real-world context is the portability and readily availableness, contrary to mobile devices, which many students with severe disabilities may not own or possess. For example, when shopping in a grocery store, an individual could easily count and solve a problem to determine the quantity needed to purchase using his or her fingers. The use of finger counting to solve mathematical problems may readily be incorporated into classroom instruction through video-based interventions (VBIs).

Simulations of Real-World Mathematical Problems

Classroom-simulated instruction delivered using VBI is one method for presenting real-world mathematical problems to better enhance generalization to real-world situations (Mechling & O'Brien, 2010). Simulations offer ways to build generalization within VBI by simulating real-world, naturally occurring settings (i.e., programming common stimuli, Ayres, Langone, Boon, & Norman, 2006; Stokes & Baer, 1977), providing and training multiple exemplars (Ayres et al., 2006; Stokes & Baer, 1977), and reducing irrelevant stimuli that may otherwise be distracting (e.g., excess noise or people, Bellini & Akullian, 2007). Additional benefits include cost-effectiveness—both in the sense the developer can record numerous settings without the expense of CBI and that videos can be made relatively inexpensively, and practicality—providing opportunity for repeated viewing, increasing time efficiency, and providing consistency of delivery of instruction (Ayres, Maguire, & McClimon, 2009; Gardner & Mechling, 2005; Gardner & Wolfe, 2013).

Two types of VBI include video modeling (VM) and video prompting (VP; Cannella-Malone et al., 2011; Cannella-Malone et al., 2006; Gardner & Wolfe, 2013). In VM, the learner views a peer, adult, or the student observes himself or herself performing a skill or chained task in entirety followed by an opportunity for the learner to perform the skill or chained task (Banda, Dogoe, & Matuszny, 2011). In VP, rather than showing the entire skill or chained task, it is broken into steps and presented sequentially with an opportunity for the learner to perform before advancing to the next step (Banda et al., 2011). A few studies have shown VP to be more effective than VM for the majority of participants with developmental disabilities (Cannella-Malone et al., 2011; Cannella-Malone et al., 2006). These studies suggested that future research should continue to examine the factors that might make VP more effective than VM (e.g., the use of systematic prompting strategies in conjunction with VP and VM, as well as fading procedures) so that enhancements can continue to be made with the instructional technology.

To further investigate the use of VP to teach skills to individuals with developmental disabilities, Banda and colleagues (2011) reviewed the research on VP between 1990 and 2010 with this population and found 18 studies that included 68 participants. Results of this review showed that VP was successful at teaching individuals with various developmental disabilities domestic, life, vocational, and independent living skills. Findings suggest that VP may be more effective at teaching chained tasks to individuals with developmental disabilities, as opposed to other strategies like VM or static picture prompting, as it may reduce cognitive load requirements in learners because behaviors are taught in steps or chunks. VP is likely to be so effective because it includes several EBPs for teaching individuals with developmental disabilities including task analytic instruction, prompting, repeated opportunities for practice, and feedback. Several of the studies showed that VP was more effective when paired with a systematic prompting strategy (e.g., constant time delay, least-to-most prompting), video feedback, and/or error correction procedures to teach chained tasks. The authors cautioned the need for future research to include prompt fading strategies to increase independence and decrease prompt dependency, a common problem for individuals with developmental disabilities.

Although the majority of research using VM and VP has targeted functional and daily living skills (Banda et al., 2011; Cannella-Malone et al., 2011; Gardner & Wolfe, 2013; Odom, Boyd, Hall, & Hume, 2010), both VBIs have been shown to teach a variety of primarily functional mathematical skills to individuals with ID, such as estimating money needed for a purchase and calculating change (Burton, Anderson, Prater, & Dyches, 2013), using an ATM (e.g., Cihak, Alberto, Taber-Doughty, & Gama, 2006), purchasing using an ATM card (Mechling, Gast, & Barthold, 2003), price comparison (Weng & Bouck, 2014), and multistep mathematics skills such as calculating a tip, unit prices, and adjusting measurements in a recipe (Kellems et al., 2016). Three of these studies directly taught mathematical problem solving to students with autism spectrum disorder (ASD) and/or ID (Burton et al., 2013; Kellems et al., 2016; Weng & Bouck, 2014), but all in different ways. Burton and colleagues (2013) examined the use of video self-modeling (VSM) to complete a seven-step task analysis to identify the price, estimate the cost, pay the teacher, and estimate the change with five problems. Although the intervention detailed was VSM, participants in this study were able to stop, pause, and restart as much as they needed to complete the problem, as opposed to viewing the entire video first and then solving the problem, so students may have done their own VP by chunking or viewing step-by-step. Weng and Bouck (2014) evaluated the use of VP with and without systematic prompting strategies to teach price comparison using an adapted number line to three secondary students with ASD and mild to moderate ID in simulation classroom settings and natural settings (i.e., grocery stores). Two of the three students in the study demonstrated the need for VP combined with systematic prompting strategies (most-to-least prompting), supporting previous findings in the literature (Banda et al., 2011). Kellems et al. (2016) expanded the VP research on teaching chained mathematics skills aligned to the Common Core State Standards to nine transition-aged adults with ID (IQ range = 40–78) with systematic instruction (system of least prompts).

Despite these positive findings for using VBI to teach mathematical problem solving to adolescents with disabilities, none of these studies examined the use of simulated real-world mathematical problems students may encounter in their everyday lives. A majority of the participants had mild ID and/or ASD and there is a need to expand this research to other populations with more significant disabilities, such as adolescents with moderate ID. In addition, these studies used treatment packages with varying instructional strategies, and more research is needed to support the use of VP in combination with systematic prompting (e.g., system of least prompts) and error correction procedures. Finally, research is needed on additional strategies for solving mathematical problems for students who lack fact recall, such as finger counting. Given these areas of need, the purpose of this study was to investigate the effects of using VP to teach real-world mathematical problem solving of video-simulation problems using finger counting to individuals with moderate ID. The following research questions were addressed:

> **Research Question 1:** What were the effects of using VBI and simulated real-world mathematical problems on generalized mathematical problem-solving skills (number of steps performed correctly on task analysis) for students with moderate ID?
>
> **Research Question 2:** What were the perceptions of participants and their teacher on the effectiveness and/or feasibility of learning mathematical problem solving through VBI in students with moderate ID?

Method

Participants

Three middle school participants with moderate ID in seventh and eighth grades were selected via convenience sampling by teacher nomination to be in this study. Participants were prescreened to determine whether the participants met the following inclusion criteria: (a) a diagnosis of moderate ID, (b) ability to independently rote count from 1 to 10, (c) ability count with one-to-one correspondence to 10, (c) ability to make sets of numbers up to 10, (d) ability to sustain attention to a video presentation for up to 5 min, and (e) both a signed parental consent and participant assent form.

Brad. Brad was a 13-year-old Caucasian American male in the seventh grade. He was diagnosed with Down syndrome with moderate ID and had a full-scale IQ of 42 (*Wechsler Intelligence Scale*, Wechsler, 2008). Brad was eligible to take the state alternate assessment and had Individual Education Program (IEP) goals pertaining directly to mathematics. According to his IEP, Brad was able to follow along with and identify numbers in a word problem; however, he was unable to solve math word problems independently.

Heather. Heather was a 14-year-old African American female in the eighth grade. She was diagnosed with moderate ID and had a full-scale IQ of 54 (Wechsler Intelligence Scale, Wechsler, 2008). Heather was eligible to take the state alternate assessment and had IEP goals pertaining directly to mathematics. According to her IEP, Heather was able to follow along with a story-based math lesson, identify numbers, and use a number line to assist her in solving with assistance; however, she was unable to solve independently or without the number line.

Benito. Benito was a 13-year-old Hispanic male in the seventh grade. He was diagnosed with Down syndrome with moderate ID and had a full-scale IQ of 42 (Wechsler Intelligence Scale; Wechsler, 2008). Benito was eligible to take the state alternate assessment and had IEP goals pertaining directly to mathematics. According to his IEP, Benito was able to identify numbers and rote count to 10 with minimal assistance. He could count movable items with 1:1 correspondence; however, he was unable to independently solve simple word problems even when given a graphic organizer.

Setting

The study took place in an urban middle school in the Southeast United States. The school served approximately 1,128 students in sixth through eighth grades with 38% of students eligible to receive free and reduced lunch. The racial and ethnic diversity of the students in the school were reported as 56% Caucasian, 26% African American, 15% Hispanic, and 3% Asian. Participants received the majority of their daily instruction in a self-contained classroom for students with severe disabilities within the middle school, but were included in elective classes (i.e., art, physical education, and music). Due to the small size and setup of the classroom with all desks in a U-shape facing the SMART Board, sessions took place in a conference room to minimize distractions and retain attention to the videos. Sessions were done individually and took place each day between 9:30 a.m. and 11:00 a.m.

Materials

Video-simulation problems were created using Camtasia® software and were displayed on a laptop computer using Windows Media Player. Other materials used for this study included a USB thumb drive with folders of videos for each session loaded, a wireless mouse, a neutral hand placement mat showing where to place hands prior to starting a problem, a laminated checklist with the numbers one to six on it so participants could self-monitor their progress of problems completed, data collection forms, and a Flip® camera to video record each session.

Video-simulation problems were developed as a generalization component by the research team for (The Solutions Project, IES Grant R324A130001). A total of 285 real-world mathematical problems were developed and filmed by the third author. The *change* problem type was used for all problems and is defined as a dynamic problem where the initial quantity of an item is either increased (addition) or decreased (subtraction) resulting in an ending quantity. The action in the problem determines the operation (addition/subtraction; Jitendra, 2008). Videos were filmed in various settings including the grocery store, the home, the pet store, the thrift store, the yard for outside chores (e.g., raking, watering, planting), and the sporting goods store using adults as actors. All videos were narrated and each problem was shown in a structured format including (a) contextual statement, (b) the initial set stated and shown, (c) the action stated and demonstrated, (d) the change amount stated and partially shown, and (e) a question callout screen with the question written and read aloud. The purpose of covering the change action amount was to prevent the participant from relying on counting with one-to-one correspondence to find the answer, and to use the problem-solving strategies being taught within the training video to solve. A sample script for video-simulation problems is included in Table 1. The videos problems were divided into 24 electronic folders with varying themes, sums, and differences prior to the study starting. These files were placed into folders in varying order so the sequence of addition and subtraction would vary from session to session. Video problems repeated after 24 sessions with 1 to 2 months duration between. Training videos were created separately and were never assessed in video problems. Problems were validated by an elementary education mathematics expert for quality and equivalency (see Table 1).

Experimenters

Two doctoral-level graduate research assistants in special education worked collaboratively to deliver the intervention. The first experimenter was a second-year doctoral student with a total of 16 years of teaching experience working with students with moderate/severe ID and delivered 60%

Table 1. Sample Script for Change Problem Type Addition and Subtraction Video-Simulation Problems.

Contextual Math: Anchoring Instruction	*Location: Thrift store* **Mike likes to shop at the thrift store. Today he needs to shop for a few things for himself.** (pan thrift store)
Addition	***Mike needs to buy new shirts from the thrift store. Mike already has 3 shirts in his cart*** *(show cart with 3 shirts).* ***He puts 2 more shirts in the cart*** *(show him moving shirts to cart then immediately cover set with question callout).* Callout: ***How many shirts does he have now?***
Subtraction	***Mike has money to spend at the thrift store. Mike has US$10 to spend*** *(show dollars).* ***He spends US$7*** *(show him handing money to cashier then immediately cover set with question callout).* Callout: ***How many dollars does he have now?***

Note. Bolded script indicates what is narrated on video. Nonbolded script states action for actor on the screen.

of all sessions. The second experimenter was a first-year doctoral student with 6 years of teaching experience working with students with moderate/severe ID and delivered 40% of all sessions. Both experimenters collected interobserver reliability and procedural fidelity data.

Dependent Variable

The dependent variable measured participant's ability to solve real-world video-simulation addition and subtraction mathematical problems of the *change* problem type. Four problems were presented each session, and each problem was task analyzed into six steps, totaling 24 possible steps possible. The dependent variable measured the number of independent correct steps performed across all four video problems (i.e., 24 steps). The task analysis was adapted from a template used in previous research to teach mathematical word problem solving (Saunders, 2014), and included the following steps: (a) view the video problem (the participant independently clicked the play button on the laptop to start the video); (b) identify the initial set (the participant independently verbalized or made the initial set on his or her fingers); (c) demonstrate the change action of adding or subtracting (participant independently used a finger counting strategy to demonstrate the targeted change behavior of adding on or taking away, verbalized counting up or down, or demonstrated using mental math); (d) identify the change amount (participant independently demonstrated via finger counting adding on or taking away the change amount, verbalized counting up or down to the correct number, or demonstrated using mental math); (e) solve and state correct ending amount; and (f) verbally label ending amount (i.e., state object being counted, such as "flowers").

Experimental Design and Procedures

This study used a multiple probe across participants design (Gast & Ledford, 2014; Horner & Baer, 1978). The implementation of the design adhered to the criteria established by the What Works Clearinghouse (WWC; Kratochwill et al., 2013). There were three conditions (baseline, intervention, maintenance) and three phases within the intervention condition: (a) addition, (b) subtraction, and (c) mixed addition and subtraction. The decision to split change problems by operation and teach addition and subtraction to mastery prior to mixing them together was based on the data and implications for practice from Saunders (2014). She did not separate addition and subtraction into different phases and found this likely overloaded the cognitive demands of her participants and led to frustration and confusion. Participants were overwhelmed learning to solve problems and discriminating between addition and subtraction at the same time. During baseline, mixed intervention, and maintenance, participants solved two addition and two subtraction video problems. During addition and subtraction only phases, participants solved the targeted problem type to avoid frustration and confusion.

After a minimum of five data points were collected in baseline and a decreasing trend was observed, the participant with the most variability (Brad) entered intervention to control for learning during baseline. Baseline probes continued to occur for the remaining participants a minimum of every eighth session until he or she entered the intervention condition. After the first participant showed a clear accelerating trend for a minimum of three sessions, the next participant with the lowest, most stable baseline was brought into intervention (Heather). When that participant showed an increasing trend, the final participant was brought into intervention (Benito). Once a participant met mastery criterion in the addition phase (correctly solving three of four video problems independently for two consecutive sessions), progression across phases depended on that participant meeting the mastery criteria for each phase (e.g., addition, subtraction, mixed). The study lasted approximately 4 months from baseline through maintenance condition for the first two participants and was concluded following mastery of the addition phase for the third participant as the school year ended.

Procedures

Baseline. During baseline, participants received daily math instruction using the Unique Learning Systems (N2Y, 2014) and *Teaching to Standards: Mathematics* (Trela, Jimenez, & Browder, 2012) curricula. The experimenter pulled each participant individually to the conference room and presented each session in a one-to-one format. During baseline probes, no training videos were shown. Participants were asked to solve four problems (two addition and two subtraction). The experimenter began each baseline session with the laptop open with the video displayed and delivered the instructional cue to begin (i.e., “Today I want you to solve some video problems on your own. Watch this video, solve the problem, and do your best!”). The experimenter then waited for the participant to independently click the play button on the laptop to begin the video. If the participant did not click play, the experimenter asked whether the participant needed help and clicked the play button on the computer when asked. Following the presentation of each video, the experimenter waited 5 s for the participant to provide a response. If the participant did not respond, the experimenter asked, “What’s your answer?” and recorded the response as correct or incorrect on the data sheet. The experimenter then opened the next video problem and this process repeated until all four problems were completed. No instruction, feedback, or error correction was given during baseline. Intermittent praise for participation was given if the participant needed encouragement to keep working.

Finger counting training. The participants were trained to place their hands with closed fists on the hand placement mat to indicate the starting position for finger counting. They were taught to count on their fingers in a specific order starting with their right hand (right index finger was “1,” the right middle finger “2,” the right ring finger “3,” the right pinky finger “4,” the right thumb “5,”), and then move to the left hand (left hand thumb being “6,” the left index finger “7,” the left middle finger “8,” the left ring finger “9,” and the left pinky “10”). An elementary mathematics expert at the university advised this method. This order was used for addition (counting up with their fingers) and was reversed for subtraction (counting down with their fingers), starting with the left fingers folded down in reverse order of addition to represent subtracting, or taking away. The decision to teach finger counting using a consistent pattern prior to entering intervention was made after the first participant was observed finger counting with inconsistency which resulted in errors during baseline probes. Finger counting was taught in one session for Brad and two sessions for Heather and Benito. Mastery was considered when the student could count up from 1 to 10 and backward from 10 to 1 using the method with 100% accuracy for two consecutive sessions.

Intervention. The intervention condition was divided into three phases: addition, subtraction, and mixed addition and subtraction. Participants watched two training videos and then solved four video problems. The laptop was turned on with the videos cued to play, the hand placement mat set in front of the laptop, and the participant self-monitoring checklist with dry erase marker set to the side.

Training videos. Each intervention session began with two training videos with VP. The participant was instructed to place their hands on the hand placement mat, and then given the prompt, “Today we are going to solve some video problems. The first thing we are going to do is watch two movies where you practice problem solving with me. Listen and pay close attention.” The participant was trained to press the play button on the laptop, view, and interact with the video simulated real-world mathematical problems with embedded video prompts.

Participants watched a video problem in entirety first showing all components of the *change* problem, and the second viewing explicitly taught them how to solve the video problem with VP. The six steps of the task analysis were demonstrated step-by-step using a video model with narration, and then the participant was given the opportunity to perform each step immediately. The six steps for solving included the following: (a) listen for and identify the initial set, (b) create the initial set using finger counting, (c) identify the change action and change amount (e.g., “Were they adding to or taking away AND how many?”), (d) perform the change action and change amount on their fingers, (e) solve by counting the total or remaining fingers, and (f) state the answer and the label (e.g., “3 dog treats”). Finger counting was modeled with a pop-up feature of Camtasia® where it superimposed a video of hands on a hand placement mat, shot from first-person perspective, modeling the finger solving strategy synchronized with the progression of the problem. Following each video prompted step, if the participant did not respond to the embedded cue (e.g., “Now it’s your turn”), the experimenter stopped the video and provided least intrusive prompting until the participant generated the correct response. To encourage independence, excited praise was given for immediately imitating the observed behavior without experimenter help. This procedure was repeated with the second training video. Training videos lasted approximately 3 to 4 min each. No data were collected during the training videos. Following the completion of each training video problem, participants were taught to check off the training video problems on the self-monitoring checklist.

Video problems. Immediately following the two training videos, the participants completed four video problems. Video-simulation problems used no explicit commentary or embedded prompts (see Table 1 for sample) and lasted approximately 20 to 30 s. The experimenter secured the participant’s attention, ensured hands were placed on the mat, and then delivered the cue, “Now it’s your turn to try some problems on your own. Watch this video and solve the problem. Do your best!" Data were recorded by the experimenter on each step of the six-step task analysis across all four problems for a total of 24 steps. Excited praise was delivered for an independent correctly solved video problem. If the participant made an error or responded with an incorrect answer, the experimenter cued the video problem to replay and said, "We are going to try this problem again, and this time I am going to help you." Then, the experimenter delivered least intrusive prompting until the participant elicited a correct response for each step (e.g., Level 1: scripted, specific verbal prompt; Level 2: model prompt; Level 3: physical prompt to help manipulate the fingers correctly). The participant was not scored on the second, prompted attempt as this was considered error correction. This procedure was repeated for the three remaining video problems. After completing each video problem, the participant was taught to check off the self-monitoring checklist, which served as both a source of motivation and a schedule for how much work needed to be done.

Maintenance. Maintenance probes consisted of four video problems (two additions and two subtractions) presented in random order. No training videos with VP, experimenter feedback, or error correction were provided to replicate the baseline conditions. Intermittent nonspecific praise was provided only as needed for motivation to continue participation (e.g., "You are working hard! Keep going!"). Maintenance probes were given approximately once per week for the duration of the study until the school year ended for the first two participants.

Interobserver Reliability and Procedural Fidelity

Interobserver reliability was collected and scored by the experimenter not conducting the session, using both in vivo and video recordings, across 52% of all sessions, across all participants, and all conditions. Interobserver reliability was calculated using the item-by-item method by dividing the number of agreements by the total number of agreements plus disagreements, and then multiplied by 100, and averaged 98.9% agreement (range = 95.2%–100%) across all participants and conditions.

A detailed procedural fidelity checklist was created to ensure both experimenters were delivering the intervention with replicable precision. The project coordinator for the grant observed each experimenter implement the intervention with one another, and they had to achieve 100% fidelity prior to implementing with participants in the study. Each of the experimenters collected procedural fidelity in vivo when possible, and viewed video recordings of the other experimenters' sessions when only one experimenter was able to deliver the intervention. Fidelity was collected across 52% of the baseline, intervention, and generalization sessions. Procedural fidelity was calculated by dividing the number of steps implemented correctly by the experimenter by the total number of possible steps and multiplied by 100, averaging 98.4% across all participants and conditions (range = 94.6%–100%).

Results

The visual analysis of the effect of the intervention on students' mathematical problem-solving skills is presented in Figure 1. Results for the number of independent correct steps on the 24-step mathematical word problem-solving task analysis for all three participants, Brad, Heather, and Benito, can be seen in the figure.

Brad

Brad's responses during the baseline condition were slightly variable, and he was brought into the intervention condition when he demonstrated a descending trend to ensure learning was not occurring during baseline. Brad received six baseline probes (M = 10.5; range = 7–13). Brad demonstrated an increasing trend from baseline to intervention. Mastery criterion for all phases in intervention was set at three out of four problems correct for two consecutive sessions. For a problem to be counted correct, the participant had to state both the numeral and label of what they were solving. In Phase I (addition), Brad took 13 sessions to reach mastery (M = 18.8; range = 14–22). Brad was absent during Sessions 14 to 19, and was brought into Phase II (subtraction) in Session 20, taking seven sessions to reach mastery (M = 20; range 16–22). He then moved into Phase III (mixed addition and subtraction), where he quickly met mastery in four sessions (M = 22; range 19–24). Brad received five maintenance probes (M = 23.25; range = 21–24) and correctly answered 19 of 20 possible video problems (95% accuracy).

Heather

Heather's responses during the baseline condition were stable with very little variability (nine sessions, M = 4.75; range = 4–6). Heather demonstrated an immediate jump in level and an increasing trend from baseline to intervention. Heather met mastery across all phases, Phase I (addition) in 20 sessions (M = 15.65; range = 10–24), Phase II (subtraction) in six sessions (M = 18.5; range = 15–22), and quickly in Phase III (mixed addition and subtraction) in four sessions (M = 19.75; range = 17–24). Heather received three maintenance probes (M = 22.7; range = 20–24) and correctly answered 11 of 12 possible video problems (92% accuracy).

Benito

The third participant (Benito) received 11 baseline probes (M = 3.1; range = 0–6) and his responses during baseline were relatively low and stable. Benito demonstrated an

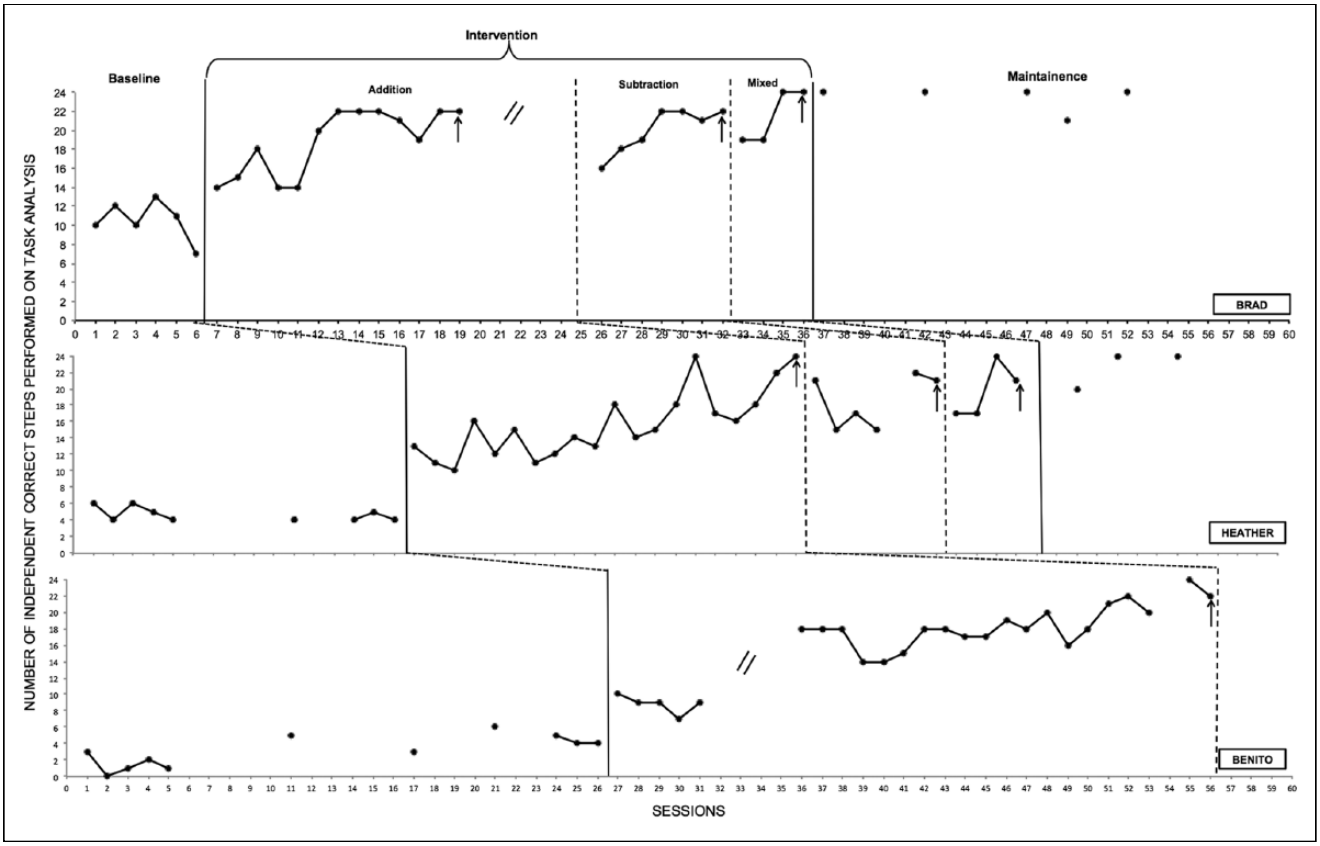

Figure 1. Number of independent correct steps of task analysis on video problems across three participants for baseline; intervention including addition, subtraction, and mixed addition and subtraction phases; and maintenance.

Note. Four problems were administered with six steps each for a total of 24 possible steps. Arrows indicate the sessions at which mastery was met within each phase. The track marks indicate prolonged participant absences for Brad and Benito.

immediate jump in level upon entering intervention and showed a steady, increasing trend ($M = 16.5$; range = 7–24). Benito was absent for five sessions, but had an immediate jump from 9 to 18 correct steps during this phase when he returned. Benito showed slow growth but was able to meet mastery of Phase I (addition) in 25 sessions. During this phase, Benito correctly solved a total of 51 of the 100 possible problems, but was unable to verbalize/indicate the label with the numerical answer (the final step of the task analysis) resulting in a lower score and inability to meet mastery criterion until the last two sessions. His performance in Phase II to Phase III was indeterminable as the school year ended and researchers were no longer able to collect data.

Visual analysis of the data show a functional relation between VP in combination with systematic prompting and error correction procedures and participants' independent correct responses on the task analysis steps. The number of correct independent responses on steps of the task analysis for all three participants showed an ascending trend across sessions and a clear increase in response level with no overlapping data between baseline and intervention sessions.

Social Validity

A teacher survey to assess the social acceptability of the goals, procedures, and outcomes was given to the special education teacher and paraprofessional, consisted of eight yes or no questions regarding whether the intervention was well received by the participants, whether it was beneficial to or enhanced their overall mathematical skills, whether it could be used with other participants or problem types, whether it generalized to other contexts, and a section for written comments or suggestions for improvement. Both the teacher and paraprofessional indicated "yes" to all eight questions, and the teacher included in the comments that if she were provided with the videos, it would be very time and cost-effective for her to implement. The participant survey consisted of five yes or no questions with two written response questions. All participants indicated the video problems were fun to use, they liked solving math problems on the computer, the problems helped them to learn to solve more math problems on their own, they could use what they knew to now solve everyday math on their own, and that they would like to learn more math problems using videos on the computer. Two participants indicated the model videos took too long and became boring after they "got it." One participant reported liking the pet store videos most and the sporting good videos least.

Discussion

This study investigated the effects of using VP with systematic prompting and error correction procedures to teach mathematical problem solving of real-world video-simulation problems to individuals with moderate ID. Results indicated a functional relation between the use of VP with systematic prompting and error correction procedures and students' mathematical problem-solving skills. There were three demonstrations of effect for the addition problem type, but only two demonstrations of effect were observed for the subtraction and mixed addition and subtraction phases due to time constraints of the school year ending. Participants were able to solve the video problems using the finger counting strategy taught through first-person perspective VM during VP.

Mathematical problem solving and increased competence in mathematics likely leads to better outcomes for individuals with ID by increasing access to general curriculum content, giving students exposure to a variety of real-world mathematical problems, and building opportunities for future mathematical success (Browder et al., 2012; NCTM, 2000). Explicitly teaching mathematical problem solving in a systematic manner through the use of VBI and video simulations was successful at improving students' problem-solving skills. The field of teaching mathematical problem solving to students with moderate ID is emerging (e.g., Root, Browder, Saunders, & Lo, 2017; Saunders, 2014), but the knowledge that this population can learn mathematics when taught with high quality instruction is well documented (Browder et al., 2008; Spooner et al., 2017).

Findings expand the literature on VBI, specifically using VP to teach chained academic tasks to students with moderate ID (Banda et al., 2011). This study in conjunction with the Burton et al. (2013), Kellems et al. (2016), and Weng and Bouck (2014) studies indicate that students with ID can use VBI to meaningfully participate in grade-appropriate mathematical experiences. This study found the intervention package could be used to teach solving video-simulation mathematical problems students may encounter in their everyday lives. The use of simulated, real-world mathematical problems is a feasible option that builds generality by replicating natural settings and situations outside of classroom environments and provides multiple exemplars to practice in a controlled environment without competing factors encountered during community-based trips, such as noise, time, limited trials, and added social interaction pressures (Ayres et al., 2009; Cihak et al., 2006; Mechling, 2005).

This study was likely successful because it incorporated EBPs for teaching mathematics to students with moderate ID (Browder et al., 2008). First, the basis for VP is task analytic instruction. The chained task of solving a real-world video-simulation problem was broken down into six steps and presented in small segments using VM with narrated explicit commentary followed by an opportunity for the student to immediately practice each step in a progressive format so the student could successfully complete the entire chained task (VP). To ensure the student performed each step of the chained task correctly, systematic instruction, specifically least intrusive prompting with scripted error correction and feedback, was embedded in each step of the response chain. Finally, repeated opportunities for practice were used with a variety of themes, problems, addends, and sums for better generality. The study also incorporated self-monitoring in the form of a checklist of problems completed so students could monitor their progress. One added benefit for using VBI to teach problem solving is alleviating the challenges that written word problems present, such as decoding. Students were able to visually see what was occurring in the problem, as well as hear it narrated, and they were provided with the opportunity to replay the problem if needed.

Implications for Practice

There are several implications for practice from this study. First, video problems can be developed with relative ease and are cost-effective (Mechling & O'Brien, 2010). Although more front-end time is needed to build the training videos using computer software, the video problems or segments can be recorded with a smartphone, tablet, or portable video camera. Second, laptops are widely available and are versatile (e.g., equipped with video editing software, text-to-speech options, video viewing software). In a review of 21st-century devices, Mechling and Bishop (2011) found that digital mediums with flexible formats can easily be altered to meet the individual needs across students and can increase the accessibility for all students. Third, simulated instruction alleviated the constraints associated with community-based learning (e.g., diminishing budget constraints, transportation, time away from school, scheduling, staffing requirements; Mechling et al., 2003). Although simulated instruction is a feasible and cost-effective option for teaching real-world problem solving, ideally it should be paired with in vivo opportunities for practice for better generalizability but that was not possible in the current study (Ayres et al., 2009; Cihak et al., 2006). Teachers may be able to provide video-simulation problems to students by preteaching problems prior to community-based outings. Finally, the variety of themed videos (e.g., chores at home, pet store, grocery store, outside chores, thrift store) may be helpful in exposing students to important home and community-based mathematical problems they may encounter in real life in an engaging and motivating way.

Limitations and Future Research

As with any research study, there are limitations to the investigation. First and foremost, the setting in which the study was conducted is a restriction. Although continued progress on including students with severe disabilities is improving, recent reports (e.g., Kleinert et al., 2015; Smith, 2007) indicate that a vast majority of these students (e.g., more than 90%) continue to receive their education in separate settings (self-contained classroom, separate school). Even though evidence suggests positive outcomes for inclusive placements for this population (Feldman, Carter, Asmus, & Brock, 2015; Morningstar et al., 2016; Ruppar, Allcock, & Gonsier-Gerdin, 2017), the reality in many sections of the country leaves much to be desired. In the geographic location where the investigation was conducted, unfortunately, separate settings are more the norm than the exception.

Second, during the addition and subtraction phases, only problems of the targeted problem type were administered. Although this was intentional to prevent confusion and alleviate cognitive demands as found by Saunders (2014), it weakens the internal validity of the study. From a practitioner standpoint and for future consideration when replicating, if students had been given mixed problems during the addition phase, they would have learned to solve all problems using addition by default, and then the behavior would have to be unlearned during subtraction (Saunders). Third, the school year ended before the final participant, Benito, could complete all phases, thus limiting the replication of effects for subtraction and mixed phases. Finally, due to liability and cost, the researchers were not permitted to measure whether participants could generalize their problem-solving skills to community settings.

Future research can focus on using the limitations cited in this study to extend what we know and need to learn about teaching mathematical problem-solving skills to students with moderate ID and other disabilities. There is a need to replicate the findings from this study, adding more investigations, a dispersed group of investigators, and more participants to build an evidence base. In addition, investigators should examine the effects of implementing this intervention with students in their natural classroom setting, by their special education teachers, or in more inclusive settings. Inclusive general education settings provide a place to work on grade-aligned skills, such as mathematical problem solving, with a context expert (e.g., mathematics teacher). One method for practicing generalizing to real-world simulation problems in inclusive settings would be to embed trials during naturally occurring opportunities. Given the need for repeated opportunities for practice for this population, researchers have suggested targeting at least five trials per lesson (Jimenez, Browder, Spooner, & DiBiase, 2012). Although the suggested number of trials may be too cumbersome for a general education teacher or special education teacher to implement, researchers have found that peers can embed the trials using systematic instruction with high levels of fidelity in inclusive academic settings, and this leaves much potential for replication of this study in inclusive settings (Hudson, Browder, & Jimenez, 2014; Jimenez et al., 2012; Miracle, Collins, Schuster, & Grisham-Brown, 2001). Future research should expand to other problem types, such as *group* (i.e., part-part-whole) and *comparative* problem types (Jitendra, 2008). Finally, although measures were in place to train for generality (programming common stimuli and multiple exemplar training), future research should directly measure generalization to community settings, as an inability to generalize remains one the characteristics of this population (Stokes & Baer, 1977). After all, the ability to generalize real-world mathematical problem-solving skills may open many doors and lead to more opportunities in the future for individuals with moderate ID.

Authors' Note

The opinions expressed do not necessarily reflect the position or policy of the Department of Education, and no official endorsement should be inferred.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Support for this research was provided in part by of the U.S. Department of Education, Institute of Education Sciences award R324A130001, The Solutions Project.

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