USING POINT-OF-VIEW VIDEO PROMPTING TO TEACH ALGEBRAIC EQUATIONS TO HIGH SCHOOL STUDENTS WITH DISABILITIES

by

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(Under the Direction of Thomas Clees)

ABSTRACT

The present study evaluated the effectiveness of point-of-view video prompting delivered via an iPad in teaching four participants with disabilities to solve algebraic equations that required use of the distributive property. Participants were taught to independently use the video software on an iPad that presented steps of the targeted skill. A multiple probe across participants design was used to evaluate the effects of the intervention on the percent of equations solved correctly and the percent of steps completed correctly. All participants learned to accurately solve the targeted algebraic equations following the introduction of intervention. In addition, participants' skills generalized to a similar yet untaught equation type. Participants' skills maintained at varying levels following treatment. Implications and limitations are discussed.

INDEX WORDS: Video modeling, Video prompting, Point-of-view, Video-based instruction, Video-based teaching, Video-based intervention, Video instruction, Video tutorial, High-incidence disabilities, Math instruction, Algebra, Equations, Technology, iPad, Secondary students, High school, Total-task chaining, Task analysis, Imitation

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A Dissertation Submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

ATHENS, GEORGIA

2015

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May 2015

DEDICATION

For Ashley.

ACKNOWLEDGEMENTS

Thank you to Dr. Thomas Clees for being my academic advisor, guiding me through the landscape of higher education, and collaborating with me as a researcher and author. Your thorough knowledge of the field and gregarious approach to collaboration and pedagogy are truly an inspiration.

Thank you to Dr. Cynthia Vail, Dr. Kristin Sayeski, and Dr. Kevin Ayres for providing feedback on my dissertation. Thank you to all the faculty and fellow doctoral students that have assisted me throughout this process. Finally, thank you to the participants of my dissertation study and all the practitioners involved at the research site.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

According to federal regulations, students are deemed eligible to receive special education services if they have a disability that adversely affects academic and/or functional performance (IDEA, 2004). Based on the various academic, functional, and social needs of the heterogeneous population of students with disabilities, it is essential that educational practitioners utilize interventions that are both empirically validated and capable of individualization. One such intervention is practitioner-created video-based instruction (VBI) (Cannella-Malone & Tullis, 2010; Mechling, 2005; Rayner, Denhold, Sigafoos, 2009).

Overview of Video-Based Instruction

For the purpose of this paper, VBI will be used as an umbrella term referring to any form of instruction that requires a learner to view a model, or the perspective of a model, engaging in a correct demonstration of a targeted behavior, or sequence of behaviors, via video format (Hitchcock, Prater, & Dowrick, 2004). The purpose of this paper is to examine flexible instructional methods based on the individualized needs of learners with disabilities; therefore, the term VBI as used herein will refer only to practitioner-created (i.e., not commercially produced) video interventions (Mechling, 2005). VBI can refer to the following subsets: video modeling other, video self-modeling, point-of-view video modeling, or video prompting (Hitchcock et al., 2004; Rayner et al., 2009). Video-based instruction is a flexible and cost-efficient intervention and has been shown to facilitate therapeutic changes across a variety of dependent variables, as exemplified by compliance (Axelrod, Bellini, & Markoff, 2014), word recognition and pronunciation (Morlock, Reynolds, Fisher, & Comer, 2015), cleaning/self-help skills (Nikopoulos, Canavan, & Nikopoulou-Smyrni, 2008), cooking skills (Graves, Collins, Schuster, & Kleinert, 2005), conversation skills (Sherer et al., 2001), and social skills (Simpson, Langone, & Ayres, 2004). Video-based instruction is partially rooted in *social learning theory*, which posits that people learn through observation (Bandura, 1977). Advantages of VBI interventions include: Modeling targeted skills in relevant environments (e.g., classrooms, cafeteria, playground); implementing multiple stimulus and response exemplars; increasing salience of stimuli; and facilitating independence of the learner (Baker, Lang, O'Reilly, 2009; Wilson, 2013).

The overall effectiveness of VBI may vary across individuals, but video instruction can be superior to *in vivo* instruction for some learners (Axelrod et al., 2014; Morlock et al., 2015). Video footage does not change, which allows the learner to observe a consistently accurate model of the targeted behavior frequently. Some students may find the social interactions typical of traditional methods of instruction (e.g., group work) aversive; therefore, productivity and progress towards individualized goals may be negatively affected (Delano, 2007; Morlock et al., 2015). Video based instruction provides students with an alternative form of instruction that can alleviate aversive situations and promote independence (i.e., intervention is not mediated by adults or peers). Goodwyn, Hatton, Vannest, and Ganz (2013) documented that VBI is well suited to work with reluctant learners. The researchers hypothesized that reluctant learners' positive response to VBI could be because the mode of instructional presentation (e.g., computers or tablets) may be associated with recreation. The authors surmised that pairing recreational stimuli with instruction could increase reluctant learners' compliance to task requests. Further, learners probably lack a learning history or aversive association with VBI, which may make the activity more approachable.

Categories of Video-Based Instruction

Video Modeling Other. *Videos Modeling Other* (VMO) interventions involve a learner watching the entire occurrence of a behavior, or sequence of behaviors, from a third person perspective. That is, footage in VMO interventions involves peers and/or adults (i.e., anyone other than the learner) engaging in an accurate demonstration of the targeted behavior(s). Bandura (1977) proposed that practitioners use models that resemble the observer (i.e., the targeted learner). However, research on the importance of *model-observer-similarity* is mixed (Bandura & Kuper; 1964; Barry & Overman; Schunk & Hanson, 1985; Weeks et al., 2005). That is, some researchers have compared the efficacy of using "self" models and "other" models and documented that students learned equally as well regardless of the model type (Sherer et al., 2001; McKoy & Hermansen, 2007). VMO interventions have been effective in facilitating positive changes across a variety of dependent variables for learners with disabilities such as vocalization and communication skills (Charlop & Walsh, 1986; Charlop & Milstein, 1989), social and play skills (D'Ateno et al., 2003; Taylor et al., 1999; Wert & Neisworth, 2003), perspective-taking skills (Charlop-Christy & Daneshvar, 2002; LeBlanc et al., 2003), and adaptive behavior (Shipley-Benamou et al. 2002). VMO interventions have been utilized with a variety of learners such as students with autism (ASD) (Charlop & Milstein, 1989), students with social skills deficits (Dorwick & Jesdale, 1991), and students with language disorders (Irwin, 1981).

Video Self-Modeling. Similar to VMO, *Video Self-Modeling* (VSM) interventions involve a learner watching the entire demonstration of a behavior, or sequence of behaviors, from a third person perspective; however, VSM interventions present a third person perspective of the learner modeling a target behavior (Buggey, 2005; Buggey & Ogle, 2013; Dowrick, 2000; Hitchcock et al., 2003; Collier-Meek et al., 2012). Video self-modeling utilizes footage of previously successful examples of a target behavior in order to potentially increase future occurrences of that behavior (Buggey, 2005; Bellini & McConnell, 2010; Collier-Meek, 2012). Video self-modeling has been used across a variety of dependent variables such as: language training (Hepting & Goldstein, 1996), solving fractions problems (Schunk & Hanson, 1989), and on-task behaviors (Walker & Clement, 1992). Video self-modeling has been used with students of various ages (Clare, Jenson, Kehle, & Bray, 2000; Rickards-Schlichting, Kehle, & Bray, 2004) and disability types such as selective mutism (Kehle, Madaus, Baratta, & Bray,1998), ASD (Bellini, Akullian, & Hopf, 2007), emotional/behavioral disorders (EBD) (Baker et al., 2009; Goodwyn et al., 2013), and Tourette's syndrome (Clarke, Bray, Kehle, & Truscott, 2001).

Two classes of VSM have been outlined in the literature: *positive self-review and feed-forward*. Positive self-review (Dowrick, 2000; Hitchcock et al., 2003) involves editing extensive footage of video so that the video depicts the participant enaging only in accurate occurrences of a target behavior. Another form of positive self-review involves recording an adult prompting a student to engage in a target behavior, and then editing the adult's prompts from the footage so that only the student demonstrating the behaviors is portrayed in the video model. Feed-forward VSM is nearly identical to positive self-review. However, feed-forward involves editing a video so that footage of a learner engaging in the appropriate behavior in a separate environment is embedded within footage of the learner in a target environment such as a classroom (Collier-Meek, 2012). Essentially, feed-forward would be typically used when the learner engages in the appropriate behavior in one setting, but not in the target setting. Kehle et al. (1998) implemented a feed-forward VSM intervention in which video segments of a student with selective mutism speaking with a parent at home were embedded within footage of the student in the classroom setting.

Essentially, positive self-review focuses on optimal occurrences or approximations of an existing behavior, whereas feed-forward models an appropriate occurrence of a skill that has not yet been demonstrated in a particular setting (Dowrick, 2000). Positive self-review is more challenging to produce than feed-forward due to the considerable amount of time required to collect extensive footage and edit the video model (Buggey, 2005; Dowrick, 2000).

Point-of-View Video Modeling. *In Point-of-View Video Modeling* (POV) interventions the learner is given a first-person perspective of an entire behavior, or sequence of behaviors, being completed. POV interventions require no model (peer, adult, or self) to be depicted in the video footage (Le Grice & Blampied, 1994; Schreibman, Whalen, & Stahmer, 2000), although body parts such as hands are often included to show topographical responses associated with the stimuli (e.g., pressing a button). POV interventions are cost- and time-efficient, easily individualized, reduce extraneous stimuli, and are particularly effective for teaching behaviors that include fine motor skills (Hine & Wolery, 2006; Mason, Davis, Boles, & Goodwyn, 2013; Shipley-Benamou et al. 2002; Shrestha, Anderson, & Moore, 2012). POV has been used to teach play and social skills (Hine & Wolery, 2006; Tetreault & Lerman, 2010), letter printing (Ayala & Connor, 2013; Hitchcock et al., 2004), independent living and recreational skills (Alberto, Cihak, & Gama, 2005; Hammond, Whatley, Ayres, & Gast, 2010; Le Grice & Blampied, 1994), and to decrease aberrant behavior (Cihak, 2011; Cihak, Fahrenkrog, Ayres, & Smith, 2010; Schreibman et al., 2000). The majority of published POV research has included secondary- and post-secondary age participants with ASD, developmental disorders, intellectual disability (ID), Tourette's syndrome, or Down syndrome (Mason et al., 2013).

Video Prompting. In contrast to video modeling (i.e., a model demonstrating all steps in a behavior), video prompting (VP) involves breaking a complex (i.e., multi-step) behavior into individual steps and recording each step with incorporated pauses during which the learner may attempt the step before viewing subsequent steps (Ciha, Alberto, Taber-Doughty, & Gama, 2006). During a pause, the learner attempts an individual step before proceeding to the subsequent step in the chain. Video prompting may be done with either the learner or someone else acting as a model. When teaching students to complete longer behavior chains, embedding video prompting (VP) procedures within VBI interventions has been examined (Cannella-Malone et al., 2006; Graves et al., 2005; Shresta, Anderson, & Moore, 2013). For example, VP has been demonstrated to be effective for teaching functional skills such as putting away groceries (Cannella-Malone et al., 2006), teaching food preparation (Graves et al., 2005; Sigafoos, O'Reilly, and

Cannella, 2005), and washing dishes (Sigafoos et al., 2007). However, such prompting methods may also result in prompt dependency (i.e., increased performance may deteriorate when VBI is withdrawn); therefore, practitioners may need to *chunk* videos (i.e., combine longer chains of the requisite steps of the skill) in order to fade the intervention and increase independence (Shresta, Anderson, & Moore, 2012; Sigafoos et al., 2007). Essentially, *chunking* involves combining separate video segments in order to create a larger video clip, then systematically fading the individual segments over time. For example, Sigafoos et al. (2006) taught three participants with disabilities to wash dishes using VM, but the skill deteriorated for all participants when the videos were withdrawn. The researcher used the chunking procedures described above. Video footage of steps in the TA was gradually faded until the participants were able to demonstrate the skill independently. To further individualize VBI interventions, auditory cues can be included which provide a description of the target behavior and/or direct the learner to attend to the task (Shipley-Benamou et al., 2002).

Considerations for Use of Video-Based Instruction

Maintenance and Generalization. Researchers have documented that skills acquired from VBI interventions can be maintained and generalized across settings, materials, and people using specific procedures (Bellini & Akullian, 2007; Charlop & Milstein, 1989; Delano, 2007; Nikopoulos & Keenan, 2004; Nikopoulos & Keenan, 2007; Rayner et al., 2009; Wilson, 2013). Initial acquisition of target skills can be promoted and maintained by using settings and materials in the video that are familiar to the student (Bellini et al., 2007). Practitioners can promote generalization by utilizing video footage from a variety of familiar settings (e.g., playground, cafeteria, classroom) and with a variety of materials and interaction partners (Mechling, 2005). Wilson (2013) cautioned that not all skills are appropriate targets for VBI interventions. Target behaviors should be concrete skills that can be clearly modeled and easily observed. For example, reading comprehension or inference skills are not appropriate targets for video modeling unless they can be linked to observable, correlated behaviors (Wilson, 2013). Wilson (2013) also documented that VBI instruction may not be appropriate for all learners.

Prerequisite Skills. Historically, VBI has been most effective if the targeted learners possess the following prerequisite skills: visual attention (i.e., ability to attend to a video for at least 1 min), basic motor and verbal imitation, visual and hearing acuity within normal or corrected normal limits, visual information processing, and comprehension level appropriate for length and complexity of video (Delano, 2007; Rayner et al., 2009; Shukla-Mehta et al., 2010). These skills have been linked to success with video modeling and therefore are suggested criteria for determining appropriateness of VBI interventions for individual learners.

Characteristics of Models. Research indicates that there is no consistent advantage in using VMO versus VSM (Bellini & Akullian, 2007; Mason, Ganz, Parker, Burke, & Camargo, 2012); questions still remain regarding which model type is best suited for a specific learner or targeted skill. Practitioners should consider the target learner's individual traits (e.g., age), personal preferences, and the nature of the target skill (Wilson, 2013) when choosing a variation of VM. For example, if the target student is a primary-age student with a disability, it may be an inefficient use of time to train a peer model for the video; therefore, VMO with an adult model may be the better option

(Bellini & Akullian, 2007). Some studies have compared using adult models to peer models and found no significant difference in participant results based on model type (Cihak & Schrader, 2008; Nikopoulos & Keenan, 2003; Maione & Mirenda, 2006). Though the data on model-observer-similarity is mixed, practitioners should be aware that some learners might demonstrate specific preferences and/or aversions to particular peer or adult models. For example, if the learner does not attend to the model, yet has demonstrated the ability to sustain attention, or appears to have an aversion to the person in the video, practitioners should consider changing the model to a preferred peer, sibling, or adult (Wilson, 2013). For highly-distractible students or dependent variables that involve fine motor manipulations, practitioners might consider using POV (Mason, 2013).

Auditory and Visual Components. Research has also yielded information on the inclusion of auditory components (e.g., narration, verbal prompts) in VBI (Bennett, Gutierrez, & Honsberger, 2013; Smith, Ayres, Mechling, & Smith, 2013). The inclusion of prompting and/or instruction in VBI interventions may yield positive effects on target behaviors; however, it may be overwhelming or difficult for some learners to learn new information from a video that involves both visual and auditory stimuli (Mason et al., 2013). The amount of information presented should be minimized for these learners by muting the video or incorporating behaviors that do not require an auditory accompaniment such as gestures or nonverbal play sequences (Wilson, 2013). If a targeted learner continues to demonstrate difficulty processing the information presented, the video may be shortened or recorded at a slower pace of movement (Charlop & Milstein, 1989; Charlop-Christy et al., 2000).

Setting. The setting of the VBI recording should be the environment in which the student is expected to demonstrate the targeted behavior (Wilson, 2013). For example, if the goal of the intervention is to teach the learner to engage in turn-taking during play activities, then the video model should be recorded on the playground or in the location which play activities will occur. Incorporating natural settings in VBI interventions has been demonstrated as an effective strategy for skill acquisition, as well as increasing maintenance and generalization (Bellini, Peters, Benner, & Hopf, 2007). Moreover, the video footage should include naturally occurring stimuli such as materials that the student is familiar with.

In sum, the empirical literature base has provided extensive information regarding best practices and the overall utility of VM. Despite the results provided by previous studies, some questions regarding VBI remain and should be examined by future research. For example, future researchers should investigate the effectiveness of each variation of VBI across diverse populations of students with disabilities (e.g., age, disability category). Additionally, future research should target the effectiveness of using VBI for teaching academic skills to learners with disabilities. Empirical studies have repeatedly demonstrated the utility of VBI for increasing social and functional skills; therefore, it seems intuitive that the attributes of VBI that make the intervention so successful would generate similar results when applied to academic variables.

CHAPTER 2

LITERATURE REVIEW

In preparation of the study, a literature review was conducted to identify single-case design studies that used VBI interventions to target academic dependent variables.

Search Method

To identify relevant studies, a computer-based search was implemented via the search engine Galileo, using the “all providers” option for databases. The search terms *video, instruction,* and *disabilit** were used. Inclusionary criteria included: (1) the study was written in English, (2) the study was a data-based publication from a peer-reviewed journal, (3) the study identified an academic task (i.e., reading, writing, language arts, math, science, or history) as an isolated dependent variable, (4) the study identified participants in the study as having a disability or demonstrating significant low-achievement in an academic area, and (5) the study utilized a single-case research design. No stipulation was made on the year of publication. An initial search yielded 1989 studies, and a total of 15 were selected based on a review of each study’s abstract. Upon further inspection of the identified 15 studies, a total of 9 studies met the inclusionary criteria. After identifying the initial 9 publications, an ancestral search of each study’s references was conducted in order to locate related articles. This method yielded an additional 2 studies for a total of 11.

Synthesis of Studies

Participants. The 11 studies included a total of 48 participants who ranged in age from 4 – 18 years. Nine studies included participants with disabilities including: learning disability (LD) (n = 11), developmental delay (n = 1), ASD (n = 9), ID (n = 4), or comorbid diagnoses (n = 1). Three studies included participants identified as low-achieving (n = 21). Eight studies included participants that were elementary-age students (4 – 12 years), and only three studies included participants with secondary-age students (13 – 21). Table 1 provides information on age and disability category for all included participants.

Independent variables. The following VBI interventions and comparisons were examined in the reviewed studies: VMO alone (n = 1), VSM alone (n = 3), VMO compared to VSM (n = 2), VSM combined with tutoring compared to tutoring alone (n = 2), VSM combined with self-regulated strategy development (n = 1), VSM combined with a constant time delay procedure (n = 1), and POV combined with backward chaining, a reinforcement menu, and a token economy (n = 1). Table 1 provides information on independent variables for all included studies.

Dependent Variables. Academic skills targeted included reading fluency and comprehension (n = 1), reading fluency alone (n =2), essay writing (n = 1), identification of novel letters (n = 1), receptive identification of prepositions (n = 1), decoding, sightwords, and nonsense word fluency (n = 1), letter writing (n = 1), mathematics word problems involving money skills (n =1), geometry processes (n = 1), and science conceptual knowledge (n = 1).

Experimental Designs. All of the identified studies were published between the years of 2004 – 2014. A variety of single-case research designs were used including: multiple baseline across behaviors (n = 3), multiple baseline across participants (n = 3), multiple baseline across participants combined with A-B-BC-B (n = 1), multiple baseline across participants combined with multi-element (n = 1), multiple probe across behaviors (n = 2), and ABAB (n = 1). The identified studies measured the effects of VBI interventions in the following academic areas: reading (n = 5), mathematics (n = 2), writing (n = 2), language arts (n = 1), and science (n = 1). Table 1 displays summary information for all studies. Within the table, studies are organized chronologically by publication date for a historical perspective.

Summary of Individual Studies

The following is a summary of the 11 identified studies organized by academic/content area. Within each academic category, studies are organized by publication date.

Reading. Five of the 11 studies indicated that VBI interventions improved participants' reading skills. Four of the studies used VBI to enhance oral reading fluency (Ayala & Connor, 2013; Decker & Buggey, 2013; Dowrick et al., 2006; Hitchcock et al., 2004), one study used VBI to teach reading comprehension in addition to fluency (Hitchcock et al., 2004) and one study used VBI to teach novel letters (Marcus & Wilder, 2009).

Hitchcock et al. (2004) examined the effectiveness of VSM combined with tutoring on teaching reading fluency and comprehension to four participants (ages 6 – 7 years). Two of the participants were diagnosed with LD, one with a Developmental

Delay, and one was low-achieving in reading (this participant was referred for special education services during the course of the study). A multiple baseline design across behaviors (fluency and comprehension) was used. The design included six phases for each target behavior including: baseline, tutoring only (targeting fluency), tutoring combined with VSM (fluency), tutoring only (targeting comprehension), tutoring combined with VSM (comprehension), and a follow-up/maintenance phase for both behaviors. Participants received intervention daily for 30 min during each phase in a pull-out classroom. Two 2-min videos were created for each participant, one depicting the student reading a 100-word instructional-level passage with adult support, and one depicting the student accurately using a story map for comprehension with adult support. During tutoring combined with VSM conditions, the participant and tutor would view the corresponding video (fluency or comprehension) prior to the tutoring session which involved reading the passage used in the video. The authors reported that reading fluency, which was measured in correct words read per min (CWPM), doubled for three of the participants and quadrupled for the fourth by the end of eight weeks. The authors also indicated that reading comprehension, measured in number of correct responses, reached pre-established mastery criteria for all participants. Finally, the authors reported that follow-up data collected 1 and 6 months later indicated that both reading fluency and comprehension skills were maintained and generalized to the general education classroom.

Dowrick et al. (2006) investigated the effects of VSM and tutoring on the reading fluency of 10 students (ages 6 – 7 years) identified as Low-Achieving (LA) in reading. A multiple baseline across participants with a combined A-B-BC-B (baseline, tutoring only, tutoring combined with VSM, tutoring only) design was used. During the tutoring phases of treatment, participants received individualized instruction from trained adults for approximately 25 min a day, four days a week. Tutoring sessions involved unison reading, echo reading, and sightword drill and practice. During tutoring combined with VSM treatment phases, students were shown feed-forward videos of themselves accurately reading difficult (instructional level) text and correctly identifying sightwords prior to daily tutoring sessions. The aforementioned footage was obtained from echo reading conducted during previous tutoring sessions in which the participant would imitate the tutor's reading. The footage was then edited so that only the accurate reading of the participant was depicted on the video. The authors reported that all participants' CWPM improved during treatment conditions indicating that VSM and tutoring were both effective reading fluency interventions; however, the daily rate of fluency gains was greatest during the VSM combined with tutoring condition as indicated by a greater slope in CWPM.

Marcus and Wilder (2009) examined the effects of VSM compared to VMO on teaching novel letters to 3 participants (ages 4 – 9 years) with ASD. A multiple baseline across participants design was combined with a multi-element design to compare participants' letter-identification performance in the VMO and VSM conditions. Intervention occurred at home for two of the participants and in a separate room at a preschool for one participant. The participants primary language was English, but to control for individual learning histories and incidental learning during the study, participants were taught Greek and Arabic letters. Researchers created two videos for each participant. The first video depicted a typically-developing peer providing an accurate letter-identification response following a teacher prompt (VMO). The other video created by editing out footage of the teacher providing support, showed the participant providing a correct letter-identification response following a teacher prompt (VSM). For both the VMO and VSM sessions, a total of five trials, with each trial depicting a different letter or series of letters, were depicted on the video. During alternating sessions, participants were shown either the VMO or VSM videos and then asked to identify the same letters depicted in the video. The authors reported that all three participants demonstrated mastery of novel letter-identification during the VSM condition, but only one participant demonstrated mastery during the VMO condition; however, this participant reached mastery faster during the VSM condition. The authors suggested that VSM is potentially the superior intervention for teaching letter-identification to students with autism.

Ayala and Connor (2013) utilized a multiple baseline across participants design to investigate the effects of VSM and adult tutoring on three reading fluency measures (decoding, sightword recognition, and nonsense word decoding) for 10 students (ages 6 – 7 years) who were identified as LA in reading. Intervention occurred for all participants in a one-to-one setting with an adult tutor in a private room. First, researchers created VSM footage by taping sessions in which the tutor prompted students to accurately respond on decoding, sightword, and nonsense word decoding tasks. Next, the footage was edited by removing tutor prompting and modeling so that the video depicted the student “independently” providing accurate responses. Students viewed the videos at least four times per week prior to routine tutoring sessions. The authors reported all participants demonstrated increased rates of accurate decoding, sightword recognition, and nonsense word decoding following the introduction of intervention. A 2-week posttest maintenance assessment showed retention or increases in the targeted skill areas for seven of the 10 participants.

Decker and Buggey (2014) used a multiple baseline across participants design to examine the effects of using VSM compared to VMO on the reading fluency (CWPM) of six students (ages 8 – 12 years) with LD. Data collection occurred during three phases in this study: baseline, intervention, and follow-up/maintenance. Participants were assigned to either a VSM (*n* = 3) or VMO (*n* = 3) group. Researchers created video footage for the VSM group using footage of the students during echo reading tutoring sessions; all prompting and modeling was edited out so that only accurate reading footage of the participant was depicted. During intervention, participants viewed their video once daily in a one-on-one instructional format before a reading probe was administered. During the maintenance condition, VBI intervention was withdrawn, and measures of reading fluency were collected similarly to the previous conditions. The authors reported that CWPM increased for all participants in both conditions proving that both VSM and VMO are potentially effective reading fluency interventions for students with LD; however, two of the participants more than doubled their reading fluency rates during intervention in the VSM group. Follow-up data indicated that all participants maintained increased fluency rates after intervention was withdrawn.

Math. Two of the 11 studies indicated that VBI interventions enhanced participants' mathematics skills. One study used VBI to teach geometry skills (Cihak & Bowlin, 2009), and one study used VBI to teach problem solving skills involving money (Burton et al., 2013).

Cihak and Bowlin (2009) investigated the effectiveness of using VMO (with a teacher model) to teach geometry skills (finding the perimeter of: squares/rectangles, triangles/trapezoids, and polygons) to three students (ages 15 – 18 years) with LD. A multiple probe across behaviors (the three types of geometry perimeter problems) design was used. Intervention occurred daily prior to the beginning of the school day during a tutoring program. Videos were created of the teacher providing verbal step-by-step directions while completing the steps necessary to accurately calculate the perimeter of squares/rectangles, triangles/trapezoids, and various polygons. After the construction of the videos, participants were taught how to operate handheld computers and access the instructional videos. During daily sessions, participants were instructed to watch a specified video of one of the targeted tasks, and then complete a corresponding 10-problem assignment independently. If participants made errors, they were instructed to view the video again and make corrections to the assignment. Once a participant demonstrated mastery in one behavior (e.g., calculating the perimeter of squares/rectangles), the student would move to the next video depicting a different target skill (e.g., calculating the perimeter of triangles/trapezoids). The authors reported that the percentage of accurately completed geometry problems increased to mastery levels almost immediately following the introduction of the intervention for all three participants.

Burton, Anderson, Prater, and Dyches (2013) used a multiple baseline across participants design to investigate the effectiveness of using VSM and a token economy to teach mathematics problem solving skills to 4 participants (ages 13 – 15 years). Three of the 4 participants were diagnosed with ASD, and 1 was diagnosed with ID. All intervention sessions occurred twice daily for four days a week in a partitioned section of the resource room in which the participants typically received instruction. Feedforward VSM videos were created by presenting participants with a script for a seven-step task analysis used for calculating amounts of change when presented with word problems involving money. During video recording sessions, the classroom teacher prompted participants to read the steps and solve the word problem. The teacher provided prompting and modeling to ensure that the participants correctly solved the word problem. Participants were prompted through five word problems involving money, resulting in five individualized videos for each participant. Researchers then edited the videos so that no adult prompting was contained in the footage. Videos depicting the participants reading the task analysis and accurately completing the steps were approximately 3 to 5 min in length.

During intervention, the participants would view one of the VSM videos via an iPad, and then complete the same problem on paper. Students were allowed to view the video as often as necessary in order to solve the word problem. This sequence was used for five word problems. During intervention, the teacher did not provide assistance on the math word problems. The authors reported that the percentage of steps completed accurately increased to near-mastery levels immediately following intervention for each participant. During follow-up sessions, the number of video models used was gradually reduced, yet participants maintained mastery-level responding on the word problems.

Table 1
Description of Studies Targeting Academic Skill Development Using Video-Based Instruction

Reference	*N*	Age	Special Needs	Independent Variable	Dependent Variable	Research Design	Results
Hitchcock, Prater, & Dowrick (2004)	4	6 – 7 years	LD (n =2) DD (n = 1) LA (n = 1)	VSM combined with tutoring versus tutoring only	Reading fluency: CWPM Reading comprehension: number of correct responses	Multiple baseline design across behaviors (fluency, comprehension)	VSM combined with tutoring increased fluency for three participants and increased comp. for all participants
Dowrick, Kim-Rupnow, & Power (2006)	10	6 – 7 years	LA	VSM combined with tutoring versus tutoring only	Reading fluency: CWPM	Multiple baseline across participants combined with an A-B-BC-B design (baseline, tutoring, tutoring + VSM, tutoring)	Reading fluency improved for all students following each intervention; fluency gains were higher during the VSM + tutoring for nine participants
Delano (2007)	3	10 years	Asperger Syndrome	VSM combined with SRSD	Writing: Number of written words and number of functional essay elements (e.g., premise, elaboration, conclusion)	Multiple baseline across behaviors (words written and functional essay elements)	All participants increased the number of words written and number of functional essay elements included on persuasive essays following intervention

Note. LD = Learning Disability; VSM = Video Self-Modeling; VMO = Video Modeling Other; DD = Developmental Delay; LA = Low-Achieving; CWPM = Correct Words Per Min; SRSD = Self-Regulated Strategy Development.

Table 1 continued
Description of Studies Targeting Academic Skill Development Using Video Modeling

Reference	*N*	Age	Special Needs	Independent Variable	Dependent Variable	Research Design	Results
Cihak & Bowlin (2009)	3	15 – 18 years	LD	VMO	Mathematics: Percentage of geometry problems (calculating perimeter of rectangles, triangles/trapezo-ids and polygons) solved correctly	Multiple probe across behaviors (three types of geometry perimeter problems)	Percent of accurate geometry problems completed increased to mastery level after introduction of the intervention for all participants
Marcus & Wilder (2009)	3	4 – 9 years	ASD	VMO compared to VSM	Reading: Identification of novel letters	Combined multiple baseline across participants and multi-element to compare VMO to VSM	All participants demonstrated mastery of identifying novel letters during VSM condition. 1 participant demonstrated mastery during VMO condition
Mechling & Hunnicutt (2011)	3	7 - 8 years	ID	VSM, computer presentation of photographs with prepositional captions, and a constant time delay prompting procedure	Language Arts: Identification of prepositions (i.e., touching a picture correlated to a verbally presented preposition)	Multiple probe design within participants across three pairs of prepositions	All participants mastered the identification of the prepositional pairs following introduction of the intervention package

Note. ASD = Autism Spectrum Disorder; ID = Intellectual Disability; LD = Learning Disability; VSM = Video-Self Modeling; VMO = Video Modeling Other.

Table 1 continued

Description of Studies Targeting Academic Skill Development Using Video Modeling

Reference	*N*	Age	Special Needs	Independent Variable	Dependent Variable	Research Design	Results
Hart & Whalon (2012)	1	16 years	ASD, ID, and OHI (hearing impairment)	VSM	Science: Number of accurate, unprompted academic responses during science lessons (e.g., classification of organisms)	ABAB Reversal Design	The participant increased the number of accurate, unprompted academic responses during VSM intervention
Ayala & Connor (2013)	10	6 - 7 years	LA	VSM	Three reading fluency measures: Decoding, Sightwords, and Nonsense Words (number correct per min for all)	Multiple baseline across participants	All participants demonstrated an increased rate in accurate decoding skills and sight word recognition following intervention
Burton, Anderson, Prater, & Dyches, (2013)	4	13 – 15 years	ASD (*n* = 3) ID (*n* = 1)	VSM	Mathematics: Percentage of steps completed accurately for solving word problems involving money skills	Multiple baseline across participants	The percentage of steps completed accurately increased immediately following intervention for each participant

Note. ASD = Autism Spectrum Disorder; ID = Intellectual Disability; OHI = Other Health Impairment; LA = Low-Achieving; VSM = Video Self-Modeling.

Table 1 continued

Description of Studies Targeting Academic Skill Development Using Video Modeling

Reference	*n*	Age	Special Needs	Independent Variable	Dependent Variable	Research Design	Results
Moore et al. (2013)	1	5 years	ASD	POV, backward chaining, reinforcement menu, and a token economy	Writing: independent, accurate production of letters in the participant's name	Multiple baseline across behaviors (each letter treated as a behavior)	Introduction of the intervention package resulted in increased accurate production of all handwritten letters for the participant
Decker & Buggey (2014)	6	8 – 12 years	LD	VSM versus VMO	Reading fluency: CWPM	Multiple baseline across participants	Reading fluency increased for all participants in both conditions (VSM and VMO)

Note. LD = Learning Disability; ASD = Autism Spectrum Disorder; VSM = Video Self-Modeling; VMO = Video Modeling Other; POV = Point of View Video Modeling; CWPM = Correct Words Per Min.

Writing and Language Arts. Three of the 11 studies indicated that VBI interventions improved participants' writing and language arts skills. One study targeted essay writing (Delano, 2007), 1 study targeted receptive identification of prepositional phrases (Mechling & Hunnicutt, 2011), and 1 study targeted letter writing (Moore et al., 2013).

Delano (2007) investigated the effectiveness of using VSM, Self-Regulated Strategy Development (SRSD) and goal setting to teach written composition skills to 3 participants (age 10 years) with Asperger Syndrome. A multiple baseline across behaviors (total words written and functional essay elements included) was used to evaluate the effects of the intervention. All intervention sessions occurred in a room separate from each participant's classroom in a one-on-one format. Data were collected on the number of words written per session as well as the number of functional essay elements included in each participant's written response to a persuasive essay topic. Researchers created two feedforward VSM videos for intervention. The first video contained footage of each participant reading a self-management script that included the following strategies: counting the number of words in a student-created essay, graphing the number of words on a chart, determining if their goal was met, and setting a goal for next time. After participants increased their total number of words written by 10%, that intervention was faded. The second video showed footage of the participant modeling the TREE strategy, (note the Topic sentence, note Reasons, Explain each reason, not the Ending), for writing a persuasive essay. The author reported that all participants increased the number of words written and number of functional essay elements included on persuasive essays following the introduction of intervention. Maintenance data, obtained

1 week and 3 months following intervention, indicated that written performance decreased from treatment levels for each participant, yet remained higher than baseline levels.

Mechling and Hunnicutt (2011) examined the effectiveness of using an intervention package consisting of feedforward VSM, computer presentation of photographs with captions, and a constant time delay procedure to teach receptive identification of prepositions to 3 students (ages 7 – 8 years) with ID. Intervention sessions occurred in a one-on-one format, within a self-contained classroom, one to two times a day, four to five days a week, and were 5 – 15 min in length. Researchers created VSM footage by prompting students to position themselves or objects according to target prepositions (on/under, in/next to, in front of/behind). After the footage was obtained, the researchers edited out any teacher assistance so that participants only saw themselves engaging in the accurate prepositional positioning. Pictures were also taken of the participants or objects in the prepositional positions. During intervention, students were shown three photographs on a computer. Initially, the instructor asked participants to touch the picture representing a specific preposition and immediately provided a gestural prompt to the correct picture (0-sec time delay procedure). After touching the correct photograph, a video would play showing the student modeling the corresponding preposition. After the student had demonstrated mastery at the 0-sec delay level, the instructor used a 3-sec delay and error correction if necessary. The authors reported that all participants mastered the receptive identification of the three prepositional pairs following introduction of the intervention package.

Moore et al. (2013) examined the effectiveness of using POV, backward chaining, and reinforcement to teach a participant (age 5 years) with ASD to write her name. A multiple baseline across behaviors (writing each letter was treated as a behavior) design was used. Intervention occurred within the participant's home twice a day, four times a week, and sessions were 15 – 25 min in length. During intervention, researchers used a video that depicted the first four letters of the participant's name (her name contained five letters) and a first-person perspective model of the last letter being written. After the participant demonstrated mastery writing the final letter of her name, a new video was used that showed only the first three letters of her name and a first-person perspective model of the last two letters being written. This sequence continued until each letter was faded and the participant was required to write her name with no letters (backward chaining). The videos ranged in length from 1 – 4 min based on the number of letters written in the video. Additionally, a reinforcer menu and token economy (flower stickers with Velcro backs and a laminated chart) were introduced during the intervention when diminishing productivity from the participant was observed. The authors reported that the intervention was successful for teaching the participant to write her name accurately and independently.

Science. One of the 11 studies indicated that VSM intervention improved a participant's science performance (Hart & Whalon, 2012). Hart and Whalon (2012) used an ABAB reversal design to examine the effects of feedforward VSM on the number of accurate, unprompted academic responses during science lessons of one participant (age 16 years) with ASD, ID, and a hearing impairment. Intervention occurred in a group setting of 18 students in a resource classroom four days a week. Video footage was obtained of the participant being asked science questions from the teacher (e.g., *give me an example of a reptile*) and then being prompted to provide an accurate response (e.g., *snake*). This process was repeated in order to obtain footage of the participant answering a variety of science-related questions. Researchers then removed the teacher verbal prompts from the video and had the participant view the edited 1-min video three times prior to the beginning of science class. The authors reported that the participant increased the number of accurate, unprompted academic responses during both VSM intervention conditions and decreased responses when VSM was withdrawn (i.e., indicating a functional relation between the VSM intervention and the increased independent academic responses during science lessons).

Summary

The majority of empirical literature utilizing VBI has targeted functional living skills or social skills improvement, and the number of VBI studies targeting academic skill development is much smaller by comparison (Burton et al., 2013; Prater et al., 2011). Though few VBI studies have targeted academics, this review presents evidence that VBI interventions can have positive effects on the academic skill development of students with disabilities; however, gaps in the research are apparent. First, the reviewed VBI interventions targeted a small number of the academic tasks in which students with disabilities are required to demonstrate competency. Future research should apply the variations of VBI to various academic skill sets in mathematics (e.g., computation, conversions, patterns, and algebraic equations), written expression (e.g., paragraph and sentence formation across different genres), reading comprehension (e.g., vocabulary), science (vocabulary, chemistry equations, formulas), and history (e.g., vocabulary, themes, critical dates).

Researchers should also investigate the effectiveness of VBI interventions to teach academic tasks across a variety of populations. The majority of studies in this review utilized VBI with students with LD, ASD, ID, or who demonstrated low-achievement in an academic area. Future studies should seek to use VBI interventions to enhance the academic skills in other disability areas such as EBD and other health impairments (OHI).

The majority of studies were limited primarily to elementary-age students (i.e., 5 – 12 years). Only three studies targeted students in secondary settings (Burton et al., 2013; Cihak & Bowlin, 2009; Hart & Whalon, 2012); therefore, research should extend the literature to include the effectiveness of VBI on the academic skill repertoires of adolescent students with disabilities. Finally, modern mobile technology has become progressively advanced (i.e., compact design, large memory capacity, and high-resolution video capabilities) over the course of the past decade; therefore, future research should design VBI interventions that capitalize on the transportable, potentially motivating, and non-stigmatizing nature of current mobile technology. devices (e.g., tablets, smartphones, portable media players, and netbook computers).

Purpose of Study

The purpose of the current study was to extend the literature on using VBI to teach academic skills. Specifically, the study examined the effectiveness of using VP to teach grade-level chained math tasks to high school students with disabilities. The targeted chained task was solving algebraic equations that required students to use the distributive property, combine like numerical terms, and isolate the variable to one side of the equation. The video models were delivered via an iPad, and each model contained auditory prompts to pause the video between steps, as well as for accurately completing the steps of the target equations. The study utilized a point-of-view variation of VP because the focused perspective of the video models directed the participants' attention to the critical, fine motor features of the target task (Gardner & Wolfe, 2013).

Research Questions

The research questions were as follows:

a. Does video prompting with audio prompts, presented with whole-task instruction within a mobile technology format (iPad), result in the (i) acquisition and (ii) maintenance and/or generalization of chained math tasks (i.e., algebraic equations), as measured by the percentage of equations solved correctly and the percentage of steps completed correctly by high school students with disabilities?
b. Does video prompting with auditory prompts, presented with whole-task instruction within a mobile technology format (iPad), result in increased imitation of topographical responses, as measured by the percentage of steps imitated correctly during VP training sessions?
c. Do participants and practitioners report the video prompting intervention as effective, time-efficient, and/or enjoyable?

CHAPTER 3

METHODS

Participants

Participants included five high school students receiving special education services in a self-contained setting in a public school in a Southeastern school system. Prior to data collection, the researcher obtained approval for human subjects research from the participants' school research review board and the University of Georgia Institutional Review Board. Participants were selected based on the following inclusionary criteria: (a) demonstrated deficits in the target math task, (b) enrolled in any grade level at the high school setting, (c) served in special education under any high-incidence disability category (e.g., EBD, ASD, OHI, LD), (d) consistent school attendance based on teacher report, (e) parental permission and student assent forms obtained.

The classroom teacher at the research site nominated four students that met the first four criteria listed above. After acquiring research approval, signed parental permission forms, and student assent forms, nominated students were screened on necessary pre-requisite skills, including: attention, digit printing skills, calculator skills, performing computations involving variables and negative/positive numbers, and understanding of a task-related construct (i.e., the relationship between a variable and a coefficient). Following screening of pre-requisite skills the students were assessed for the ability to solve algebraic equations that required (i) using the distributive property, (ii) combining like numerical terms, (iii) and isolating the variable to one side of the equation. All 4 nominated students met inclusion criteria.

All participants received daily math instruction in a self-contained setting in a small-group instructional format (i.e., a total of 8 students). The learning objectives for daily math lessons were derived from the 9th grade Common Core Standards. All participants had math goals specifically related to multi-step algebraic equations in their current Individualized Education Programs. All participants' IEPs included use of a calculator as an accommodation for classroom and standardized testing. All participants had experience with technology-based instruction (e.g., smartboard for classroom instruction, and math-based instructional software (e.g., *Edgenuity*) on the classroom's desktop computers). Daily math instruction typically involved the students receiving direct instruction from the teacher, followed by independent practice via worksheets and/or instruction on the classroom computers. During math instruction in their assigned classroom, students sat in an assigned desk at a cluster of four desks. Based on teacher report, the student's had not received any VP instruction for math skills during the academic school year in which the study was conducted.

Eugene was a 15-year old male with EBD in ninth grade. On the *Differential Abilities Scale – Second Edition*, Eugene scored a general conceptual ability of 77, a verbal ability of 83, a nonverbal ability of 79, and a spatial ability of 78; each of these scores are below average. On the *Iowa Test of Basic Skills*, he scored in the 12th percentile. On the *Wechsler Individual Achievement Test*, he scored in the 14th percentile for math problem solving. During the previous school year, Eugene scored a 328 (out of a possible 430) in math on the *Criterion Referenced Competency Test – Modified* (CRCT – M), which is considered "Emerging Proficiency."

Noah was a 15-year old male with EBD. On the *Wechsler Intelligence Scale for Children – Fourth Edition*, Noah demonstrated a full scale IQ of 83 (13^{th} percentile), an 88 for perceptual reasoning (21^{st} percentile), a 71 for working memory (3^{rd} percentile), and a 100 for processing speed (50^{th} percentile). On the *Woodcock Johnson – Third Edition*, he scored an 81 in math calculation (10^{th} percentile), 75 in math applied problems (5^{th} percentile), 95 in math fluency (37^{th} percentile), and 74 in brief math (4^{th} percentile. During the previous school year, Noah scored a 297 (out of a possible 430) in math on the *Criterion Referenced Competency Test – Modified*, which is considered "Below Proficiency."

Morgan was a 14-year old male with ASD and a Speech Language Impairment. On the *Reynolds Intellectual Assessment Scale*, Eugene demonstrated a composite score of 77, a verbal ability of 82 (12^{th} percentile), and a nonverbal intelligence score of 82 (12^{th} percentile), On the *Wechsler Individual Achievement Test*, he scored in the 1^{st} percentile for all mathematics subtests (fluency, problem solving, operations). During the previous school year, Morgan scored a 288 (out of a possible 430) in math on the *Criterion Referenced Competency Test – Modified*, which is considered "Below Proficiency."

Carol was a 16-year old female with OHI (Attention Deficit Hyperactivity Disorder). On the *Wechsler Intelligence Scale for Children – Fourth Edition*, Carol demonstrated a full scale IQ of 74 (5^{th} percentile), an 84 for perceptual reasoning (low average range), and a 68 for working memory (extremely low range). On the *Woodcock*

Johnson – Third Edition, she scored a 60 in math calculation. On the *Kauffman Test of Educational Achievement – Second* Edition she demonstrated a 71 math composite score (3^{rd} percentile), 72 in math concepts and applications (3^{rd} percentile), and 74 in math computation (4^{th} percentile). During the previous school year, Carol scored a 293 (out of a possible 430) in math on the *Criterion Referenced Competency Test – Modified*, which is considered "Below Proficiency."

See Table 2 for students' IQ score as well as scores from relevant achievement tests (e.g., Woodcock Johnson Achievement Test 3^{rd} edition). See Table 2 for results (relevant to the study) from participants' most recent psychological evaluations.

Setting

The study was conducted in a rural public high school in the Southeastern United States. The total school enrollment was approximately 1400. Fifteen percent of the students were served in special education, and 54% of the students were eligible for free or reduced meals. The ethnic makeup of the school was 82% White, 11% Black, 4% Hispanic, 2% Multiracial, and 1% Asian. All participants typically received daily math instruction from their teacher in a self-contained, small group setting consisting of eight total students. All screening, instruction, data collection, and maintenance sessions were conducted in a classroom at a student desk with only the researcher, and the participant present. However, an independent observer was also present for sessions PF and IOA sessions.

Materials and Device

Screening materials included a calculator, a pencil, a dry erase marker, a small white dry erase board, a 3 x 5 inch index card, and worksheets. Training on the iPad involved a pencil, a blank sheet of paper, and an iPad. During intervention, participants were provided with an iPad containing point-of-view video models of the targeted math skill. The volume of the device was turned on to a clearly discernible level so the participant could hear the auditory narration component. Headphones were not used so that the researcher could correlate participant responses with the verbal prompts embedded in the video. During VP training the students were also provided with a pencil and worksheets containing the 2 target equations modeled in the 2 videos. Prior to each daily VP intervention session the participants were given a pencil and 5 novel equations to solve. In order to ensure randomized stimuli variation during VP sessions, a statistical chart (RAND Corporation, 1955) that contained one million random digits and 100,000 normal deviates was used to generate digits 1 – 9 for constants within the equations, and only digits 2 – 9 were used for coefficients (i.e., 1x would simply be represented as x). The researcher did not use 0 in any equations. All target equations for the pre-VP session probes and VP sessions used subtraction exclusively as the operation, e.g., $3 - 5(2x - 1) = 3(3 - x)$.The random digits was also used to generate digits for the generalization equations.

Each of 2 video models of solving an equation was recorded prior to intervention by the researcher using a *GoPro Hero 3*® camera and a *Pedco UltraPod II Lightweight*® camera tripod. *The GoPro Hero 3*® camera was used due to the high-resolution and frame rate recording capabilities (i.e., increased clarity of presented stimuli) of the device. The tripod-mounted camera simulated a first-person point-of-view process of solving the target equations. Each video model displayed a worksheet with an exemplar equation, the researcher's hands, a marker, and a calculator. The researcher used a black dry erase marker as the writing utensil in the video models because it increased the visibility of the written digits and numerical symbols. That is, the written digits and symbols were wider and darker using the marker as opposed to using a pencil.

Cooper et al. (2007) discussed necessary procedures for developing a TA, including determining the number of steps and order of the steps for the behavior chain. In order to determine the steps and order of the chain, there are three recommended methods, including: 1) the researcher can complete the task his/herself, 2) observe others performing the task, or 3) consult an expert. For this study, the researcher created the 30-step TA (see Table 3) by first consulting an expert (i.e., the participants' classroom teacher), then personally completing the target equations, then watching others complete the target equations. The TA was designed to result in a written response for each step for measurement purposes.

Videos were made for two different exemplars demonstrating accurate completion of each step for solving the target equations. When recording the videos, the researcher completed the problem using the steps outlined in the TA. Each video also contained auditory narration for all depicted steps. Table 4 contains the script used by the researcher when recording the video models. The script outlines auditory prompts/narration, and indicates the researcher's physical cues (denoted by italicized font) displayed in the video model.

Dependent Measures

Data were collected during screening, baseline, intervention, and post-treatment and generalization probes. Screening is described below. The percentage of equations solved

Table 2
Participant Information

Participant	Age	Disability	IQ	Achievement Scores	Summative Assessments
Eugene	15 years	EBD	Differential Abilities Scale – Second Edition: 77 (Below Average)	Iowa Test of Basic Skills: 12th percentile Math Wechsler Individual Achievement Test: - Math Problem Solving: 84 (14th Percentile)	Criterion Referenced Competency Test - Modified: - 328 in Math (Emerging Proficiency)
Noah	15 years	EBD	Wechsler Intelligence Scale for Children – Fourth Edition: 83 (13th Percentile)	Woodcock Johnson-Third Edition: - Calculation: 81 (10th Percentile) - Applied Problems: 75 (5th Percentile) - Math Fluency: 95 – (37th Percentile) - Brief Math: 74 (4th percentile)	Criterion Referenced Competency Test – Modified: - 297 in Math (Below Proficiency)
Morgan	14 years	ASD/SLI	Reynolds Intellectual Assessment Scale**:** 82 (12th percentile)	Wechsler Individual Achievement Test – Third Edition: -Mathematics: 63 (1st percentile) - All subtests (Fluency, problem solving, operations,) 1st percentile	Criterion Referenced Competency Test – Modified: - 288 in Math (Below Proficiency)
Carol	16 years	OHI (ADHD)	Wechsler Intelligence Scale for Children – Fourth Edition: 74 (5th Percentile)	Kauffman Test of Educational Achievement – Second Edition: - Math Composite: 71 (3rd Percentile) - Math Concepts and applications: 72 (3rd percentile) - Math Computation: 74 (4th percentile) Woodcock Johnson-Third Edition: Brief – Math: 60	Criterion Referenced Competency Test – Modified: - 293 in Math (Below Proficiency)

Note. ADHD = Attention Deficit Hyperactivity Disorder; ASD = Autism Spectrum Disorder; EBD = Emotional/Behavior Disorder; ID = Intellectual Disability; LD = Learning Disability; OHI = Other Health Impairment; SLI = Speech Language Impairment

Table 3

Task Analysis for Target Equations

Step 1: distribute first term on left and write product below Step 2: distribute second term on left and write product below Step 3: drop down constant on left Step 4: drop down equal sign Step 5: distribute first term on right and write product below Step 6: distribute second term on right and write product below Step 7: combine terms and write sum below Step 8: drop constant on left Step 9: drop equal sign Step 10: drop constant on right Step 11: drop variable on right Step 12: write variable under right side Step 13: cross out cancelling variables on the right Step 14: write variable under left side Step 15: add left variables and write sum below Step 16: drop constant on left Step 17: drop equal sign Step 18: drop constant on right Step 19: write constant under left side Step 20: cross out cancelling terms on the left Step 21: write constant under right side Step 22: subtract numbers and write difference below Step 23: drop variable Step 24: drop equal sign Step 25: write coefficient under the left side Step 26: cross out cancelling terms on the left Step 27: write coefficient under the right side Step 28: divide numbers on right and write answer below Step 29: drop variable Step 30: drop equal sign

Table 4

Script used for Narration and Visual/Auditory Prompts in Videos

This is an equation. The variable "x" represents an unknown number (*point to x*). You must solve for x.

Step 1.
Start by simplifying the left side of the equation using the distributive property (*point to the left side*). To use the distributive property you must multiply the number outside of the parentheses (*point to number*) by both numbers inside the parentheses (*point to both numbers*).

First, multiply the number outside of the parentheses (*point to the number*) to the first number inside the parentheses (*point to the number*) and write the answer below (*use calculator to multiply then write the answer below*). Pause the video, you multiply the numbers, then continue watching the video. *5-sec pause*

Next, multiply the number outside of the parentheses (*point to the number*) to the next number inside the parentheses (*point to the second number*) and write your answer below (*use calculator to multiply then write the answer below*). Pause the video, you multiply the numbers, then continue watching the video. *5-sec pause*

Next, drop down the constant and the equal sign (*point to both and write them both below*). Pause the video, you drop down the constant and equal sign, then continue watching the video.

Step 2.
Now you must simplify the right side of the equation using the distributive property (*point to right side*).

First, multiply the number outside of the parentheses (*point to the number*) to the first number inside the parentheses (*point to the number*) and write the answer below (*use calculator to multiply then write the answer below*). Pause the video, you multiply the numbers, then continue watching the video. *5-sec pause*

Next, multiply the number outside of the parentheses (*point to the number*) to the next number inside the parentheses (*point to the second number*) and write your answer below (*use calculator to multiply then write the answer below*). Pause the video, you multiply the numbers, then continue watching the video. *5-sec pause*

Step 3.
Now you must combine like terms on the left side of the equation (*point to the left side*). These two numbers (*point to the constants*) are like terms because they do not have a variable.

First you must add the two like terms together and write the answer below (*point to both constants, use calculator to add the numbers, and write the answer below*). Pause the video, you add the like terms on the left side, then continue watching the video. *5-sec pause*

Next, drop down the variable (*point to the variable and write it below*). You must write an addition symbol after the variable to show that the constant is a positive number in this example (*write addition symbol between variable and constant*). Then drop the equal sign. Pause the video, you drop the variable, write the addition symbol, drop the equal sign, and then continue watching the video. *5-sec pause.*

There are no like terms on the right side, so you do not need to combine. Drop the constant and the variable down. *(point to constant and variable, write them both below).* Pause the video, you drop the constant and variable down, then continue watching the video.

Step 4.
Now you must move the variable x (*point to both variables*) to one side of the equation. To move the variable, you must get rid of the variable on the right (*point to variable on right*). In this example the variable is a negative number (*point to the negative symbol*) so you must add that variable to both sides.

First, add the variable to the right side (*write the variable and addition symbol under the right side*). A positive and a negative number cancel out (*point to numbers*), so cross out the variables on the right (*cross out variables on the right*). Pause the video, you add the variable to the right side, cross out the cancelling numbers, then continue watching the video. *5-sec pause*

Next, add the variable to the left side of the equation and write your answer (*use calculator to add numbers, write the answer*). Pause the video, you add the variable, then continue watching the video. *5-sec pause*

Next, drop down the constants and the equal sign (*point to constants and equal sign and write them below*). Pause the video, you drop the constant and the equal sign, then continue watching the video. *5-sec pause*

Step 5.
Now you must remove the constant (*point to the constant on the left*) on the left side. In this example the constant is a positive number (*point to the constant*), so you must subtract the constant from both sides.

First, subtract the constant from the left side (*write the constant and subtraction symbol under the left side*). A negative and a positive number cancel so cross out the numbers (*draw a line through cancelling numbers*). Pause the video, you subtract the constant from the left side, cross out the cancelling numbers, then continue watching the video. *5-sec pause*

Next, subtract the constant from the right side and write the answer below (*write constant and subtraction symbol under right side, use calculator to subtract numbers, write the answer below*). Pause the video, you subtract the constant from the right side, then continue watching the video. *5-sec pause*

Next, drop down the variable and the equal sign (*point to both and write both below*). Pause the video, you drop the variable and the equal sign, then continue watching the video. *5-sec pause*

Step 6.
Now you must remove the coefficient (*point to the coefficient*). To get the variable x by itself you must divide both sides of the equation by the coefficient (*point to the coefficient*).

First, divide the left side of the equation by the coefficient (*draw a fraction bar and write the coefficient under the variable*). The divisor and the coefficient cancel so cross them out (*point to coefficient and divisor and draw a line through cancelling numbers*). Pause the video, you divide the left side of the equation by the coefficient, cross out cancelling numbers, then continue watching the video. *5-sec pause*

Next, divide the number on the right by the coefficient and write your answer below (*write coefficient under number on right, divide using calculator, write the answer below*). If your answer is a decimal, write a 0, the decimal, and the first two places of the decimal only. Pause the video, you divide the number on the right by the coefficient, then continue watching the video. *5-sec pause*

Next, drop down the variable and the equal sign. Pause the video, you drop the variable and the equal sign, then continue watching the video. *5-sec pause*

You have solved for the variable “x”

correctly served as the primary dependent variable during baseline, intervention, probe, and post-treatment sessions, and was calculated as the number of correct answers divided by the number of equations given (2 during instruction and 5 for pre-VP session and probe assessments), with the resultant quotient multiplied by 100. An equation was scored as correctly completed if the participant wrote the variable and the corresponding value that included the exact whole number (correctly notated as positive or negative) and, if applicable, the tenths and hundredths place digits (e.g., $x = -2.31$). A secondary dependent variable, the percentage of steps completed correctly, was calculated as the number of correct steps written on the worksheets divided by the number of possible steps across all problems (60 steps during instruction and 150 steps for pre-VP and probe assessments), with the resultant quotient multiplied by 100. A step was scored as correct if the participant performed the written behavior (e.g., writing a digit, writing a numerical symbol, or crossing out cancelling digits) associated with the corresponding step identified in the TA. Data were also collected on the number of generalization equations (i.e., equations with addition as the primary computation rather than subtraction) solved correctly, and scored and calculated in the same manner as for the percentage of target equations solved correctly. The number of steps imitated correctly during the VP training sessions was also recorded. Social validity data were obtained from participants' and the classroom teacher's via a questionnaire that asked if the VVP intervention was enjoyable, effective, and/or efficient.

Experimental Design

A multiple probe across participants design (Cooper et al., 2007; Horner & Baer, 1978) was used to evaluate the effectiveness of VP on the percentage of target equations solved correctly. Multiple probe designs can be used to demonstrate a functional relation between the systematic implementation of an independent variable and the acquisition of a chained sequence (Cooper et al., 2007; Horner & Baer, 1978). The staggered introduction of the VP intervention within a multiple-probe design across four participants allowed for an initial affirmation and three replications of effect at different points in time across participants (Horner et al., 2005). The use of probes provided an alternative to continuous measurement during the extended multiple baselines as it was unnecessary for participants that had not yet received intervention to repeatedly demonstrate inaccurate responding (Horner & Baer, 1978). For each of the participants, data were collected and reported for baseline, intervention, and post-treatment conditions.

Procedures

The following describes procedures for pre-baseline screening, iPad/VP training, data collection for all conditions, and reliability measures.

Pre-Baseline Screening. Prior to baseline, nominated students were on the following prerequisite skills: attention; digit printing skills; calculator skills for computing computations involving variables and negative/positive numbers; and comprehension of a task-related construct; target task proficiency (i.e., did they already possess the skills to complete target equations); and generalization task proficiency (i.e., did they possess the skills to complete generalization equations). See *Appendix B* for a copy of the data sheet that was used for screening and iPad training.

***Attention*.** Ability to attend was determined during iPad training (below). If students were able to complete the novel task (see below) both accurately and independently then it was evident that they were able to attend to a video model for a duration of time necessary to complete a novel chained task. All participants demonstrated the necessary attention skills to benefit from instruction (see iPad Training below).

Digit Printing Skills. The study required participants to print individual digits, when solving target and generalization equations. During pre-baseline screening, nominated students were provided with a 3-inch by 5-inch notecard and instructed to neatly write the digits 1 – 9 in sequential order on the second line of the notecard. The second line of the notecard was highlighted in yellow ink for clarification of the task. Students that wrote all nine digits sequentially between the *floor* and *ceiling* of the allotted line with minimal or no overlap were provided additional screening for calculator skills. The researcher and an independent observer examined the printed digits to determine if students met the fine motor prerequisite skills (i.e., legible digits of acceptable size). All students demonstrated 100% accuracy on the digit writing assessment.

Calculator Skills. Some steps in the TA required participants to use a calculator to complete computations (e.g., division, addition, multiplication, and subtraction). During pre-baseline screening, students were presented with a worksheet containing ten vertically aligned improper fractions (e.g., $\frac{24}{6}$), and instructed to divide the numerator by the denominator using the calculator and write the quotient on their paper. Students were also presented with a worksheet containing ten vertically aligned 2-digit addition problems with and without regrouping, and instructed to complete the problems using the calculator and write the sum on their paper. Additionally, students were presented with a worksheet containing ten vertically aligned 2-digit subtraction problems, with and without regrouping, and instructed to complete the problems using the calculator and write the difference on their paper. Students were also presented with a worksheet containing ten vertically aligned 1-digit by 1-digit multiplication facts, and instructed to complete the problems using the calculator and to write the product on their paper. The calculator used during screening was the same calculator that students used during all subsequent measurements. To be considered as a participant for this study, students must have completed the division, addition, subtraction, and multiplication calculator tasks with at least 80% accuracy across ten items per computation type. All students met this criterion.

Computations Involving Variables. All equations required the students to multiply a whole number by a term containing a variable (e.g., $7 * x$), and add/subtract variables (e.g., $4x + 7x$; $8x – 5x$). Prior to training, students were screened for understanding (and instructed as necessary) of the processes of adding, subtracting, and multiplying variables. For screening of computation of variables, students were provided with a calculator and a dry erase marker. For each computation skill, the researcher presented three problems, one at a time on a small white dry erase board, and instructed the students to solve the problem. Students were screened for understanding of multiplying a constant (i.e., a whole number) by a term containing a variable (e.g., $7 * x$). Students were also screened for an understanding of adding variables (e.g., $5x + 2x$). Students were also screened for understanding of subtracting variables (e.g., $8x – 3x$). To be considered as a participant in the study, students must have correctly solved three consecutive trials of the each computation task involving variables. All students met this criterion.

Computations Involving Positive and Negative Numbers. Solving the target equations required participants to add positive and negative numbers, multiply negative and positive numbers, and divide positive and negative numbers. Prior to training, the students were screened for an understanding of adding positive and negative numbers. Students were provided with a marker and a calculator, and presented with three addition problems, one at a time on a dry erase board, and instructed to "Solve the addition problem." The three addition problems involved adding a negative addend to a positive addend (e.g., *5 + -3*). Additionally, the students were presented with three addition problems involving adding a positive addend to a negative addend (e.g., *-9 + 7*), three multiplication problems involving multiplying a negative multiplier and a positive multiplicand (e.g., *-4 * 8*), three division problems (in fraction form) involving a negative dividend and a positive divisor (e.g., $\frac{-8}{7}$), and three division problems (in fraction form) involving a positive dividend and a positive divisor (e.g., $\frac{9}{-4}$). To be considered as a participant in the study, students must have correctly solved three consecutive trials of the each computation task involving positive and negative numbers. All students met this criterion.

***Task-Related Construct*.** All equations contained variables with a coefficient (e.g., *4x*), and students were screened for understanding of the relationship between a variable and the coefficient. Each participant was individually shown the example *4x*. The researcher pointed to the example and asked: "what does this mean?" The researcher waited 5 seconds for the participant to initiate and complete a response. (e.g., "This means 4 multiplied by *x*, and *x* is a number that we do not know the value for"). All participants were able to accurately identify the relationship between the coefficient and the variable independently.

Target Task Proficiency. Participants were provided with three target equations on a worksheet. The researcher provided the participant with a pencil and calculator and said, “Solve the equations.” The researcher then waited for the participant to complete the equations (no duration time limit was used). If the participant accurately identified the value of the variable, that equation was scored correct. Equations were scored correct if the participant wrote the variable and the exact corresponding value (e.g., $x = -14.78$). Students who solved 0 – 40% of equations correctly were considered as participants for the study.

All participants solved 0% of equations accurately; therefore, screening was then conducted to determine what steps of the task each student was able to complete. The student was provided with a dry-erase marker, presented with one target equation written on a small white dry erase board, and instructed to “Solve the equation. Tell me when you are done.” The researcher then waited 5 sec for the participant to initiate/attempt the first step (write on the dry erase board, pick up the calculator, or direct eye gaze towards the dry erase board), and 30 sec for the participant to complete the step once he/she began an attempt. If the participant did not attempt the step in 5 sec, could not complete the step accurately (writing the correct number or symbol associated with that step) within 30 sec of beginning an attempt, or began an inaccurate response (i.e., wrote the wrong digit, wrong symbol, or wrote the digit/symbol in the incorrect location), the researcher interrupted the student, blocked his/her view of the equation, correctly completed the targeted step, unblocked the student’s view, and then instructed the student to “Solve the equation." Incorrect or nonresponses for each step were recorded as an inaccurate response. Correct responses completed within the specified latency (5 sec) and delay (30 sec) intervals were recorded as accurate completions of that step. This assessment was conducted for all steps for one target equation, and the researcher recorded the percentage of steps completed correctly. When the researcher implemented blocking for the target task, Eugene was able to correctly complete 70% of the steps independently (steps 5, 6, 12 – 30), and Noah, Morgan and Carol were able to complete 46% of the steps independently (steps 1, 5, 19 – 30).

Generalization. Students were also assessed on three generalization equations (i.e., equations that used addition rather than subtraction as the operation). Generalization equations were assessed periodically throughout the study (baseline, probes, post-treatment) to determine if mastery of target equations would generalize across equation requirements. Students were presented with three generalization equations and the prompt "Solve the equations. Tell me when you are done." The researcher then waited for the students to complete all equations. Equations were recorded as correct if the participant wrote a number sentence containing the variable and the exact value of the variable (e.g., $x = 8.32$). The total number of equations completed accurately was calculated, and this procedure was repeated for all students. All students completed 0% of generalization equations correctly.

iPad Training. Prior to intervention the researcher individually provided iPad training on a novel chained task to each participant. The novel chained task was drawing a *contour combination* (a sequence of geometrical figures created by the researcher to ensure training on a novel task that was dissimilar than the target task). The individualized iPad training was conducted to (a) establish that the participants could independently operate the iPad to show VP instruction and (b) acquire a skill via the instruction. Training sessions with the iPad began with the researcher demonstrating how to play and pause a sample video (i.e., a nonsensical video that involved drawing an upside-down stick figure) while the student observed. The student was then prompted to imitate playing and pausing the sample video while the teacher observed for accuracy. During training sessions, each participant was required to independently draw the *contour combination* after being shown the corresponding video model. The sequence of geometric shapes for the contour combination was: circle, square, triangle, triangle, circle, and square. The training video model showed each shape in the combination being drawn with auditory prompts to pause the video between steps (i.e., each shape was considered a step). If the student did not accurately complete the sequence, he/she was instructed to again watch the video model and then try to replicate the sequence on paper. This continued until the participant was able to accurately recreate the contour combination. Once the student was able to recreate the sequence independently, it was determined that he/she had the skills to use VP via mobile technology for learning a chained task. If students were able to recreate the sequence of figures in the video, this demonstrated adequate attention skills required to participate in the study. All students accurately and independently completed the novel task in one attempt. Accurate completion of the novel task demonstrated participants' ability to operate the video software, and the ability to attend to a video model for the duration of time necessary to learn a chained task.

Upon completion of screening and iPad training, the researcher determined that all students met the prerequisite skill requirements to participate in the student and were subsequently referred to as “participants.” See *Appendix B* for a copy of the data sheet that was used for screening and iPad training.

Baseline. During baseline sessions, the participant was provided with a pencil, a calculator, a worksheet containing five target equations, and was instructed to “Solve the equations.” The researcher would then wait for the participant to solve all five equations. No duration time limit was used; durations to complete the equations ranged from 3 min, 50 sec (Carol) to 7 min, 30 sec (Eugene). Questions from participants regarding procedures to complete the equation were not answered directly. The researcher responded to such queries with, "Do your best and raise your hand when you are finished." General off-task behaviors (e.g., looking away from the worksheet, drawing) resulted in one reminder to “remember to solve the equation.” If the student did not initiate a response within 1 min (i.e., no digits were written, the student was not holding the calculator or pencil in his/her hands, or his/her eye gaze was not directed towards the worksheet), or signaled completion and the problems had not been attempted (i.e., no digits were present), one reminder was given to “Solve the equations.” If the student subsequently said they could not complete the problem, or did not initiate a response with 1 min, the session was terminated and all problems were scored as if attempted. The percentage of problems solved correctly and the percentage of steps completed correctly were calculated and recorded for all sessions. During the first session of baseline, the participants were also assessed on five generalization equations. The percentage of generalization equations solved correctly and the percentage of steps completed correctly were calculated and recorded for session 1. See *Appendix C* for the data sheet that was used to record data for baseline and pre-VP sessions.

VP Intervention Condition. The initial session for each participant's intervention phase consisted of the VP intervention. Each subsequent session (generally the next school day excluding absences and a weeklong spring break) began with a pre-VP probe followed immediately by the VP intervention. This minimum 24 hour delay between the intervention and probe was implemented to limit priming effects within the session and to determine if skills were maintained across a day or more.

***Pre-VP Session Probes*.** Each participant's pre-VP session probes occurred daily prior to the VP intervention (except on the first day of intervention, during which no probe was conducted, as noted), and were conducted in exactly the same manner as the baseline probes. The percent of equations solved correctly and the percent of steps completed correctly were recorded for each probe. Mastery was defined as a participant solving four of the five equations correctly (80%) for two consecutive sessions, as determined by the pre-VP session probes. Mastery was not set higher because the probability of participants randomly guessing the correct answer for each equation, given that the answers ranged from responses containing one digit (e.g., $x = 9$) to responses containing four digits (e.g., $x = 12.58$), ranged from approximately .1 to .0001; even smaller given that answers also required correct sequencing of "x" and the numerical answer; and in some cases a negative value. Therefore, the likelihood of students correctly solving 4/5 (80%) of the equations by chance alone was extremely low. Once a student reached mastery, all participants were probed, and intervention began for the next participant.

***VP Instructional Procedures*.** Following daily VP session probes (excluding the first intervention session day, during which a VP probe was not administered), the participant was provided with an iPad containing two uploaded point-of-view video models, each of which depicted all of the steps for solving an equation, a pencil, a calculator, and a worksheet with the same two equations depicted on the iPad. Both exemplars presented during VP sessions used subtraction as the primary computation and the letter x as the variable, e.g., $3 – 5 (2x – 1) = 3(3 - x)$, and varied only in the digits used in the equation, The participant was instructed to “Use the video to solve the equation. Follow all the directions. Tell me when you are done.” The auditory component described each step and prompted the participants to pause the video between steps, complete the step on their own, and to resume watching the video after the step was completed. The researcher responded to any questions from participants regarding procedures to complete steps of the equation with “Do your best“. If the participant signaled completion and the problems had not been attempted (i.e., no digits were present), one reminder to “Remember to solve the equations” was given. This procedure was repeated for the video model of the second exemplar. The number of steps imitated correctly was summed across the two exemplars (30 steps per exemplar = 60 steps) and recorded as percentage of steps imitated correctly per session. See *Appendix D* for the data sheet used to record the percentage of steps imitated correctly during VP training.

Probe Sessions. After the participant currently receiving intervention demonstrated mastery (i.e., at least 80% of equations solved correctly across two consecutive VP probes), a probe session was conducted for each participant. Probe sessions were conducted using the baseline procedures described above. The probes functioned as evaluations for maintenance data for students that had previously demonstrated mastery, as well as for additional baseline data for participants that had not yet received intervention. Participants did not view video models prior to completing the maintenance/baseline probes.

Generalization Across Equation Types. Generalization probes were conducted during the first baseline session and during subsequent probe sessions. Generalization probes involved the researcher administering five equations in which addition was used exclusively as the computation rather than subtraction. Students did not view a video model during this session in order to determine if skills learned on the previous equations involving subtraction as the primary computation generalized to equations involving addition as the primary computation. Participants were provided with as much time as necessary to complete all equations. Participant questions and off-task behaviors were addressed as previously described.

Reliability

The primary researcher and two independent observers collected IOA during screening and all phases of the study. The first independent observer was a graduate student at the university attended by the researcher. The first independent observer was involved in PF and IOA for all measures during screening for all participants. The second independent observer was a special education teacher employed at the research site, and was involved in PF and IOA for all measures during baseline, intervention, and post-treatment sessions for all participants.

Inter-Observer Agreement. During screening, the first independent observer examined all permanent products and conducted direct observations with the researcher to verify participants' demonstrations of prerequisite skills. During training, the first independent observer examined permanent products and conducted direct observations to verify participants' demonstrations of prerequisite skills. The primary researcher and the second independent observer independently examined participant's permanent products and recorded the percentage of equations solved correctly and the percentage of steps completed correctly during baseline, intervention sessions (pre-PV probes), and subsequent probe sessions. The researcher and independent observer also examined the participant's permanent products from the training session and recorded the number of steps imitated correctly for the two training exemplars. IOA was calculated using point-by-point agreement, which involved comparing each step recorded on the researcher's data sheet and the independent observer's data sheet and dividing the number of agreements by the number of agreements plus disagreements and multiplying the resulting quotient by 100 (Ayres & Ledford, 2014).

Procedural Fidelity. Procedural fidelity (PF) data were collected in at least 20% of sessions in each condition for all participants. PF data involved documentation of the participants being provided necessary materials and consistent directions. The primary researcher was required to provide participants with the necessary materials to complete the math tasks, and to provide only scripted directions regarding behavioral expectations, assignment instruction, and appropriate use of the technology materials. Procedural fidelity was collected by the independent observer and was calculated by dividing the number of observed researcher behaviors (i.e., what the researcher did during the session) by the number of planned researcher behaviors (i.e., what the researcher was supposed to do during the session) and multiplying by 100 (Ayres & Ledford, 2014). See *Appendix E* for the PF data collection form used for procedural fidelity during screening/iPad training, and see *Appendix F* for the Pf data sheet used during baseline, intervention, and post-treatment sessions.

IOA and PF data were calculated in 100% of screening sessions for all measures and for all participants. IOA and PF data were calculated in 33% of baseline sessions, 25% of intervention sessions, and 100% of probe sessions for Eugene. IOA and PF data were calculated in 33% of baseline sessions, 20% of intervention sessions, and 100% of probe sessions for Noah. IOA and PF data were calculated in 33% of baseline sessions, 22% of intervention sessions, and 100% of probe sessions for Morgan. IOA and PF data were calculated in 33% of baseline sessions, 25% of intervention sessions, and 100% of probe sessions for Carol.

IOA and PF was 100% across all measures and participants during screening sessions. IOA on percent of equations solved correctly and percent of steps completed correctly was 100% across all conditions for Eugene, Noah, and Carol. For Morgan, IOA on percent of equations correct was 100% for baseline and probe sessions, and 98% for intervention. Morgan’s IOA data on percent of steps completed correctly was 100% for baseline and probe sessions, and 99% for intervention. IOA on percent of steps imitated correctly was 100% across all conditions and for all participants. PF was 100% across participants for all students. See Table 5 for IOA and PF data for all participants.

Social Validity

After data collection was completed, the primary researcher administered social validity questionnaires to the participants and the teacher. The form contained statements regarding preference and perceived benefits of the intervention. Participants and the classroom teacher responded to each statement using a Likert scale. See *Appendix F* for a copy of the social validity questionnaire for participants, and see *Appendix G* for a copy of the social validity questionnaire for the classroom teacher.

CHAPTER 4

RESULTS

Figure 1 depicts the percentage of equations solved correctly by the participants for baseline, pre-VP session probes, probe sessions, and generalization probe sessions, and portrays the functional relation between VP and the percent of equations solved correctly. Figure 2 depicts the percentage of task analysis steps completed correctly by the participants for baseline, pre-VP session probes, probe sessions, and generalization probe sessions.

Individual Participant Results

Eugene. As shown by Figure 1, Eugene correctly solved 0% of five equations across three consecutive baseline sessions. For each baseline session he correctly completed 40% of the steps (12 steps per equation), as shown in Figure 2. During intervention Eugene imitated the steps in the video models with 100% accuracy across four consecutive sessions (see Figure 2). A pre-VP session probe was not administered in session 4 because it was the first day of intervention for Eugene (This was the case for all participants). Upon introduction of VP there was an immediate therapeutic increase in level from 0% of equations correct in session 1-3 to 40% in session 5 (see Figure 1), followed by an upward trend in the data across sessions 6 and 7 (80% and 100%, respectively). These data provide an initial affirmation (Cooper et al., 2007) of treatment

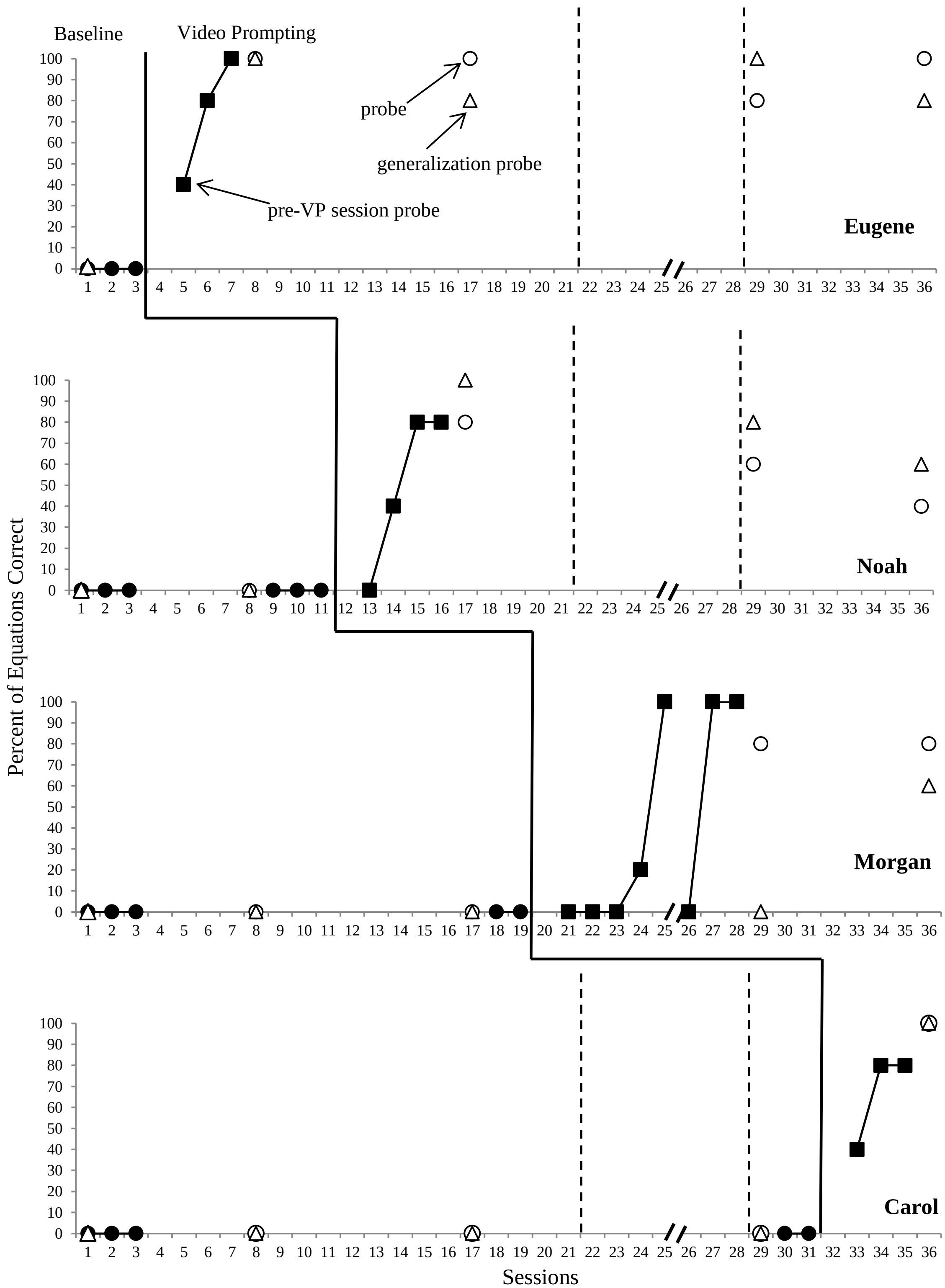

Figure 1. *Percentage of equations solved correctly by the participants for baseline, pre-Video Prompting (VP), probe and generalization probe sessions. The scale break designates a week long spring break. The area between the dashed lines represents the sessions in which Eugene, Noah, and Carol received classroom instruction on the target task.*

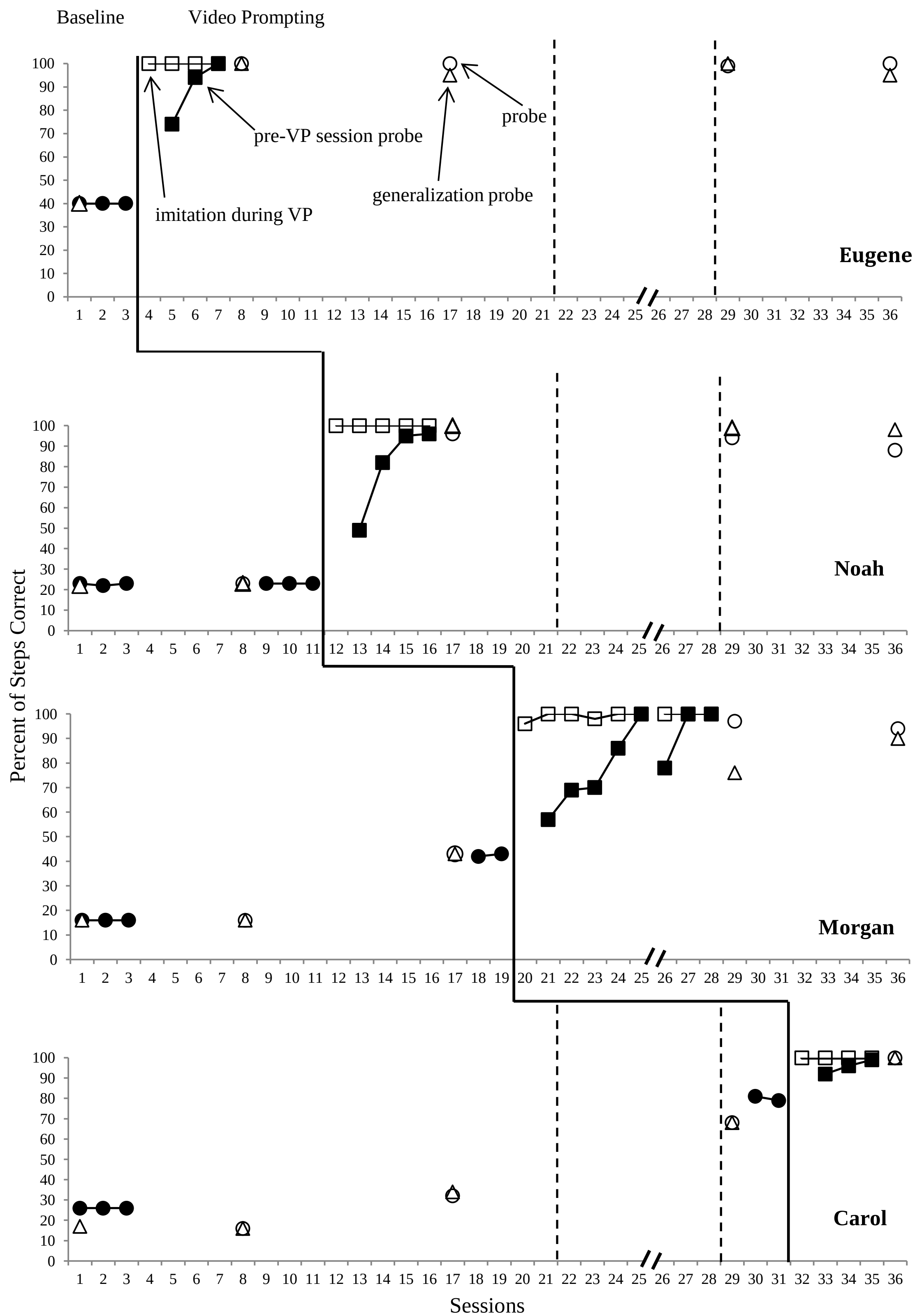

Figure 2. *Percentage of steps completed correctly by the participants for baseline, pre-Video Prompting (VP) session probe, VP, probe, and generalization probe sessions. The scale break designates a week long spring break. The area between the dashed lines represents the sessions in which Eugene, Noah, and Carol received classroom instruction on the target task.*

effectiveness, i.e., the therapeutic change in data support, albeit with limited confidence, the logical conclusion that intervention was effective. Eugene reached mastery criterion in a total of four intervention sessions. Eugene's post-treatment probes for percent of equations solved correctly yielded 100%, 100%, 80%, and 100% correct (sessions 8, 17, 29, 36). His probes on the generalization equations yielded 0%, 100%, 80%, 100%, and 80% correct (sessions 1, 8, 17, 29 and 36). Maintenance and generalization are discussed under a separate heading below.

Following Eugene's intervention condition, all participants were probed on solving equations and the generalization equations. The probe data for Noah, Morgan, and Carol indicated no discernible changes from earlier baseline data; thus, their probe data served as verification of earlier baseline levels.

Noah. Noah correctly solved 0% of five equations across three consecutive baseline sessions (1-3). He completed 23%, 22%, and 23% correct steps for the same sessions. Following Eugene's intervention, Noah's probe yielded 0% correct equations and 23% correct steps. Baseline data were collected for Noah for three additional days to establish clear stability before VP was initiated. As shown by Figure 1 he correctly solved 0% of five equations across three consecutive sessions (9-11), and 23% of steps correct for each of the same sessions. During intervention (sessions 12 – 16) Noah imitated the steps in the video models with 100% accuracy across five consecutive sessions (see Figure 2). Upon introduction of VP, the percent of equations correct did not immediately increase, as indicated by 0% of five equations correct in session 13 (Figure 1). Following session 13, the percentage of equations solved correctly increased, as indicated by an upward, therapeutic trend in the data across sessions 14 – 16 (40%, 80%, 80% correct equations). Noah reached mastery criterion in a total of five intervention sessions. Upon introduction of VP there was a therapeutic change in level from 23% of steps correct in baseline (session 11) to 49% (session 13), followed by an upward trend in the data across sessions 14 - 16 (82%, 95%, 96% respectively). These data provide an initial replication of the therapeutic effects of VP and established a functional relation, albeit with limited confidence given only one replication, between VP and correct completion of target equations and steps. Noah's post-treatment probes for percent of equations solved correctly yielded 80%, 60%, and 40% correct (sessions 17, 29, 36). His probes on the generalization equations yielded 0%, 0%, 100%, 80%, and 60% (sessions 1, 8, 17, 29, and 36).

Following Noah's VP condition, all participants were probed on the target equations and the generalization equations (session 17). The probe data for Morgan and Carol indicated a slight increase in the number of steps completed correctly from earlier baseline data. However, the percentage of equations solved correctly remained at 0% for Morgan and Carol, which served as verification of earlier baseline levels.

Morgan. Morgan correctly solved 0% of five equations across three consecutive baseline sessions (1-3). He completed 16% of steps across all three sessions. Following Eugene's intervention, Morgan's probe yielded 0% correct equations and 16% correct steps. Following Noah's intervention, Morgan's probe yielded 0% correct equations and 43% correct steps. Baseline was reestablished for Morgan in sessions 18 – 19, and he correctly solved 0% of five equations across two consecutive sessions. During the two baseline sessions he correctly completed 42% of the steps (approximately 12 steps per equation) in session 18, and 43% (approximately 13 steps per equation) of the steps in session 19, as shown in Figure 2. During intervention (sessions 20 – 28) Morgan imitated 96% of steps correctly during session 20, 100% in sessions 21 and 22, 98% in session 23, and 100% in sessions 24 - 28 (see Figure 2). Upon introduction of VP, the percent of equations correct did not increase immediately (Figure 1), remaining at 0% across three session (21 – 23). The percentage of equations solved correctly showed a therapeutic upward trend across sessions 24 and 25 (20% and 100%). Although Morgan's percent of equations solved correctly did not immediately increase, his percent of steps completed correctly did improve immediately following the introduction of VP (see Figure 2). Upon introduction of VP there was an immediate therapeutic increase in level from 43% of steps correct in session 19 (baseline) to 57% in session 21 (session 20 was the first day of intervention for Morgan), followed by an upward trend in the data across sessions 22 - 25 (69%, 70%, 86% and 100%, respectively). Following session 25, a week long Spring Break occurred for all participants, resulting in a 10-day gap between sessions 25 and 26, as indicated by a scale break in Figures 1 and 2. As seen in Figure 1, there was a contratherapeutic change in level from 100% of equations correct in session 25 to 0% in session 26. Morgan's data (Figure 2) also show a contratherapeutic change in level from 100% of steps correct in session 25 to 78% in session 26. Although his percent of equations correct decreased to zero for 1 session (26) after the 10-day break, percent correct equations increased to 100% for the next two sessions (27, 28). Data on the percent of steps correct decreased slightly following spring break (from 100% correct on session 25 to 78% on session 26), then increased to 100% for two consecutive sessions (27, 28). Morgan reached mastery criterion in a total of nine intervention sessions. These data provide a second replication of the therapeutic effects of VP and strengthen confidence in the functional relation between VP and correct completion of target steps and equations. Morgan's post-instruction probe data for percent correct of equations yielded 80% for sessions 29 and 36. Morgan's probe data on generalization equations yielded 0% correct for sessions 1, 8, 17, and 29, and 60% for session 36. Following Morgan's VP condition, all participants were probed on solving target equations and generalization equations. The probe data for Carol indicated an increase in the number of steps completed correctly from earlier baseline and probe session data. Her percent of equations solved correctly remained at 0%, serving as verification of earlier baseline levels.

Carol. Carol correctly solved 0% of five equations across three consecutive baseline sessions (1-3). She completed 26% of steps correctly for each of these three sessions. Following Eugene's intervention, Carol's probe yielded 0% correct equations and 16% correct steps. Following Noah's intervention, Carol's probe yielded 0% correct equations and 32% correct steps. Following Morgan's intervention, Carol's probe yielded 0% correct equations and 68% correct steps. After session 29, baseline data were collected for Carol for two additional sessions to reestablish stability before VP was initiated. As shown by Figure 1, baseline was reestablished for Carol in sessions 30 – 31. She correctly solved 0% of five equations across the two sessions and correctly completed 81% of the steps (approximately 24 steps per equation) in session 30, and 79% (approximately 23 steps per equation) of the steps in session 31 (Figure 2). During intervention (sessions 32 – 35), Carol imitated 100% of steps correctly across four sessions e Figure 2). Upon introduction of VP, there was an immediate change in level to 40% in session 33 (Figure 1). Carol solved 80% of equations correctly for sessions 34 –

35. Carol reached mastery criterion in a total of four intervention sessions. Carol's data provided a third replication of the effects of VP and increased the confidence in the established functional relation between VP and solving the target equations. Carol's post-instruction probes for percent correct of equations yielded 100% (session 36). Her probes on the generalization equations yielded 0% correct for sessions 1, 8, 17, and 29, and 100% correct for session 36.

Following Carol's VP condition, all participants were probed on solving equations and the generalization equations.

Maintenance and Generalization

Given a functional relation, some participants' post-instruction probe data provided evidence of maintenance of the effects of VP, as well as generalization of the skill to equations requiring the same number of procedural steps as the target equations, but which involved addition instead of subtraction.

Figure 1 shows the percentage of target equations solved correctly on post-treatment probe sessions for Eugene (sessions 8, 17, 29, and 36). These data indicate that Eugene maintained accurate performance up to 29 sessions after initially demonstrating mastery. Figure 1 also shows the percentage of generalization equations solved correctly in sessions 1, 8, 17, 29, and 36 for Eugene. Data from the generalization probes indicated that correct completion of equations and steps generalized from the target skill to equations which involved addition instead of subtraction, and that generalized responding maintained for the duration of the study.

Figure 1 shows the percentage of target equations solved correctly on post-treatment probe sessions (sessions 17, 29, and 36) for Noah. These data indicate that

Noah maintained accurate responding at the mastery level immediately following treatment (session 17). Noah's percent of equations correct decreased to 60% in session 29. For session 36, Noah's percent of equations correct was 40. These data indicate degradation in performance for Noah during the post-treatment condition; however, Noah's percentage of steps completed maintained at an increased level. Figure 1 also shows the percentage of generalization equations solved correctly in sessions 1, 8, 17, 29, and 36 for Noah. Data from the generalization probes indicated that correct completion of equations and steps generalized from the target skill to equations which involved addition instead of subtraction.

Figure 1 shows the percentage of target equations solved correctly on post-treatment probe sessions (sessions 29 and 36) for Morgan. Post-treatment data indicated that Morgan maintained mastery-level responding (80% of equations correct) in sessions 29 and 36; therefore, he maintained mastery-level responding up to 8 sessions after initially demonstrating mastery. Figure 1 also shows the percentage of generalization equations solved correctly in sessions 1, 8, 17, 29 and 36 for Morgan. Morgan completed 0% of generalization equations correct for sessions 1, 8, 12, and 29, and 60% of equations correct in session 36. Data from the generalization probes indicate that correct completion of steps generalized from the target skill to equations which involved addition instead of subtraction. The number of steps completed correctly on generalization tasks increased, and Morgan's percent of generalization equations solved correctly increased from 0% in sessions 1, 8, 12, and 29, to 60% in session 36.

Figure 1 shows the percentage of target equations solved correctly on post-treatment probe sessions (sessions 36) for Carol. Post-treatment data indicated that Carol demonstrated mastery level responding (100% of equations solved correctly) in session 36. Figure 1 also shows the percentage of generalization equations solved correctly in sessions 1, 8, 17, 29 and 36 for Carol. Data from the generalization probes indicated that correct completion of equations and steps generalized from the target skill to equations which involved addition instead of subtraction.

Figure 2 shows the effects of VP on the percentage of steps completed correctly on generalization equations for all participants. Eugene completed 40% of steps correctly on generalization equations in session 1 (approximately 12 steps per equation), 100% correct in session 8, 95% of steps in session 17 (approximately 28 steps per equation), 100% in session 29, and 100 % in session 36. Noah completed 22% of steps correctly on generalization equations in session 1 (approximately 6 steps per equation), 23% correct in session 8 (approximately 7 steps per equation), 100% of steps in session 17, 99% in session 29 (approximately 29 steps per equation), and 94% in session 36. Morgan completed 16% of steps correctly on generalization equations in session 1 and session 8 (approximately 4 steps per equation), 43% of steps in session 17 (approximately 12 steps per equation), 76% of steps in session 29 (approximately 23 steps per equation), and 90% of steps in session 36. Carol completed 17% of steps correctly on generalization equations in session 1 (approximately 5 steps per equation), 16% of steps in session 8 (approximately 4 steps per equation), 34% of steps in session 17 (approximately 10 steps per equation), 68% of steps in session 29 (approximately 20 steps per equation), and 100% of steps in session 36. Data for Eugene and Noah provided evidence that the percent of steps completed correctly on generalization equations increased only following the systematic introduction of VP. A therapeutic change in level for the percentage of steps correct on generalization equations was observed prior to intervention for Morgan and Carol; however, they did not demonstrate mastery-level responding on generalization tasks until after VP had been introduced.

Summative Data

During baseline, the mean of equations solved correctly was 0% for all participants. The mean of steps completed correctly during baseline was 33%, and ranged from 16% (Morgan) to 81% (Carol), indicating the existence of some prerequisite skills; however, during baseline and all subsequent probe sessions all participants consistently solved 0% of equations correctly. After implementation of VP, each participant demonstrated improved percentage of equations solved correctly, as well as immediate improved percentage of steps completed correctly, and each participant's correct responding continued to improve until mastery criterion of the target task was observed. The mean percentage of steps imitated correctly during VP sessions was 100% across Eugene, Noah and Carol. Morgan's mean percentage of steps imitated correctly was 99%.

CHAPTER 5

DISCUSSION

The purpose of this study was to evaluate the effectiveness of a VP intervention delivered via a mobile technology device (i.e., iPads) on the accurate completion of algebraic equations by high school students with disabilities. The majority of current empirical literature utilizing the various subsets of VBI has targeted functional living skills or social skills training, and there is limited research targeting academic skill development using video modeling (Burton et al., 2013; Cihak & Bowlin, 2009; Prater et al., 2012). This study extended the literature base by using VP via mobile technology to provide independent instruction of chained math tasks (i.e., algebraic equations) for high school students with high-incidence disabilities. This study supports previous findings relating to VBI interventions that targeted math skills (Burton et al., 2013; Cihak & Bowlin, 2009) and contributes to the literature base regarding academic supports for secondary students with disabilities.

The first research question of the study was: Does video prompting with audio prompts, presented with whole-task instruction within a mobile technology format (iPad), result in the (i) acquisition and (ii) maintenance and/or generalization of chained math tasks (i.e., algebraic equations), as measured by the percentage of equations solved correctly and the percentage of steps completed correctly by high school students with disabilities? The data indicated that all participants' percentage of equations solved correctly increased from 0% during baseline to mastery levels following the introduction of VP. Additionally, all participants' percentage of steps completed correctly increased following the systematic introduction of VP. Three participants maintained mastery-level responding during the post-treatment condition, and one participant maintained accurate responding albeit not at the mastery-level. Furthermore, all participants demonstrated an increase in the percentage of generalizations equations solved correctly following the introduction of VP. In response to the first research question, VP with auditory prompts presented with whole task instruction within a mobile technology format did result in increased accurate responding to the point of mastery on the target equations for all participants, maintained accurate responding, and resulted in increased accuracy on generalization equations for all participants. All data discussed herein were based on a specific group of participants within a specific context, and future direct and systematic replications are needed to increase the external validity of the findings.

The second research question was: Does video prompting with auditory prompts, presented with whole-task instruction within a mobile technology format (iPad), result in increased imitation of topographical responses, as measured by the percentage of steps imitated correctly during VP training sessions? All participants imitated topographical responses from the video with 100% accuracy for all sessions, with the exception of Morgan who imitated topographical responses with a mean of 99% accuracy. In response to the second research question, VP did result in accurate imitation of topographical responses for a specific group of participants given the specific context of this study. Future replications are needed to increase the external of the study's findings.

The third research question was: Do participants and practitioners report the video prompting intervention as effective, time-efficient, and/or enjoyable? After all participants had demonstrated mastery, a social validity interview was given to them and the classroom teacher. Based on the social validity questionnaire, all participants "strongly agreed" they enjoyed using the videos and the iPad to learn new math skills. Three participants "strongly agreed," and one participant (Morgan) "agreed" that the videos and iPad taught them how to solve the target equations. Three participants "strongly agreed," and one participant (Noah) "agreed" that using an iPad would be useful for future instruction. Three participants "strongly agreed," and one participant (Noah) "disagreed" that using videos on an iPad to learn math is an efficient use of time. The participants' math teacher "strongly agreed" that the participants reported enjoying the video intervention, "agreed" that the video taught the participants the target skill, "strongly agreed" that VP would be useful for future instruction of math tasks, and "strongly agreed" that the use of VP was an efficient use of the participants' time.

Based on the data, the intervention was effective for teaching all participants to solve algebraic equations that involved (i) using the distributive property, (ii) combining like numerical terms, and (iii) isolating the variable to one side of the equation. On average, students reached criterion within five sessions, which was the equivalent of five school days when provided with 1, 30 – 45 min intervention session daily. Following the implementation of VP, all participants showed improvement in the percentage of equations solved correctly. Furthermore, 3 of 4 participants (Eugene, Morgan, and Carol) demonstrated mastery-level maintenance of the target skill on post-treatment probes of up to x days. Noah demonstrated maintained performance of the target skill, albeit not at mastery-level. All participants demonstrated generalization of the target skill to generalization equations following the introduction of VP. A functional relation was established following the systematic, staggered introduction of VP within four different data series at four different points in time. Though some students showed decreased percent of equations correct during post-treatment, all participants maintained high levels of percent of steps completed correctly.

Limitations

There were some limitations to this study. First, the external validity of the results within one single-case design research study is limited (Richards, Taylor, & Ramasamy, 2013). Extending the results of studies such as the current one to larger populations, settings, and behaviors is achieved via systematic and direct replications (Birnbrauer, Peterson, & Solnick, 1974). Therefore, the generalizability of the study is limited without further replications.

Though the results of the intervention were positive, the results could have been influenced by the idiosyncratic learning histories of the target participants. That is, all participants in this study demonstrated some pre-existing skills in relation to the target task (see Figure 2 for percent of steps completed correctly per session); therefore, the rapid acquisition of the task may have been related to those prerequisite skills. Still, such qualification does not negate that a functional relation was demonstrated.

The study was also limited because the intervention occurred in a segregated setting (i.e., a separate classroom outside of the participants' classroom). Though VP was effective in facilitating increased accurate responding in the controlled setting, the question remains regarding the effectiveness of the intervention in a group setting with individual or groups instruction.

Another limitation was that the classroom math teacher provided some instruction on the target task during the participants' daily math segment from sessions 22 - 28. Eugene and Noah were in the post-treatment phase of the study prior to this, therefore their acquisition and post-intervention probe data through session 17 were independent of the instruction.. However, it should be noted that probe sessions 29 and 36 may not represent true measures of skill maintenance because Eugene and Noah were present during this math instruction on the days sessions 22-28 were conducted. Morgan was receiving intervention from sessions 18 – 28 in the study's separate setting during the math class instruction; therefore, he only received instruction on the skill within the context of the VP intervention. Carol had not yet received intervention by session 22, so her acquisition of the task may have been influenced somewhat by the instruction she received in the classroom prior to beginning VP intervention. Her baseline data are consistent with this with respect to steps correct, which evidenced a change in level during baseline after the classroom math instruction was introduced. However, although her steps complete did increase, additional baseline after her probe on session 29 seemed to stabilize and her percent of equations correct remained at zero for all baseline sessions.

Finally, it should be noted that it is impossible to determine if changes in the dependent variable were the result of the visual component of the intervention alone, or resultant of the visual stimuli in combination with the auditory directions/prompts.

Implications for Practice

Based on this study's findings, there are potential benefits for practitioners to incorporate VP interventions within their classrooms. First, the primary researcher in this study used the iPad to create the video models of approximately 20 min per video.

Creating and implementing the VP intervention using a point-of-view perspective was time-efficient because no model(s) needed training and substantial editing was not required (i.e., as would be the case with VSM). Therefore, the viability of the intervention may prove appealing to practitioners.

Practitioners might consider VP interventions to facilitate the acquisition of secondary grade-level skills for high school students seeking future enrollment in post-secondary institutions. VP interventions may be useful for teaching skills necessary for students with disabilities to satisfactorily complete secondary courses, obtain a high school diploma, and/or pass mandatory college entrance exams.

The minimal weight and size of mobile devices facilitates portability so that students could transport a VP tool across instructional settings throughout the school day, and use the device within their homes for independent practice of targeted skills (e.g., homework assignments; leisure activities).

Through use of the mobile technology devices and VP, practitioners could provide individually tailored, high-fidelity instruction to some students in a whole-group classroom setting while simultaneously delivering in vivo instruction to other learners.

Finally, delivering instruction using mobile technology provides students with an intervention that is potentially motivating and non-stigmatizing (Goodwyn et al., 2013).

Implications for Future Research

The empirical literature has identified interventions for improving math skills for learners with disabilities such as: computer-assisted instruction (Bahr & Rieth, 1989), strategy instruction (Cae, Harris, & Graham, 1992; Jitendra, Hoff, & Beck, 1999; Naglieri & Gottling; 1995), the TOUCHMATH program (Fletcher, Book, & Cihak, 2010), mnemonics (Maccini, Mulcahy, & Wilson, 2007), and self-regulation (Miller, Butler, & Lee, 1998); however, the literature base for mathematics interventions is much smaller in comparison to the literature on literacy interventions (Gersten, Clarke, & Mazzocco, 2007). Therefore, there is a demonstrated need for studies that contribute to the identification of evidence-based mathematics interventions.

Further research is warranted to develop methods of facilitating mathematics skill development for learners with disabilities by improving upon the current study's use of VP via mobile technology devices. Future research should seek to identify additional ways that mobile technology and video modeling can maximize both effectiveness and efficiency for mathematics instruction. Though this study demonstrated that VP combined with mobile technology devices was effective for teaching algebraic equations to the participants, it did not compare the intervention to other independent variables for measures of efficiency. For example, though the intervention was effective, the students might have met mastery criterion in fewer trials using another method of instruction (e.g., errorless learning procedures).

Future researchers should investigate the number of video models shown during intervention sessions. Two video models were used during intervention sessions in the current study, but students may have demonstrated similar levels of responding if only one video was used during daily interventions, and/or longer maintenance of skills if additional video exemplars were used. Future research should explore the effectiveness of using different numbers of videos during instructional sessions in order to increase the efficiency of VP interventions.

Implications for future research also include applying VP and mobile technology to mathematical skills besides algebraic equations (e.g., basic computations, conversions, patterns, geometry skills). Additionally, future research should examine the effects of VP on other content areas such as written expression (e.g., paragraph and sentence formation), reading comprehension (e.g., vocabulary), and science (chemistry equations, formulas). Future research should investigate the effectiveness of VP interventions within natural learning environments (i.e., assigned classrooms and whole group settings). Finally, Future research should investigate the effectiveness of practitioner-created VBI compared to commercially distributed VBI (e.g., *Kahn Academy, MathTV, LearnZillion*).

Despite some limitations and a need for continued research, the results of this study provided compelling evidence of the potential utility of VP combined with mobile technology devices for improving the math performance of secondary students with high-incidence disabilities.

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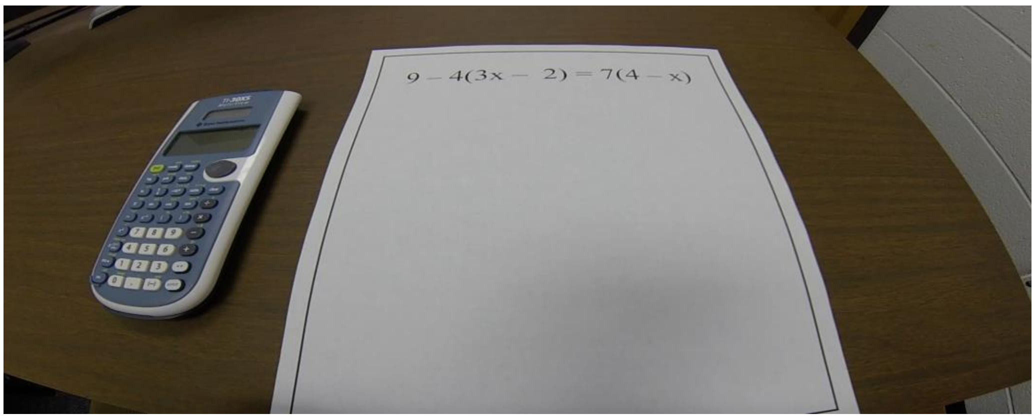
APPENDICES

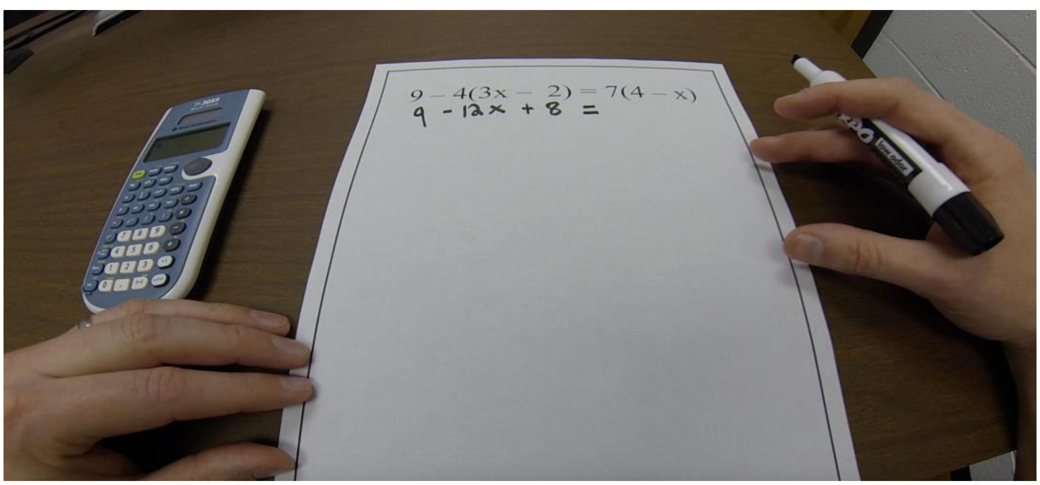
Appendix A

Screenshots of Videos

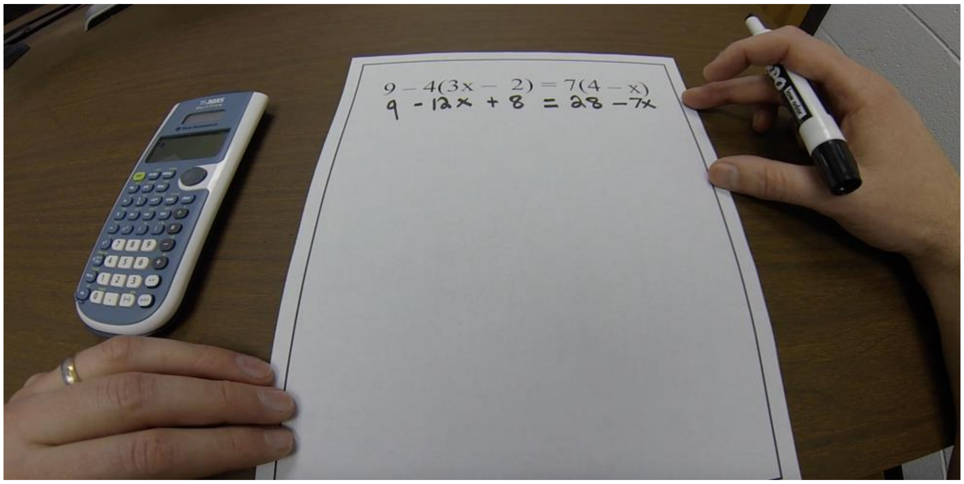
Screenshot of start of video



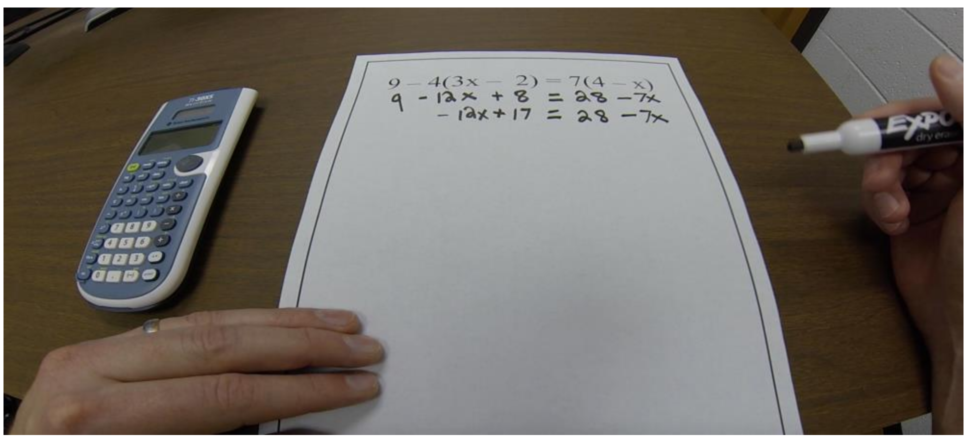
Screenshot of completed steps 1 – 4



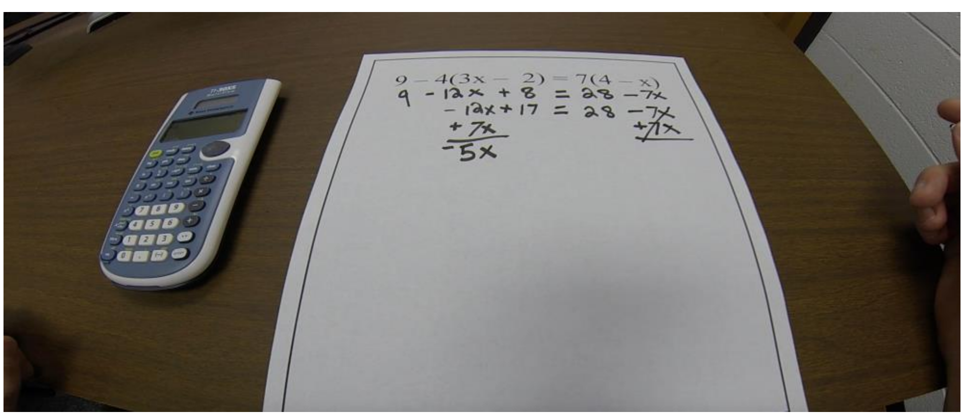
Screenshot of completed steps 5 - 6



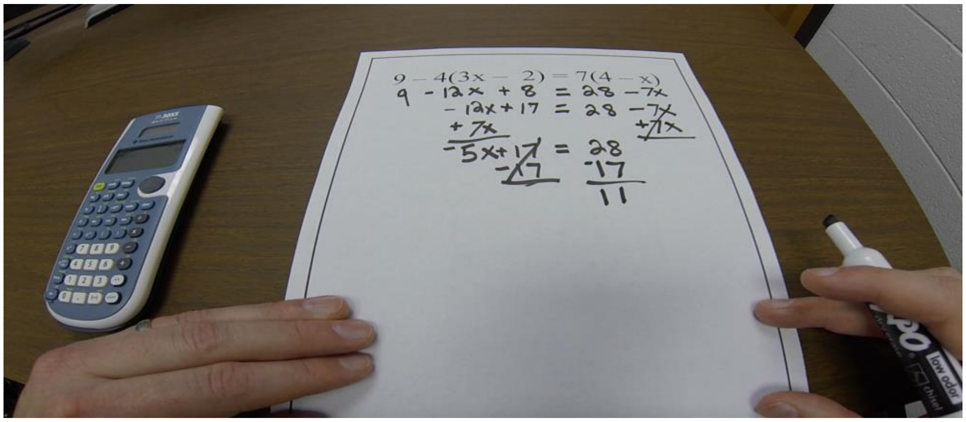
Screenshot of completed steps 7 - 11



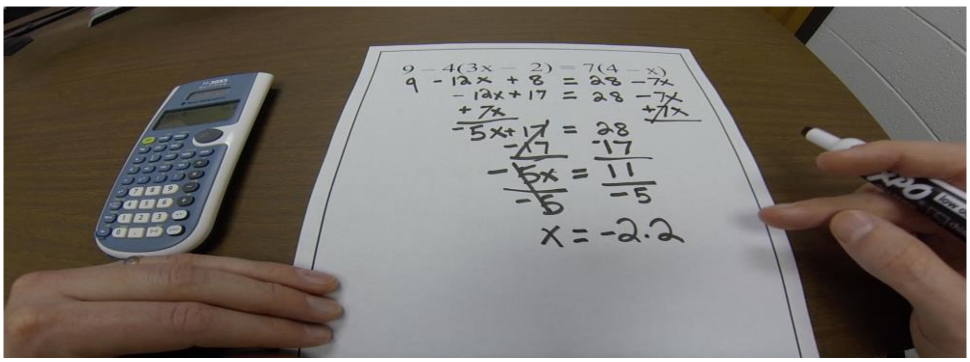
Screenshot of completed steps 12 - 15



Screenshot of completed steps 16 - 22



Screenshot of completed steps 23 - 30



Appendix B
Screening Data Sheet

Student: _______________________ Date: ______________________
Data Collection: For each skill, circle yes or no/before or after instruction, fill in relevant data (e.g., number of seconds or steps completed accurately), and calculate percentages

Screening Tasks	Criteria	Additional Information
Fine Motor Skills	Prints digit 1 – 9 sequentially with minimal overlap Yes or No	Minimal overlap confirmed by secondary independent observer - Yes or No
Calculator Skills	Used calculator to complete division, subtraction, and addition problems with 80% accuracy per computation Yes or No	Percent correct division: ___/10 = ____% Percent correct addition: ___/10 = ____% Percent correct subtraction: ___/10 = ____% Confirmed by independent observer Yes or No
Operations involving variables and negative numbers	Used calculator to solve problems across three consecutive trials Yes or no	Solved three consecutive trials of multiplying variable times whole number: Before Instruction or After Instruction Solved three consecutive trials of adding two variables: Before Instruction or After Instruction Solved three consecutive trials of subtracting two variables: Before Instruction or After Instruction Solved three consecutive trials of adding negative to positive: Before Instruction or After Instruction Solved three consecutive trials of adding positive to negative: Before Instruction or After Instruction Solved three consecutive trials of multiplying negative and positive: Before Instruction or After Instruction Solved three consecutive trials of dividing negative by positive: Before Instruction or After Instruction Solved three consecutive trials of dividing positive by negative: Before Instruction or After Instruction
Target Task Proficiency	0 – 50% of steps completed accurately Yes or No	Percent of steps completed accurately: _____/48 = _____% Confirmed by independent observer Yes or No
Generalization Task Proficiency	0 – 50% of steps completed accurately Yes or No	Percent of steps completed accurately: _____/48 = _____% Confirmed by independent observer Yes or No

Task-Related Construct	Explained relationship between a coefficient and the variable Yes or No	Identified relationship between a coefficient and the variable: Before Instruction or After Instruction Confirmed by independent observer Yes or No
Intelligence and Psychological Evaluation Information	IQ: ____________________ IQ Assessment: ________________ Mathematics Achievement Scores: Assessment: _______________________ Domain:__________ Score: _____ Domain:__________ Score: _____ Domain:__________ Score: _____ Domain:__________ Score: _____	Additional Evaluation Information:
Training Task	Criteria	Additional Information
Contour Combination	Imitated all figures in the contour combination Yes or No	Student pressed pause between steps: Yes or No Number of attempts _________ Confirmed by independent observer Yes or No

Appendix C

Baseline, Pre-VP Probe, Probe, and Generalization Data Collection Form

Pre-VBI Probes Student: ______________________________________

Date																									
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1. Distribute first term on left																									
2. Distribute second term on left																									
3. Drop down constant																									
4. Drop down equal sign																									
5. Distribute first term on right																									
6. Distribute second term on right																									
7. Combine terms																									
8. Drop constant																									
9. Drop equal sign																									
10. Drop right constant																									
11. Drop variable on right																									
12. Write variable under right																									
13. Cross out numbers																									
14. Write variable under left side																									
15. Add variables on left																									
16. Drop constant																									
17, Drop equal sign																									
18. Drop constant																									
19. Write constant under left side																									
20. Cross out cancelling numbers																									
21. Write constant under right side																									
22. Subtract numbers on right																									
23. Drop variable																									
24. Drop equal sign																									
25. Write coefficient under left side																									
26. Cross out can. numbers																									
27. Write coefficient under right side																									
28. Divide numbers on right side																									
29. Drop variable																									
30. Drop equal sign																									
# behaviors imitated correctly																									
% behaviors imitated correctly	/ 150 = %					/ 150 = %					/ 150 = %					/ 150 = %					/ 150 = %				

Appendix D
VP Training Imitation Data Collection Form

Student:______________________________

DATE										
Behaviors	1	2	1	1	2	2	1	2	1	2
1. Distribute first term on left										
2. Distribute second term on left										
3. Drop down constant										
4. Drop down equal sign										
5. Distribute first term on right										
6. Distribute second term on right										
7. Combine terms on left										
8. Drop constant										
9. Drop equal sign										
10. Drop constant on right										
11. Drop variable on right										
12. Write variable under right										
13. Cross out cancel numbers										
14. Write variable under left side										
15. Add variables on left										
16. Drop constant										
17, Drop equal sign										
18. Drop constant										
19. Write constant under left side										
20. Cross out numbers										
21. Write constant under right										
22. Subtract numbers on right										
23. Drop variable										
24. Drop equal sign										
25. Write coefficient under left side										
26. Cross out cancelling numbers										
27. Write coefficient under right side										
28. Divide numbers on right side										
26. Divide numbers on right side										
29. Drop variable										
30. Drop equal sign										
# behaviors imitated correctly										
% behaviors imitated correctly	/60 = %		/60 = %		/60 = %		/60 = %		/60 = %	

Appendix E

Procedural Reliability Data Collection Form for Screening and iPad Training

Date:____________ Participant Observed: ______________________ Condition: ____________________

Directions: If the planned researcher behavior is observed, place a check in the *yes* box. If the planned behavior is not observed, place a check in the *no* box.

Planned Researcher Behaviors	**Observed Researcher Behaviors**
Fine Motor Skills: Participant provided with an index card (with highlighted line) and pencil	yes ☐ no ☐
Fine Motor Skills: Participant given the following directions: "Look at the card. Touch the highlighted line. Write all numbers 1 – 9 on the highlighted line only."	yes ☐ no ☐
Calculator Skills (Addition, Subtraction, Division, Multiplication): Participant provided with worksheet, pencil, and calculator, Researcher demonstrates how to use the calculator to solve one practice problem for each computation type, Participant given the following directions: "Use your calculator to solve all of the problems. Write your answers on the paper."	yes ☐ no ☐
Computation Involving Variables (All skills): Participant provided with white board, marker, and calculator, Researcher says: "Solve the problem." If the student does not solve three trials in a row, the researcher provides brief instruction until participant is able to solve three in a row.	yes ☐ no ☐
Computation Involving Positive and Negative Numbers (All skills): Participant provided with white board, marker, and calculator, Researcher says: "Solve the problem." If the student does not solve three trials in a row, the researcher provides brief instruction until participant is able to solve three in a row.	yes ☐ no ☐
Target Task Proficiency: Participant provided with pencil, calculator, and worksheet containing three equations. Researcher instructs student to "Solve the equations." Student is given as much time as necessary.	yes ☐ no ☐

Target Task Proficiency: Researcher writes a equation on white board and gives the following directions: "Solve the equation." Researcher blocks and completes steps completed inaccurately or not completed within 5 sec latency and 30 sec delay interval. 1 equation only.	yes ☐ no ☐
Generalization Task Proficiency: Participant provided with pencil, calculator, and worksheet containing three equations. Researcher instructs student to "Solve the equations." Student is given as much time as necessary.	yes ☐ no ☐
Task-Related Construct: Researcher first asks participant to identify construct. If student cannot, researcher provides correct response. Researcher has participant demonstrate correct response three times in a row.	yes ☐ no ☐
Off-task behaviors are provided with 1 reminder to "solve the equation"	yes ☐ no ☐
Researcher does not directly answer participant questions regarding procedures to solve the equations during assessment	yes ☐ no ☐

Appendix F
Procedural Reliability Data Collection Form for Baseline, Intervention, and Post-treatment sessions

Date:___________ Participant Observed: _____________ Condition: ____________

Planned Researcher Behaviors	
Participant given a pencil and worksheet containing five equations	yes ☐ no ☐ N/A
Participant attempts five equations on pre-VBI session probes without watching videos	yes ☐ no ☐ N/A
Participant given iPad	yes ☐ no ☐ N/A
Researcher ensures video model is loaded on the iPad screen	yes ☐ no ☐ N/A
Researcher instructs the participant to watch each video model once	yes ☐ no ☐ N/A
Participant watches the videos	yes ☐ no ☐ N/A
While the participant is watching the video, the researcher monitors the participant to ensure he/she is attending to the video	yes ☐ no ☐ N/A
While the participant is watching the video, the researcher redirects the participant's attention to the video if he/she is not attending to the video for more than 2 sec	yes ☐ no ☐ N/A
While the participant is watching the video, the researcher restarts the video model if the participant is redirected	yes ☐ no ☐ N/A
Participant completes a total of three imitation exemplars while watching the corresponding video	yes ☐ no ☐ N/A
Off-task behaviors are provided with 1 reminder to "solve the equation" or "do your best"	yes ☐ no ☐ N/A
Researcher does not directly answer participant questions regarding procedures to solve the equations during assessment or procedural training	yes ☐ no ☐ N/A

Appendix G
Social Validity Data Collection Form for Participants

Name: ________________________ Date: _________________________

Directions: Read the statements below and circle the number that matches your opinion of the statement.

I enjoyed using the video model and the iPad to learn new math skills.	*Strongly disagree* *Disagree* *Agree* *Strongly agree* **1** **2** **3** **4**
The videos and the iPad taught me how to solve equations requiring the distributive property, combining like terms, and moving the variable to one side.	*Strongly disagree* *Disagree* *Agree* *Strongly agree* **1** **2** **3** **4**
I think using videos on an iPad will help me learn new math skills in the future.	*Strongly disagree* *Disagree* *Agree* *Strongly agree* **1** **2** **3** **4**
I think using videos on an iPad to learn math is a good use of my time.	*Strongly disagree* *Disagree* *Agree* *Strongly agree* **1** **2** **3** **4**
What could the teacher change to make iPad instruction better?	

Appendix H
Social Validity Data Collection Form for Classroom Teacher

Name: _________________________ Date: __________________________

Directions: Read the statements below and circle the number that matches your opinion of the statement.

The students seemed to enjoy using the video model and the iPad.	*Strongly disagree* **1**	*Disagree* **2**	*Agree* **3**	*Strongly agree* **4**
The video model and the iPad effectively taught the students how to solve the target equations.	*Strongly disagree* **1**	*Disagree* **2**	*Agree* **3**	*Strongly agree* **4**
The video model and the iPad could potentially facilitate skill acquisition for students during future instruction.	*Strongly disagree* **1**	*Disagree* **2**	*Agree* **3**	*Strongly agree* **4**
The video modeling intervention was an efficient use of the student’s time.	*Strongly disagree* **1**	*Disagree* **2**	*Agree* **3**	*Strongly agree* **4**