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The Effects of Teacher-Implemented Video-Enhanced Activity Schedules on the Academic Skills and Collateral Behaviors of Students with Autism

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Dedication

For my son, Henry Christopher Cho.

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The Effects of Teacher-Implemented Video-Enhanced Activity Schedules on the Academic Skills and Collateral Behaviors of Students with Autism

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Individuals with autism spectrum disorder (ASD) represent a growing proportion of students receiving special education services. Their unique challenges make acquisition and generalization of academic skills difficult, necessitating effective interventions. Unfortunately, research targeting the academic skills of students with ASD is relatively rare and most interventions have been implemented by researchers in a one-to-one context. Therefore, interventions that are feasible for teachers to implement in a classroom setting are needed.

One potentially effective option for teaching academic skills is the use of portable touch-screen devices. Teachers report using these devices frequently in their classrooms and many individuals with ASD prefer technology-based instruction. Two evidence-based approaches that are well-suited for use with portable electronic devices are visual activity schedules (VAS) and video modeling (VM). Evidence suggests that combining these two approaches, so that the user self-prompts by navigating through the images and activating the embedded video models, may decrease reliance on adult-delivered prompts. However, only two previous studies have investigated the use of VAS with embedded VM to teach academic skills to individuals with ASD and neither has described a process for training classroom teachers to use the intervention.

Therefore, the purpose of this study was to describe the process for training a classroom teacher to implement a VAS-VM intervention and to evaluate its effects on the academic skills of students with ASD. A multiple baseline design across students was used to determine the effectiveness of the intervention and to measure untargeted changes in students' stereotypy or other challenging behaviors. Additionally, the researcher conducted probes for generalization across untargeted academic problems and collected maintenance data after the intervention was removed.

Behavioral skills training was effective in training the classroom teacher to implement the intervention with high fidelity. All students demonstrated an immediate improvement in academic performance during intervention, although their performances after intervention was removed were mixed. Additionally, students engaged in lower levels of stereotypy or other challenging behaviors during the VAS-VM intervention. Generalization and maintenance of academic skills was observed.

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CHAPTER 1: INTRODUCTION

Individuals with autism spectrum disorder (ASD) constitute a growing proportion of students receiving special education services and they have unique challenges (e.g., social-communication deficits) which impede acquisition and generalization of skills (American Psychiatric Association, 2013; Office of Special Education Programs, 2017). Although individuals with ASD present with diverse skill profiles, they often exhibit poor performance on academic skills relative to their cognitive abilities, suggesting that these skills require individualized intervention (Keen, Webster, & Ridley, 2016; King, Lemons, & Davison, 2016). The adoption of the Common Core State Standards (2010) has resulted in additional academic expectations and more rigorous testing for all students, further increasing the need to identify effective practices for teaching academic content to struggling learners (King et al., 2016).

Unfortunately, research targeting the academic skills of students with ASD is relatively rare (Keen et al., 2016). Recent systematic reviews focused on teaching reading and mathematics skills to individuals with ASD have identified a narrow range of targeted skills and concluded that no specific intervention can be considered evidence-based (King et al., 2016; Knight & Sartini, 2015). Moreover, most of these interventions have been implemented by researchers in a one-to-one context, providing little information on the feasibility of such interventions for classroom staff. There is also a distinct lack of information on the perceptions of teachers regarding the social validity of the intervention procedures and outcomes (Knight & Sartini, 2015; Lang et al., 2010). Research-based instructional procedures that are both effective in teaching academic skills to students with ASD and manageable for teachers to implement on a regular basis are needed.

One potentially effective and increasingly popular intervention option for educating individuals with ASD is the use of touch-screen device technology (Kagohara et al., 2013). Portable touch-screen devices such as iPads and Android tablets are widely available and have a number of features which make them potentially desirable for use in educational contexts with individuals with ASD. Researchers have found that some individuals with ASD prefer technology-based instruction and perform better during interventions that include electronic devices (Kagohara et al., 2013; Shane & Albert, 2008). Previous literature also suggests that these devices may reduce the frequency of adult-delivered prompts during instruction, which can decrease the likelihood of prompt-dependency (Mechling, 2011; Smith, Shepley, Alexander, & Ayres, 2015).

Additionally, these mainstream devices may be less stigmatizing, more affordable, and offer additional functions compared to devices specifically designed to serve as assistive technology (e.g., highly-specialized speech generating devices). Classroom teachers also report that they find portable touch-screen devices appealing and provide their students with ASD with frequent access to them throughout the school day (Clark, Austin, & Craike, 2015). Importantly, teachers may be more likely to accurately implement and maintain intervention packages that incorporate familiar and preferred instructional approaches (Lang & Page, 2011).

Visual activity schedules (VAS) and video modeling (VM) are two evidence-based procedures for teaching individuals with ASD that are well-suited for use with portable touch-screen devices (Bellini & Akullian, 2007; Knight, Sartini, & Spriggs, 2015). Visual schedules are a series of drawings or photographs that depict the steps for completing a task in a particular sequence (e.g., washing hands, cleaning a workspace; Knight et al., 2015). Video models show an individual engaging in a targeted behavior and are filmed either from the point of view of the person performing the task (POV) or an outside observer (Hine & Wolery, 2006). These strategies may be effective in part because they highlight the salient aspects of the environment and are aligned with the visual processing strengths of many learners with ASD (Soulieres et al., 2009).

Researchers have suggested that combining the two approaches may be more efficient and lead to a decrease in adult-delivered prompts (Kimball, Kinney, Taylor, & Stromer, 2004; Smith et al., 2015). The combination of VAS and VM allows the learner to navigate to an image in the schedule, activate the embedded video model, and complete the appropriate steps of the task before advancing to the next image. The use of VAS-VM may increase students' independence by functioning like a support or adaptation to the environment while they are learning a new skill (Spriggs, Knight, & Sherrow, 2015). Students may also be more motivated to attend to and engage with instructional materials that are presented on an electronic device (Lee et al., 2015; Neely, Rispoli, Camargo, Davis, & Boles, 2013).

Using this approach, students with ASD can be taught to self-prompt, or self-instruct, during work rather than relying on extensive prompting and support from adults (Cullen & Alber-Morgan, 2015). It is also possible that prompts in VAS-VM could be faded more easily than prompts from instructors. For example, students using VAS-VM to complete daily living skills learned to re-play video models as needed and to skip videos for steps they had already mastered (Smith et al., 2016). In a classroom setting, teachers could potentially use this approach to provide more efficient instruction (e.g., leading a small group lesson while periodically checking in with a student using VAS-VM).

Despite the potential effectiveness of VAS-VM for increasing independence and skill acquisition, only two previous studies have investigated its use for teaching academic skills to individuals with ASD and neither has described a process for training teachers to use the intervention (Spriggs et al., 2015; Ledbetter-Cho et al., 2017a). Spriggs and colleagues (2015) evaluated the effects of teacher-implemented VAS-VM on the academic and daily living skills of high school students with ASD. All four students improved their performance of the targeted skills (e.g., algebra equations, paragraph-writing) and demonstrated some degree of generalization to novel academic problems. Students maintained their performance when the intervention was faded to static pictures but long-term follow-up data were not collected.

In a more recent study, researchers taught two children with ASD, ages 9 and 11, to use VAS-VM to complete a variety of academic skills (e.g., identifying synonyms, calculating fractions; Ledbetter-Cho et al., 2017a). Instructors provided redirection when participants made an error by replaying the video and reminding the participant to complete the steps like the video demonstrated. The students demonstrated mastery of the targeted academic skills, generalization to novel problems, and maintenance after the VAS-VM was completely removed. Because one of the participants displayed stereotypy and challenging behavior when accessing electronic devices during leisure activities, researchers monitored these behaviors throughout the study. No increases in stereotypy were observed and challenging behavior gradually decreased throughout the study.

When designing an intervention, it is important for researchers and practitioners to consider how intervention components may impact behaviors that are not directly targeted (i.e., collateral behaviors; Ledbetter-Cho, Lang, Watkins, O'Reilly, & Zamora, 2017). Although researchers have identified desirable collateral effects emerging from interventions (e.g., novel vocal speech), concern exists that the use of electronic devices with individuals with ASD may occasion undesirable increases in stereotypy or challenging behavior (Ledbetter-Cho et al., 2017b; King, Brady, & Voreis, 2017; Ramdoss et al., 2011). To address these concerns, studies that incorporate electronic devices into interventions for individuals with ASD should monitor for the emergence of or increase in these behaviors.

The purpose of this dissertation is to extend previous research on the use of VAS-VM to teach academic skills to students with ASD by training a classroom teacher to implement the intervention in an applied setting. Additionally, teacher input will be sought during the intervention planning (e.g., selection of targeted academic skills, creation of intervention materials), implementation, and evaluation stages. This dissertation will address the following specific research questions:

1) Will behavioral skills training (BST) be effective in training the classroom teacher to use VAS-VM with fidelity?
2) Will students with ASD demonstrate mastery and generalization of academic skills during the VAS-VM intervention and maintain these improvements when intervention is removed?
3) Will students with ASD demonstrate changes in challenging behavior or stereotypy following the introduction of the VAS-VM intervention?
4) How will the classroom teacher and outside observers perceive the social validity of the intervention procedures and outcomes?

CHAPTER 2: A SYSTEMATIC REVIEW OF TABLET-MEDIATED INTERVENTIONS FOR TEACHING ACADEMIC SKILLS TO INDIVIDUALS WITH AUTISM[1]

Academic proficiency has been found to positively impact post-graduation outcomes for individuals with ASD such as employment, independent living, and overall quality of life (Fleury et al., 2014; Migliore, Timmons, Butterworth, & Lugas, 2012). Although students with ASD are entitled to access to the general education curriculum and often included in their school's standardized assessments, their performance on academic skills remains relatively poor (Individuals with Disabilities Education Act, 2004; Keen et al., 2016). Classroom teachers are in need of research-based interventions that are effective for teaching academic skills to students with ASD and feasible to implement within the classroom.

Portable touch-screen devices are already popular with classroom teachers and could potentially be effective in teaching academic skills (Clark et al., 2015). Moreover, these devices have received attention and widespread endorsement in popular media (Knight, McKissick, & Saunders, 2013). A recent *Parenting* article advertises eleven "expert-recommended apps" for autism and describes how their use may improve skills across a variety of domains without referencing supporting research (Willets, 2017).

[1] This literature review has been published in Ledbetter-Cho, K., O'Reilly, M., Lang, R., Watkins, L., & Lim, N. (2018). Meta-analysis of tablet-mediated interventions for teaching academic skills to individuals with autism. *Journal of Autism and Developmental Disorders, 48,* 3021-3036. Ledbetter-Cho designed and conducted the systematic review, performed all data collection and analysis, and wrote the manuscript. O'Reilly and Lang provided guidance and feedback on the review and manuscript. Watkins and Lim conducted interrater agreement.

Given the enthusiasm and adoption of these devices in teaching programs for individuals with ASD, it is important for systematic reviews to illuminate how their use is supported by empirical research.

Touch-screen devices have demonstrated efficacy for improving communication in individuals with ASD, with a recent systematic review reporting generally positive results (Lorah, Parnell, Whitby, & Hantula, 2015). However, the use of touch-screen devices to target academic skills has been investigated in reviews that are focused more broadly on individuals with developmental disabilities (Mechling, 2011; Stephenson & Limbrick, 2015). Although results indicated that interventions were typically effective in teaching the targeted skills, these findings may not generalize to individuals diagnosed with ASD. Moreover, a large number of studies have been published following these reviews which may impact conclusions and treatment recommendations.

Given the widespread adoption of touch-screen devices by parents and teachers of individuals with ASD, in addition to the importance of academic skills, an updated review of the literature is warranted. We extended previous reviews by calculating multiple effect size estimates of outcomes and statistically analyzing the results to identify potential moderating variables. The purpose of the current meta-analysis was to identify how touch-screen devices have been used in teaching programs targeting academic skills of individuals with ASD. Specifically, we sought to (a) identify which touch-screen devices and applications have been used, (b) describe the specific skills targeted, (c) identify teaching procedures used by interventionists, (d) calculate the effect size estimates and identify potential moderating variables, (e) appraise the methodological quality of the included studies, and (f) establish implications for future research and practice.

Method

Protocol Registration and PRISMA Guidelines

The procedures for this review were registered with the PROSPERO International prospective register of systematic reviews (Ledbetter-Cho, O'Reilly, M., Lang, Watkins, & Lim, 2017), a database which publishes protocols from systematic reviews prior to the initiation of data extraction in an effort to reduce reporting bias (Moher et al., 2015). The procedures were conducted in accordance with PRISMA guidelines (Moher, Liberati, Tetzlaff, & Altman, 2009), a set of evidence-based reporting procedures designed to increase the quality of systematic reviews.

Search Strategy

A systematic search was conducted in the following four electronic databases: Educational Resources Information Center (ERIC), Medline, Psychology and Behavioral Sciences Collection, and PsychINFO. Search terms were designed to identify studies that included participants with an autism diagnosis (i.e., autis*, ASD, Asperger*, or pervasive developmental disord*) and the use of a touch-screen device (i.e., mobile technolog*, pocket PC, phone, portable media, Mp3, palmtop comp*, handheld comp*, PDA, personal digital assis*, multimedia device, iPhone, iPod, iPad, portable electronic devi*, or tablet). The search was limited to peer-reviewed articles published in English from

2000 through 2017. Consistent with other reviews examining comparable technology, the year 2000 was chosen because touch-screen mobile devices became widely available following this time period (Mechling, 2011; Nashville, 2009). The first author subsequently conducted ancestry searches of included articles identified through the electronic database search.

The initial database search yielded a total of 427 records. Following the removal of duplicates and non-intervention articles (e.g., systematic reviews, commentaries), the first author screened the full text of 136 articles for inclusion. Nineteen met our predetermined inclusion criteria, 17 from database searches and two from ancestry searches. Figure 1 outlines the search and screening process.

Study Selection

Studies were required to meet multiple inclusion criteria that were determined prior to literature searches. First, studies must have provided intervention to a minimum of one individual diagnosed with an autism spectrum disorder (i.e., Asperger's, ASD, autism, Autistic Disorder, or Pervasive Developmental Disorder-Not Otherwise Specified [PDD-NOS]) per author report, a medical professional, school diagnostic criteria, or alignment with criteria from the Diagnostic and Statistical Manual of Mental Disorders (DSM). If a study included participants who were not diagnosed with an ASD, only the data from participants with ASD were analyzed. Second, only studies that used experimental designs with the potential to demonstrate a functional relation between the intervention and dependent variable (e.g., multiple baseline design, reversal design, group design with appropriate randomization and controls) were considered. Additionally, studies must have utilized touch-screen mobile devices (e.g., iPods, iPads, personal digital assistants) in intervention delivery.

Finally, studies were required to target specific academic skills or academic engagement behaviors. Specific academic skills were defined as students' accuracy during activities in the content areas of language arts, science, social studies, writing, or mathematics (Knight et al., 2013; Machalicek et al., 2008; Root, Stevenson, Davis, Geddes-Hall, & Test, 2017). Academic engagement behaviors consisted of on-task behaviors that took place within the context of an academic task and were necessary for accurate performance (e.g., engagement with academic materials; on-task behavior; Koegel et al., 2014; McCurdy & Cole, 2014). Interrater agreement on the application of the inclusion criteria was conducted on 20% of articles in the database and ancestry searches and reached 100% agreement.

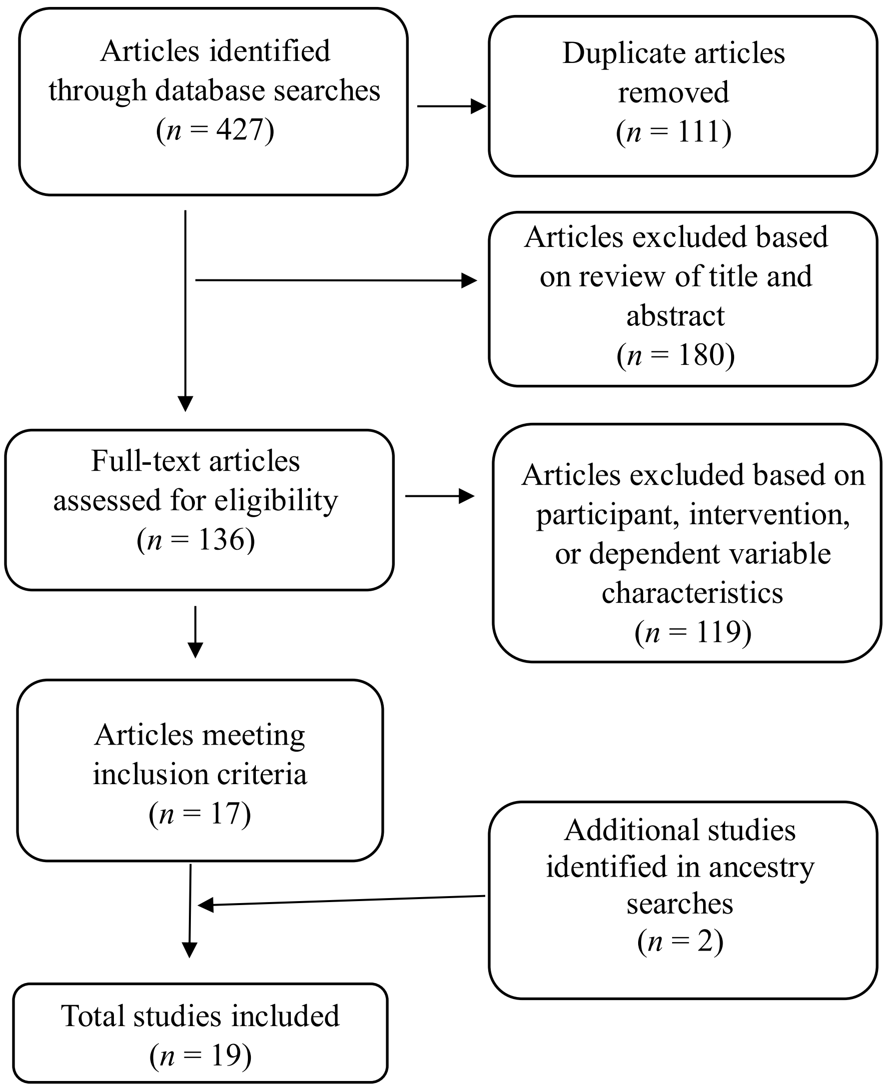

Figure 1: Flowchart of included studies

Data Extraction and Coding

Data extracted from each study are reported in Table 1 and are summarized in terms of: (a) participant characteristics, (b) intervention materials and procedures, (c) dependent variables, (d) outcomes, and (e) research design and rigor. The cost of applications used in the studies are displayed in Table 2. The first author coded and summarized variables from all included studies. Co-authors independently verified the accuracy of the summaries for 30% of studies (Watkins et al., 2014). Interrater agreement was calculated on all coded variables by dividing the number of agreements by the total number of items and multiplying by 100. Interrater agreement was scored across 142 items (e.g., setting, implementer, effect size estimates) and reached 96%. Disagreements were resolved by discussion among co-authors.

Each participant's functioning level was coded as lower, medium, or higher based upon the framework outlined by Reichow and Volkmar (2010). Specifically, individuals with limited vocal communication and/or an IQ below 55 were categorized as lower functioning. Participants were classified as medium functioning when they presented with emerging vocal communication and/or an IQ between 55 and 85. Individuals with well-developed vocal communication and/or an IQ above 85 were categorized as higher functioning.

In order to summarize outcomes using visual analysis, authors examined the data from included studies to code a success estimate for each intervention (Reichow & Volkmar, 2010; Watkins et al., 2017). The success estimate provides a ratio of the number of implementations of intervention where an effect was observed out of the total number of implementations (Reichow & Volkmar, 2010). Success is determined by employing visual analysis as described by the What Works Clearinghouse (Kratochwill et al., 2010; i.e., level, trend, stability, immediacy of effect, non-overlap, and consistency of data).

The Evaluative Method for Determining Evidence-Based Practices in Autism was applied to included studies to determine the quality of research (Reichow, Volkmar, & Cicchhetti, 2008). This method has precedence in systematic reviews of applied intervention research and has demonstrated validity and reliability (Wendt & Miller, 2012; Whalon, Conroy, Martinez, & Werch, 2015). Studies were coded as having strong, adequate, or weak methodological strength based upon the number of primary and secondary quality indicators that they displayed. Primary quality indicators consist of descriptions of participants, independent and dependent variables, baseline conditions, visual analysis of data, and evaluation of experimental control. Secondary quality indicators consist of interobserver agreement (IOA), kappa, treatment fidelity, the use of blind raters, the evaluation of maintenance and generalization of behavior change, and social validity.

Studies coded as having strong methodological rigor received high ratings on all primary quality indicators and displayed a minimum of three secondary quality indicators. Studies classified as adequate received high ratings on a minimum of four primary quality indicators and included two secondary quality indicators. Studies with weak methodological rigor received high ratings on fewer than four primary quality indicators and/or included less than two secondary quality indicators.

Statistical Analysis

In addition to using visual analysis to report outcomes, we calculated nonparametric effect size estimates in an effort to enable broader comparisons across studies. Given that there is no consensus regarding the most appropriate effect size metric for single-case research designs, we adhered to the current recommendation and utilized multiple approaches to estimating effect size. We calculated the improvement rate difference (IRD) and nonoverlap of all pairs (NAP; Kratochwill et al., 2013; Pustejovsky & Ferron, 2017).

IRD is equivalent to the difference between the rate of improvement in baseline and treatment phases and has been widely applied to medical research (Parker, Vannest, & Brown 2009). Advantages of IRD include its alignment with the Phi coefficient and compatibility with visual analysis (Parker et al., 2009). IRD scores above .70 indicate a large treatment effect, .50 to .70 moderate, and scores below .50 indicate small or questionable effects (Parker et al., 2009). NAP represents the proportion of data that are improved across contrasting phases following pairwise comparisons and is mathematically equivalent to the area under the curve (AUC; Parker & Vannest, 2009). Advantages of NAP include its ability to produce valid confidence intervals and its alignment with visual analysis. NAP scores at or above .93 indicate a large treatment effect, .66 to .92 moderate, and scores at or below .65 indicate a small effect (Parker & Vannest, 2009).

In order to prepare data for effect size calculations, graphs from each study were saved as images and imported into the WebPlotDigitizer data extraction software

(Rohatgi, 2017). WebPlotDigitizer has demonstrated validity and reliability for extraction of data from single-case design graphs (Moeyaert, Maggin, & Verkuilen, 2016). Graphed data were converted into numerical data and exported into an excel spreadsheet which organized the raw data from each phase of individual studies. IRD and NAP were calculated using online software (Pustejovksy, 2017).

Effect sizes were calculated for individual participants as well as at the study level. For studies employing multiple baseline, multiple probe, reversal, or combined designs, data from all adjacent AB phases were contrasted (Chen, Hyppa-Martin, Reichle, & Symons, 2016; Pustejovsky & Ferron, 2017). For multielement designs, effect sizes were calculated by conducting between-condition comparisons (i.e., contrasting the data from the two intervention conditions). Two separate IRD and NAP scores were reported for studies using alternating treatment designs. Specifically, effect sizes were calculated by contrasting baseline phases with best treatment phases and by conducting between-condition comparisons (Chen et al., 2016; Pustejovsky & Ferron, 2017).

In an effort to identify potential moderating variables, average IRD and NAP scores were calculated for different study and participant variables (e.g., participant functioning level, research rigor) and are reported in Table 3. We used the Stasitical Package for the Social Sciences (SPSS) to conduct the Mann-Whitney U test to determine if differences between effect size estimates in the different groups were statistically significant (i.e., contained a p-value of less than .05; Mann & Whitney, 1947). The Mann-Whitney U test is appropriate for data with a non-normal distribution, such as the effect sizes calculated for the current review, and is comparable to a non-parametric version of a t-test (McKnight & Najab, 2010).

Results

The procedures and outcomes of the 19 studies included in this review are categorized by the domain of the targeted skills (i.e., academic skills or engagement behaviors) and presented in Table 1. All studies utilized single-case research designs and were published across six different peer-reviewed journals. Table 2 summarizes the variety and cost of the software applications utilized in the studies and Table 3 reports the average effect sizes, standard deviations, and indicates statistically significant differences between groups when examining specific study variables.

Table 1: Summary of included studies

Citation	N of Participants (n female); Age Range*; Functioning Level	Setting; Implementer	Device; Software (Description)	Dosage (per participant); Pre-training on Device; Intervention Procedures	Dependent Variable	Outcomes; IRD; NAP	Design; Rigor
Studies targeting academic skills							
Burton et al. (2013)	*N* = 3 13-15 Medium (2) & Higher (1)	Partitioned area of classroom; Teacher	iPad; Videos (VSM)	*Dosage*: 20-30 min 4 x per week (up to 12 hours) *Pre-training*: None *Intervention*: Participant used VSM	Estimating change on worksheets	Participants mastered, maintained, & generalized to novel problems *VSM*: 1; 1	MBL across participants; Strong
Jowett et al. (2012)	*N* = 1 5;6 Medium	Home; Researcher	iPad; Videos (VSM with narration)	*Dosage*: 209 sessions *Pre-training*: None *Intervention*: VSM with verbal prompts & praise	Number comprehension	Mastered all seven numerals, generalized to new stimuli, & to a new setting *VSM*: .99; .99	Multiple probe across numerals; Strong
Smith et al. (2013)	*N* = 3 11-12 Medium	Classroom; Researcher	iPad; Keynote (audio-visual presentations on science)	*Dosage*: Up to 6 sessions *Pre-training*: App provided prompts *Intervention*: Participant used app which provided instruction & prompts	Answers to science vocabulary questions	All reached mastery criterion in one session; all generalized to paper & pencil questions *Audio-visual presentations*: 1; 1	Multiple probe across participants; Strong
Spriggs et al. (2015)	*N* = 4 (1) 17-19 Lower (2), Medium, (1), & NR (1)	Classroom; Teacher	iPad; My Pictures Talk (visual schedule with POV VM)	*Dosage*: 1 session per day (up to 36 sessions) *Pre-training*: Least-to-most prompting with mastered task *Intervention*: Participants used VM; VP used for two participants	Academic & daily living skills (e.g., setting table, writing paragraph)	All mastered or approached mastery; two required video chunking; all generalized & maintained *VM*: 1; 1	Multiple probe across participants; Strong
Weng & Bouck (2014)	*N* = 3 15-17 Lower (2) & Medium (1)	Classroom; Researcher	iPad; Videos (POV VP)	*Dosage*: Up to 10 sessions *Pre-training*: None *Intervention*: VP; during second intervention phase, constant time delay & most-to-least prompts	Price comparison	Two mastered (one required systematic prompting); two generalized to grocery store *VP:* .27; .65 *VP & error correction:* .50; .75	Multiple probe across participants; Adequate
Yakubova et al. (2015)	*N* = 3 17-19 Medium	Classroom; Researcher	iPad; Videos (POV VM with narration)	*Dosage*: Up to 6 sessions *Pre-training*: None *Intervention*: Participant used VM & checklist researcher reviewed checklist	Fraction word problems	Participants mastered fraction problems & two maintained without VM & checklist *VM*: 1; 1	Multiple probe across participants; Strong

Table 1: continued

Yakubova et al. (2016)	*N* = 4 (1) 5-6 Lower (1), Medium (1), & Higher (2)	Classroom; Researcher	iPad; Videos (POV VM with narration)	*Dosage*: 30 min 3 x per week (5.5 hours) *Pre-training*: None *Intervention*: Participant used VM; primed on checklist	Academic math skills (e.g., double digit subtraction)	All mastered academic skills; three maintained *VM:* .91; .98	MBL across skills; Adequate
Zein et al. (2016)	*N* = 3 9;5-10;11 Higher	Clinic; Researcher	iPad; Space Voyage (app for reading comprehension)	*Dosage*: 20 min 1 x per week (up to 5 hours) *Pre-training*: None *Intervention*: Participant used app which provided prompts; redirections	Comprehension & CB	All more accurate with teacher-based instruction compared to iPad-based instruction; all engaged in less CB during iPad-based instruction *Comprehension*: .81; .90 *CB*: .32; .69	Multielement; Adequate
Studies targeting related classroom behaviors							
Cihak, Fahrenkrog et al. (2010a)	*N* = 4 (1) 6-8 Lower	Classroom; Teacher	iPod; Videos (POV VSM)	*Dosage*: Up to 24 sessions *Pre-training*: MLT & LTM prompting & praise using mastered tasks *Intervention*: Participant used VSM; EC (LTM) & praise	Independent transitions	Participants mastered & maintained after VSM was removed *VSM*: .91; .98	ABAB; Strong
Cihak, Wright, et al. (2010b)	*N* = 3 11-13 Higher	Classroom; Teacher	HP iPAQ mobile; PowerPoint (pictures of on-task behavior)	*Dosage*: 15 min x Up to 23 sessions (up to 5.75 hours) *Pre-training*: MLT to use iPAQ *Intervention*: Participant used iPAQ & self-monitored on index card; teacher occasionally prompted on-task behavior (as in baseline)	On-task behavior	Participants mastered across all environments & teacher prompts were lower compared to baseline *Pictures*: 1; 1	MBL across settings with ABAB; Strong
Clemons et al. (2016)	*N* = 1 17 NR	Classroom; Researcher	Samsung Galaxy Tablet; I-Connect (self-monitoring app)	*Dosage*: 1 hour of pre-training + 30 min x 10 sessions (5 hours) *Pre-training*: Modeling & praise for using app; scoring videos from baseline *Intervention*: Participant used I-Connect to self-monitor; choice of reinforcer	On-task behavior	Mastered & maintained after reinforcement was removed *I-Connect:* 1; 1	ABAB; Adequate

Table 1: continued

Crutch-field et al. (2015)	*N* = 2 14 Lower	Classroom; Teacher	Samsung Galaxy Phone; I-Connect (self-monitoring app)	*Dosage*: Up to 45 min of pre-training + 5 min 3-4 x per week (up to 2.5 hours) *Pre-training*: Verbal prompts *Intervention*: Participant used I-Connect to self-monitor; verbal prompts	Stereotypy / On-task behavior	Participants engaged in lower levels of stereotypy when using app *I-Connect*: .73; .86	MBL across participants with ABAB; Adequate
Finn et al. (2015)	*N* = 4 8;7-9;10 Medium (1) & Higher (3)	Classroom; Teacher	iPad; Data Manager Pro (graphing app)	*Dosage*: Up to 44 sessions *Pre-training*: Modeling, verbal prompts, EC & reinforcement *Intervention*: Participant used WatchMinder & Data Manager Pro to self-monitor, graph performance, & chose reinforcer	On-task behavior	Participants mastered with WatchMinder alone; three showed slight increase with graphing data; two maintained in absence of devices *Self-monitoring:* .97; .99 *Self-graphing:* .97; .99	MBL across participants; Strong
Hart & Whalon (2012)	*N* = 1 16 Medium	Classroom; Teacher	iPad; Videos (VSM with narration)	*Dosage*: 5 min 4 x per week (2.1 hours) *Pre-training*: None *Intervention*: VSM	On-task behavior	On-task behaviors increased with VSM *VSM*: .66; .85	ABAB; Adequate
Lee et al. (2015)	*N* = 2 2-4 NR	Clinic; Researcher	iPad; Photos or SeeTouchLearn (app for matching)	*Dosage*: Up to 9 min x 38 sessions (5.06 hours) *Pre-training*: None *Intervention*: iPad or traditional materials for DTT with EC	Engagement & CB	One displayed more on-task behavior, correct responses, & less CB with iPad compared to traditional materials; other did not show a difference *On-task:* .49; .70 *Correct responses:* .46; .69 *CB:* .51; .72	Multielement & ABAB; Weak
Neely et al. (2013)	*N* = 2 3-7 Lower (1) & Higher (1)	Classroom or home; Researcher	iPad; WritePad (handwriting app) or Little Matchups app	*Dosage*: 5 min 2 x per week (2 hours) *Pre-training*: None *Intervention*: iPad or traditional materials for DTT with LTM prompts, brief escape for CB, & praise	Engagement & CB	Both displayed more engagement & less CB with iPad compared to paper & pencil materials *Engagement:* 1; 1 *CB:* 1 ;1	ABAB; Adequate

Table 1: continued

Siegel & Lein (2015)	*N* = 3 3;3-4;5 Lower	Classroom; Researcher	iPad; Photos (high- or low-context pictures)	*Dosage*: 8-10 min 2 x per day (up to 5.5 hours) *Pre-training*: None *Intervention*: Participant used visual schedule; LTM prompts	Independent transitions	Two performed better with high-context pictures; one performed better with low-context pictures *Photographs:* 1; 1 *High-context versus low-context*: .45; .77	ATD; Strong
Van der Meer et al. (2015)	*N* = 3 4;3-4;11 Lower (2) & Medium (1)	Clinic-based school; Researcher	iPad; Stores2Learn (picture & audio social story)	*Dosage*: 5 min x 18 sessions (1.5 hours) *Pre-training*: None *Intervention*: Participant advanced through social story	On-task behavior	One showed small improvement in on-task behavior; none maintained *Social stories*: .52; .75	MBL across participants with embedded reversal in one tier; Weak
Xin et al. (2017)	*N* = 4 (3) 10-12 Lower (1), Medium (2), & NR (1)	Classroom; Teacher	iPad; Choiceworks app (picture & audio self-modeling)	*Dosage*: 20 min x 30 (10 hours) *Pre-training*: Modeling of app features *Intervention*: Participant used app to self-monitor; identified if target behaviors were performed & received reinforcement or EC	On-task behavior & academic scores	All improved on-task behavior & academic scores when self-monitoring *Facing forward:* .98; .98 *Engagement:* .98; .99 *Looking at teacher:* 1; 1	ABAB; Adequate

*Years;months; f female; App Application; Avg Average; CB Challenging behavior; DTT Discrete trial teaching; POV Point-of-view; SP Stimulus paring; VM Video model; VP Video prompting; VSM Video self-model; VSP Video self-prompting

Participant, Setting, and Implementer Characteristics

A total of 53 individuals (including six females) diagnosed with an ASD participated in the included studies and ranged in age from 2 to 19 years (*M* = 10 years and 5 months). Participants included 32 children (coded for individuals ages birth through 11) and 21 adolescents (ages 12 to 21). Individuals received classification as lower functioning (*n* = 17), medium (*n* = 16), and higher functioning (*n* = 14) according to criteria outlined by Reichow and Volkmar (2010). For six participants, the level of functioning could not be determined due to limited information in the studies.

Interventions were most often conducted in classrooms (*n* = 16), followed by homes (*n* = 2), and clinics (*n* = 2). One study was conducted across two locations (Neely, Rispoli, Camargo, Davis, & Boles, 2013). Interventions were implemented by researchers (*n* = 13) and teachers (*n* = 6).

Devices and Software Applications

Devices priced at less than $600.00 US dollars (USD) were used in the majority of studies and consisted of iPads (*n* = 15; $329.00), iPods (*n* = 1; $199.00), and a Samsung tablet (*n* = 1; $599.00). One study utilized a smart phone which retails for $724.00 and the remaining study included an HP iPAQ mobile for which pricing data was not available.

Table 2 displays the variety and current cost in USD of the software applications used in the included studies and reveals that the applications utilized by most researchers were cost free (*n* = 13). Eight studies used applications that ranged in cost from $1.99 to $13.99 (*M* = $5.99). The applications described in two studies were not available for commercial purchase nor was the cost reported (e.g., I-Connect; Clemons, Mason, Garrison-Kane, & Wills, 2016). Two studies each used two applications or device features in their investigation (Lee et al., 2015; Neely et al., 2013).

Table 2: Summary of software applications in included studies

Application	Cost*	*N* of Studies
Keynote	Free	1
Little Matchups	Free	1
Photograph function	Free	2
PowerPoint	Free	1
See.Touch.Learn	Free	1
Video function	Free	7
Data Manager Pro	$1.99	1
My Pictures Talk	$2.99	1
Space Voyage	$4.99	1
WritePad	$4.99	1
Choiceworks	$6.99	1
Stores2Learn	$13.99	1
I-Connect	Not available	2

*Current prices in pre-tax US dollars retrieved from manufacturer's website

Pre-Training on Devices

In 14 of the included studies, participants operated the touch-screen device during intervention. Of these, six did not provide participants with pre-training on the device (e.g., Burton, Anderson, Prater, & Dyches, 2013). The use of prompting (e.g., verbal prompts, gestural prompts) was described in seven studies, including three studies that reported teaching participants to use the device within the context of a mastered skill (e.g., Spriggs, Knight, &, Sherrow, 2015). In the remaining five studies, the instructor presented and manipulated the touch-screen device during intervention.

Intervention Procedures and Dosage

In addition to the use of a touch-screen device, operated either by participants (*n* = 14 studies) or instructors (*n* = 5 studies), intervention packages included a variety of evidence-based procedures to teach the targeted skills. Studies often described a form of prompting (*n* = 9) to evoke the targeted skill, including least-to-most hierarchies (*n* = 3), priming (*n* = 2), verbal prompts (*n* = 2), time delay, and a system of most-to-least prompts (*n* = 1 each). Three studies utilized error correction procedures (e.g., replaying the video model and instructing the participant to perform the skill a second time; Cihak, Fahrenkrog, Ayres, & Smith, 2010). The use of reinforcement (e.g., delivery of a preferred item) was described in seven studies (e.g., Clemons et al., 2016). Five studies merely provided participants with the touch-screen device and did not describe the use of any prompts, program for reinforcement, nor the delivery of any supplemental instructional procedures (e.g., Spriggs et al., 2015; Van der Meer, Beamish, Milford, & Lang, 2015).

Session length was not reported in seven studies, precluding calculation of the total dosage of intervention. For the remaining studies, session length ranged from 5 to 30 minutes (*M* = 15 minutes) and sessions were implemented one to four times per week (*M* = 3). The total length of interventions ranged from 1.5 to 12 hours (*M* = 5 hours and 10 minutes), with the majority of interventions lasting no more than 5 hours.

Target Behaviors

Specific academic skills were targeted in eight studies. Five studies taught participants to complete mathematics skills (e.g., comparing prices, double-digit subtraction; Weng & Bouck, 2014; Yakubova, Hughes, & Shinaberry, 2016) and two studies targeted reading comprehension (e.g., Zein et al., 2016). One study taught both paragraph-writing and mathematics (Spriggs et al., 2015).

Researchers targeted academic engagement in the eleven remaining studies. Seven studies targeted on-task behavior during academic work, including five studies that taught participants to self-monitor their behavior (e.g., Clemons et al., 2016; Crutchfield, Mason, Chambers, Wills, & Mason, 2015). Independent transitions between activities were targeted in three studies (e.g., Cihak et al., 2010) and two studies compared participants' engagement in academic tasks during teacher-led and iPad-assisted instruction (Lee et al., 2015; Neely et al., 2013).

Four studies evaluated collateral behaviors that were not directly targeted by intervention components. Specifically, three studies targeting on-task behavior during academic work also measured participants' challenging behavior (Lee et al., 2015; Neely et al., 2013; Zein et al., 2016). Following an intervention that taught four participants to self-monitor their on-task behavior during class, researchers measured participants' scores on a vocabulary assessment that was not utilized during intervention (Xin, Sheppard, & Brown, 2017).

Intervention Effectiveness

Intervention outcomes, success estimates, and effect sizes of individual studies are reported in Table 1. Given that some studies reported multiple dependent variables (e.g., Lee et al., 2015) or utilized designs which necessitated the calculation of two effect sizes (e.g., Weng & Bouck, 2014), IRD and NAP were calculated for a total of 28 variables. Effect sizes for dependent variables ranged from small to large, with most variables producing large effect sizes (n = 17; 61%), followed by moderate (n = 6; 21%), and small

(n = 5; 18%). These effect size estimates were consistently aligned with the success estimates determined for each study using visual analysis (see Table 1).

Effect size estimates and their statistical significance were also examined across different variables of the included studies and are reported in Table 3. Participant functioning level did not significantly influence treatment effectiveness, with IRD and NAP scores indicating large effects across functioning levels. Participant age did impact treatment outcomes, with adolescent participants producing significantly higher effect size estimates than children (U_{IRD} = 377.5; p = .037; U_{NAP} = 376.5; p = .036). Effect sizes increased with ratings of methodological rigor. Studies with weak research rigor produced moderate effect size estimates but did not contain enough cases for statistical analysis. NAP scores indicated a significant difference between studies with adequate and strong methodological rigor (U_{NAP} = 324; p = .038) while IRD scores did not reach statistical significance (U_{IRD} = 331.5; p = .051).

With regard to intervention characteristics, interventions in which the participant operated the device (i.e., physically manipulated the device during intervention) resulted in significantly higher effect sizes in comparison to studies in which the instructor manipulated the device (U_{IRD} = 218; p = .007; U_{NAP} = 208; p = .004). Additionally, interventions that provided the participant with pre-training on the device prior to intervention produced significantly better treatment outcomes than those without pre-training (U_{IRD} = 254.5; $p < .001$; U_{NAP} = 250; $p < .001$). Interventions consisting of video modeling and self-monitoring produced large effect size estimates. Self-monitoring interventions resulted in significantly better treatment outcomes in comparison to explicit instruction interventions (U_{IRD} = 99.5; p = .001; U_{NAP} = 100.5; p = .002). Studies using visual supports and social stories did not contain enough cases for statistical analysis but produced moderate to large treatment effects.

Examination of the targeted skills revealed that studies teaching specific academic skills produced the largest effect size estimates, followed by interventions targeting engagement and challenging behavior. However, no statistically significant differences were found. Finally, intervention dosage did not significantly influence outcomes. Effect size estimates ranged from moderate to large and studies with the largest dosage produced the largest effects.

Table 3: Effect size estimates for study variables

Study Variables	*N* of Participants	Mean IRD (*SD*)	Mean NAP (*SD*)
Participant functioning level			
Lower	17	.85 (.17)	.95 (.06)
Medium	16	.95 (.13)	.97 (.10)
Higher	14	.82 (.26)	.92 (.13)
Participant age			
Child	32	.81 (.23)*	.91 (.14)*
Adolescent	21	.89 (.24)*	.93 (.21)*
Research rigor			
Weak**	5	.51 (.11)	.70 (.12)
Adequate	20	.83 (.26)	.91 (.19)*
Strong	28	.95 (.09)	.98 (.04)*
Instructor-operated	9	.66 (.30)*	.77 (.27)*
Participant-operated	44	.89 (.19)*	.95 (.10)*
No pre-training	28	.72 (.27)*	.84 (.20)*
Received pre-training	25	.97 (.07)*	.99 (.03)*
Intervention Type			
Video modeling	23	.88 (.23)	.93 (.21)
Self-monitoring	14	.96 (.08)*	.99 (.04)*
Explicit instruction	10	.71 (.28)*	.83 (.16)*
Visual supports**	3	.73 (.08)	.89 (.03)
Social story**	3	.53 (.17)	.76 (.17)
Targeted Skill			
Engagement	29	.85 (.20)	.92 (.13)
Academic skills	24	.89 (.22)	.93 (.21)
Challenging behavior**	7	.65 (.28)	.82 (.15)
Dosage			
1-3 hours	8	.77 (.23)	.89 (.13)
4-6 hours	16	.71 (.25)	.84 (.15)
10-12 hours**	7	.99 (.02)	.99 (.01)

* indicates significance at the $p < .05$ level; **not enough cases for statistical analysis

Research Strength

All included studies used single-case research designs to evaluate intervention effects on participants' academic skills and engagement. No group designs met inclusion criteria. Studies were most commonly awarded ratings of strong methodological rigor (n = 9). Eight studies met criteria for adequate methodological rigor, with the remaining two studies receiving ratings of weak rigor. Adequate and weak ratings were due to overlap and instability in the data (n = 7), a lack of secondary quality indicators, or a lack of detailed participant description (n = 1 each).

Discussion

This systematic review identified 19 studies that incorporated touch-screen devices into interventions targeting the academic skills (n = 8) or academic engagement behaviors (n = 11) of 53 students with ASD. The majority of studies produced moderate to large treatment effects across participant functioning levels and received methodological ratings of adequate or strong. These findings support the conclusions of previous reviews that suggested interventions using touch-screen devices are generally found to be effective and that research in this area is increasing (Hong et al., 2017; Kagohara et al., 2013). In conjunction with the touch-screen device, most studies used teaching procedures with robust support in the research-base (e.g., prompting hierarchies, systematic reinforcement), which likely contributed to the positive outcomes reported.

Most studies utilized widely available devices (e.g., iPods) and cost-free software applications. It is somewhat surprising, however, that so few commercially designed educational applications were investigated (see Table 2). Rather than using pre-configured applications designed for intervention, researchers often used the device's inherent video or photograph functions to create individualized teaching materials (e.g., video-enhanced activity schedules). Future research should examine the effectiveness of additional commercially designed educational applications on the market, such as those targeting reading or mathematics (e.g., Starfall®, Show Me Math®). In addition to the relative effectiveness of the various applications, usability and other social validity variables should be considered in future comparisons of software and device options.

Only eight studies targeted performance on specific academic skills such as writing, math, and reading comprehension, indicating a clear need for future research on the utility of touch-screen devices for teaching these skills (Kagohara et al., 2013; Stephen & Limbrick, 2015). Six of these studies utilized video modeling or prompting, supporting previous research which has found video modeling effective for teaching a variety of skills to individuals with ASD (Bellini & Akullian, 2007). Five studies taught students to utilize the touch-screen device to monitor their on-task behavior during academic work, including one in which participants monitored their own stereotypy (Crutchfield et al., 2015). Although students with ASD have been taught to use these devices, some tasks may be more complicated to perform on the device than others (require additional steps). For example, students may acquire the skills necessary to play the video model more efficiently than they acquire the skills necessary to use the same device for self-management. Because all but two self-monitoring interventions were implemented within the context of independent work, future research should evaluate the efficacy and social validity of technology-based self-monitoring during teacher-led instruction or group work.

The examination of unintended adverse effects of interventions that use touch-screen devices may have important implications for applied practice. Researchers have suggested that the use of electronic devices in teaching programs for individuals with ASD may lead to increases in untargeted stereotypy or challenging behavior (King et al., 2017; Ramdoss et al., 2011). Alternatively, interventions may produce desirable collateral effects across different skill domains, potentially increasing intervention efficiency (Ledbetter-Cho, Lang, Watkins, O'Reilly, & Zamora, 2017; McConnell, 2002). The results of the current review are promising, with three studies reporting collateral improvements in challenging behavior during interventions incorporating touch-screen devices (Lee et al., 2015; Neely et al., 2013; Zein et al., 2016) and one finding untargeted academic improvements (Xin et al., 2017). However, these findings must be interpreted with caution given the small number of studies that investigated the impact of the interventions on untargeted dependent variables.

Variations in the technology features utilized in intervention packages did not appear to influence treatment outcomes. Components such as voice-over narration and video modeling versus video prompting did not contain enough cases for statistical analysis but the data that were available indicated similar outcomes. These findings are consistent with previous studies that have reported success using various formats and approaches to video modeling (Bellini & Akullian, 2007). Based on these results, practitioners should consider individualizing technology features and teaching procedures based upon the learner's preferences (e.g., conduct a preference assessment on device features prior to intervention).

Studies were primarily conducted in applied settings, such as schools, supporting claims that individuals with ASD can benefit from using touch-screen devices in natural contexts. However, interventions were overwhelmingly implemented by researchers. This is concerning given that some adult instruction appears potentially necessary for learners to acquire targeted skills. Specifically, with the exception of three studies (Burton et al., 2013; Hart & Whalon, 2012; Van der Meer et al., 2015), interventionists used instructional procedures (e.g., prompts, reinforcement) in addition to providing participants with the touch-screen device. Future research that utilizes natural intervention agents and describes the process for training them in replicable detail would be beneficial in determining the feasibility of such interventions. Indeed, classroom teachers have indicated that they feel underprepared to implement interventions involving technology and desire training in this area (Clark et al., 2015).

Regarding moderating variables, interventions in which the participant operated the device produced significantly larger effect size estimates compared to interventions in which the adult manipulated the device (see Table 3). It is possible that requiring students to operate the application increases attending to relevant stimuli, decreasing the need for adult-delivered prompts and increasing independence (Kimball, Kinney, Taylor, &

Stromer, 2004). Additionally, some individuals may enjoy interacting with technology and be more likely to correctly perform the targeted academic skills. Providing participants with pre-training on the device prior to introducing intervention also produced significantly improved outcomes. Participants who did not receive pre-training may have experienced difficulty during intervention due to the necessity of acquiring two skills simultaneously (i.e., navigating the software and learning the targeted skill).

Interventions with adolescent participants produced significantly higher effect size estimates than those with children. This finding could be due to the fact that the targeted academic skills and engagement/self-monitoring behaviors may have been more developmentally appropriate for older participants (Lifter, Ellis, Cannon, & Anderson, 2005). Alternatively, the finding that adolescents benefited more may be due to some characteristic of the interventions more likely to be used with adolescent participants (e.g., self-monitoring, video modeling). Finally, the methodological rigor of the included studies was also found to moderate intervention effectiveness, with studies that received higher quality ratings producing significantly higher effect size estimates. This is most likely due to the method used to appraise research quality: studies with non-overlap of data across adjacent phases received higher marks for methodological rigor which contributed to larger effect size estimates (Reichow et al., 2008).

Limitations

Because all of the options for estimating effect sizes from single-case design studies have limitations, we followed current recommendations to employ multiple measures (IRD and NAP) that estimate the degree of improvement following intervention (Maggin & Odom, 2014). Although alternative effect size measures which could potentially provide a more fine-grained analysis through regression models are beginning to appear in the literature (e.g., standardized mean difference statistics), these measures cannot currently be applied to many of the designs utilized by the included studies (e.g., multielement designs; Pustejovsky & Ferron, 2017; Shadish, Hedges, & Pustejovsky, 2014).

To ensure a minimum level of study quality, we restricted our search to peer-reviewed publications that used an experimental design with the potential to demonstrate a functional relation. Studies that met these criteria were included in the analysis - even if they had ratings of weak methodological rigor - in an effort to provide a comprehensive review of a small research-base. Although there are concerns with including less methodologically rigorous studies in meta-analyses, further restricting inclusion criteria may have inflated positive outcomes (Sham & Smith, 2014).

Because the included studies differed across a number of different variables (e.g., intervention components, dosage, participant age), interpretation of moderator variables should be considered cautiously. For example, interventions in which the participant operated the device included many studies with video modeling, self-monitoring, and explicit instruction. These intervention components, rather than who operated the device, may have contributed to the positive outcomes observed. Finally, interrater agreement at the level of entering search terms during the database search was not collected.

Implications for Practice

Despite these limitations, results from the current review provide evidence that intervention packages incorporating touch-screen devices may be effective in improving the academic skills and related engagement behaviors of students with ASD in applied settings. Only eight of the included studies targeted specific academic skills, indicating that there is limited empirical support for the use of touch-screen devices in teaching academic content. The majority of included studies utilized instructor-created teaching materials. Touch screen devices are only as effective as the underlying instructional procedures and ineffective teaching procedures are not likely to become effective merely by delivery via a touch-screen device. Practitioners are encouraged to individualize touch-screen presented lessons based on the needs of the student and ensure that the instruction provided by the device is aligned with the evidence-base.

This review suggests that touch screen devices are useful in improving academic skills and academic engagement in students with ASD. However, these devices should be viewed as a supplement to carefully-planned instruction involving evidence-based teaching practices. Finally, given the promising outcomes from interventions in which pre-training was conducted, educators should consider training the student to use the device and its software prior to introducing the targeted skill.

CHAPTER 3: METHOD

The purpose of this chapter is to describe the methodology for this study. The first section describes the participant characteristics, setting, target behaviors, and materials in detail. The next section outlines the experimental design, the operational definitions of the dependent variables, and the data collection systems. Finally, a description of the procedures used throughout the different phases of the study is provided. The purpose of this study was to measure the effects of teacher-implemented video-enhanced activity schedules (VAS-VM) on the academic skills and untargeted collateral behaviors (i.e., stereotypy and other challenging behaviors) of students with ASD.

Participants

One female special education teacher was taught to implement the intervention with her students. The teacher held a master's degree in special education with an emphasis in autism and intellectual disabilities, was licensed to teach early childhood and special education, and had 24 years of teaching experience at the beginning of the study. She taught special education at a public elementary school in a self-contained classroom for students in kindergarten through third grade.

Five male students with a diagnosis of ASD participated in the study. All participants communicated vocally and demonstrated generalized motor imitation. Although the classroom teacher provided individualized instruction for each of the students, a formal intervention targeting academic skills from their IEPs had not been initiated previously. All of the students were familiar with navigating the iPad to access preferred content (e.g., videos, applications). However, the iPad had never been used to target their performance on academic skills. Table 4 provides demographic and assessment information for the student participants.

Zayn was a second-grader who communicated vocally in three to four word sentences. He very rarely initiated conversations with adults or peers. His academic IEP goals included using manipulatives to solve one digit addition and subtraction problems. Zayn frequently engaged in vocal and motor stereotypy. Specifically, he would recite scripts from television, make repetitive noises, and gesticulate with his hands and arms (e.g., waving his arms, holding his hands up). Results from the Questions About Behavioral Function (QABF; Matston & Vollmer, 1995), conducted by the classroom teacher, indicated that these behaviors were most likely automatically maintained.

Samuel was a third-grader who communicated vocally in six to eight word sentences. He frequently initiated conversation with adults - both to make requests and to discuss preferred topics - and occasionally initiated conversation with his peers. Samuel's IEP goals included using manipulatives to complete addition problems. He often engaged in motor stereotypy, picking up objects around the classroom and tapping them repetitively on surfaces. QABF results indicated that this behavior was likely automatically maintained.

Mateo was a second-grader who communicated in two to three word sentences and did not frequently initiate conversation with adults or peers. His IEP goals included using visuals and picture models to solve addition and subtraction problems. When presented with demands, Mateo frequently engaged in challenging behavior (i.e., yelling, screaming, crying, hitting and swiping at others). QABF scores suggested that these behaviors were primarily maintained by escape from tasks.

Aiden was a second-grader who communicated vocally in four to five word sentences and appeared to enjoy completing his work. He occasionally initiated conversation with adults - primarily to request items and activities - but rarely spoke to his peers. His IEP goals targeted addition problems with the use of visuals.

Bennett was kindergartener who spoke in one to two word utterances. However, he rarely used speech to request preferred items; instead, he often pointed or led adults to items to indicate his preferences. Bennett's IEP goals included counting using one-to-one correspondence. During work, Bennett often engaged in challenging behaviors (i.e., making loud, high-pitched vocalizations, pounding the table with his fists, or leaving the area). QABF results indicated that Bennett's challenging behaviors were likely maintained by escape from tasks.

Table 4: Participant demographics and assessment information

Participant	Age at the start of the study (years: months)	Ethnicity	Diagnoses	CARS 2 score[1] (level of symptoms)
Zayn	8:4	Asian American	ASD, ID[2], SI[3]	35.5 (mild to moderate)
Samuel	9:1	Hispanic/Caucasian	ASD, ID, SI	38 (severe)
Mateo	7:8	Hispanic/Caucasian	ASD, SI	45.5 (severe)
Aiden	7:7	Caucasian	ASD, SI	44.5 (severe)
Bennett	6:2	Caucasian	ASD, SI	48 (severe)

[1] CARS-2 Childhood Autism Rating Scale – 2nd Edition (Schopler, Van Bourgondien, Wellman, & Love, 2010); [2] ID Intellectual disability; [3] SI Speech impairment

Setting

Study sessions were conducted in a self-contained special education classroom at a public elementary school in the Southwest United States. The classroom served a total of twelve students and was staffed by the teacher and two teaching assistants. The front of the room was furnished with a round table, a rectangular table, cubbies for students' personal belongings, and academic materials (e.g., books, manipulatives). The back of the classroom contained the teacher's desk, additional academic materials, a horseshoe table, a mat and beanbag, two study carrels, and a Smart Board.

Prior to the study, the researcher consulted with the classroom teacher to identify the time during the school day when she preferred to implement the intervention. The teacher chose to implement the intervention during times when she was scheduled to work individually each student. All sessions were conducted while the teacher and participant were seated at a table in the classroom. Throughout the study, the other students and teaching assistants were present in the classroom but engaged in other tasks (e.g., a small group lesson, independent work).

Target Behaviors and Materials

The teacher selected one academic skill from each student's IEP that she wished to target during intervention. She chose skills on which students were not making progress, despite previous instruction. The task chosen for Zayn and Samuel was completing single-digit addition problems using manipulatives. Mateo and Aiden were taught counting on from a numeral. Counting on problems were presented as addition facts using a mixture of numerals and pictures (for example, “8 + ☺ ☺ ☺ = 11”). Bennett’s target skill was counting the total number of images using one-to-one correspondence. His worksheets contained pairs of die with different amounts (for example, a die with one dot and a die with five dots with a correct answer of six). Task analyses for each academic skill were developed with input from the classroom teacher and are presented in Table 5. Task analysis steps were performed for each problem on the worksheet. For example, Mateo and Aiden completed the four counting on task analysis steps for five math problems on each worksheet, for a total of 20 steps.

During each session, students were provided with all materials that were necessary to complete the targeted academic task. Specifically, for completing addition problems using manipulatives, Zayn and Samuel were given a worksheet that contained three single-digit addition problems and a ten frame drawn at the top, red and yellow plastic bears, a number chart, and a pencil. Mateo and Aiden were given a worksheet with five counting on problems, a number chart, and a pencil. For counting images, Bennett was given a worksheet with six problems, a number chart, and a pencil. Worksheets and materials were already being used by the classroom teacher and were not adapted for the study. A video camcorder was also present during each session for the purpose of data collection.

Intervention materials consisted of an iPad air and an external speaker for sound amplification (Leadsound portable mini speaker). The iPad contained a built-in video camera and was pre-loaded with PowerPoint software. To create the VAS-VM schedules for intervention, the researcher and teacher used PowerPoint to embed video models into slides. Each video appeared as a static image on the slide until it was pressed, at which time the video clip played. Slides contained arrows in the bottom left and right corners, allowing participants to transition back and forth. To navigate through a VAS-VM, students selected the first static image in the schedule, activated the embedded video model by pressing play, completed the modeled step(s), and then advanced to the next slide to repeat this sequence. Each VAS-VM included a number of video clips that were short in duration (3 to 14 seconds). There were 25 video clips in video schedules for counting with manipulatives, 16 videos for counting on, and 13 videos for counting images.

The researcher designed and created the video models with input from the classroom teacher. Videos depicted an adult model completing the academic task and included voice-over narration of task steps (Ledbetter-Cho et al., 2017; Spriggs et al., 2015). For example, the model might state, “count all the bears” before counting them.

Table 5: Task analyses for academic skills

Addition using manipulatives (Zayn and Samuel)	**Counting on** (Mateo and Aiden)	**Counting images** (Bennett)
1. Say the first addend 2. Place that number of bears in ten frame while counting aloud 3. Say the second addend 4. Place that number of bears in ten frame while counting aloud 5. Count the total number of bears 6. Repeat the correct total 7. Find total on number chart 8. Write correct total 9. Clear bears from ten frame	1. Say the first addend 2. Count the objects (starting at one after the first addend) 3. Write the correct total	1. Count all the dots 2. Mark the correct total (from three choices)
(Completed for three problems per worksheet)	(Completed for five problems per worksheet)	(Completed for six problems per worksheet)

Experimental Design

A multiple probe across participants design was used to evaluate the effects of the teacher-implemented VAS-VM intervention on the academic skills and collateral behaviors of the students. Phases consisted of baseline, the VAS-VM intervention package, removal of the intervention, and maintenance following a break from the study for a minimum of 15 weeks. Additionally, due to a lack of skill maintenance after intervention was withdrawn, two participants (Zayn and Samuel) participated in additional intervention and fading phases.

Dependent Variables and Data Collection

All data were scored and graphed from video recordings of the study sessions. The primary dependent variable was the percentage of task analysis steps that the participant independently completed for his targeted academic skill (see Table 5). Independent responses were scored when the participant initiated the step within 5 seconds of hearing the task direction or viewing the video model and completed it correctly. If the participant self-corrected their work, their response was scored as independent. Appendices A through C include data sheets for participants' performance on their academic skills.

The secondary dependent variable was participants' engagement in stereotypy or other challenging behaviors (i.e., collateral behaviors). Operational definitions for these behaviors were developed following discussions with the classroom teacher and direct observations. Four students engaged in stereotypy or other challenging behaviors and the operational definitions of these behaviors are reported in Table 6. Aiden did not engage in stereotypy or challenging behavior throughout the study.

Stereotypy and other challenging behaviors were scored from video recordings of sessions using a 10-second partial interval system. Appendix D shows an example of the data collection sheet used with Samuel to score his engagement in stereotypy.

Table 6: Operational definitions of stereotypy or challenging behavior

Participant	Stereotypy or challenging behavior definition
Zayn	Stereotypy: Talking to self (any words that are not numbers), making noises (e.g., a warbling sound, things that sound like "sound effects,"), and/or gesticulating with his hands/arms in a non-functional way (e.g., arms in the air, waving hands/arms)
Samuel	Stereotypy: Tapping an item (a pencil/pen or strip of paper) on a surface (e.g., the table, his knee) two times or more in a row
Mateo	Challenging behavior: Making forceful contact with pencil on paper such that it makes an audible sound, screaming/yelling (words or just sound), waving/ crumpling/ tearing paper, hitting or swiping at others (with or without making contact)
Aiden	Not applicable
Bennett	Challenging behavior: Making a guttural grunt (may or may not include a high-pitched vocalization), leaving seat (including standing up), hitting the table with an open or closed hand such that it makes an audible sound

Interobserver Agreement

The researcher observed and scored the video recordings of each session for participants' performance on the targeted academic skill and their engagement in stereotypy or other challenging behaviors. Doctoral students and masters-level practitioners in behavior analysis independently viewed and scored a minimum of 30% of randomly selected sessions for each phase of the study. For performance on the academic skill, IOA was scored by dividing the number of steps on the task analysis that were in agreement by the total number of steps and multiplying by 100. For stereotypy and challenging behavior, IOA was scored by dividing the number of intervals with an agreement by the total number of intervals and multiplying by 100. Table 7 reports detailed information on IOA collection.

Table 7: Interobserver agreement data

Participant	% of Sessions Collected	Academic Performance: Average (Range)	Stereotypy or Challenging Behavior: Average (Range)
Zayn	39%	97% (93%-100%)	89% (80%-100%)
Samuel	38%	93% (74%-100%)	93% (75%-100%)
Mateo	41%	99% (93%-100%)	96% (83-100%)
Aiden	36%	100%	NA
Bennett	40%	98% (92%-100%)	99% (90%-100%)

NA Not applicable

Treatment Fidelity

The researcher developed a checklist of teacher behaviors that were expected during intervention sessions. The checklist included critical intervention steps (e.g., presenting the correct VAS-VM, providing a prompt if the participant made an error, refraining from prompting if the child independently completed a step). The number of steps varied based upon the number of steps in the participant's task analysis. Appendix E provides an example of a fidelity checklist for implementing intervention to target counting images. The researcher scored treatment fidelity for a minimum of 30% of intervention sessions for each participant (42% of intervention sessions across all student participants). Treatment fidelity reached 94% (range 87%-98%) and was scored by dividing the number of steps performed correctly by the total and multiplying by 100.

Procedures

General Procedures

Sessions were conducted two to three days per week and one to two sessions were run per day. The sessions ranged in length from about 2 to 10 minutes, dependent on factors such as whether or not the VAS-VM was present and how long the skill took to perform. For example, addition with manipulatives included more steps than counting on and counting images; therefore, Zayn and Samuel's sessions consistently lasted longer than the other participants.

Each session began with the classroom teacher presenting the student with the materials and task direction (e.g., "It's time to do math"). Throughout the study, the teacher held reinforcement systems and responses to stereotypy and challenging behavior constant. Specifically, students were told, "first work/then (preferred activity)" at the beginning of the session. When students engaged in stereotypy, the teacher most frequently ignored it and occasionally provided redirection to the task. When challenging behavior occurred, the teacher redirected the student to the task. After students completed their work, they were given access to the preferred activity. These behavior management strategies were already being used by the teacher throughout the school day and were not changed for the purposes of the study.

Behavioral Skills Training for the Teacher

The researcher used behavioral skills training (BST) to train the classroom teacher to implement the VAS-VM intervention. The teacher and researcher met three times, each for 20 minutes, for a total of one hour of training. During each session, the researcher verbally reviewed a treatment fidelity form (see Appendix E) and answered any questions the teacher had. Afterward, the researcher modeled the skill (either with a video model or in vivo) and the teacher scored the researcher's performance. After discussing the score, the teacher practiced the skill by role-playing with the researcher, who provided praise and corrective feedback as necessary. Following the training sessions, the teacher was observed implementing the intervention with a student for two sessions. The teacher scored 100% for both sessions and was considered to have mastered the training.

Baseline

During baseline sessions, the teacher presented the student with a worksheet and gave the task direction (e.g., "do your math," "time to work"). The iPad with the VAS-VM was not present during baseline sessions. The teacher provided generic verbal praise for on-task behavior (e.g., "great working"), re-directed the student if they did not engage with the materials for more than 10 seconds (e.g., "do your worksheet"), and responded to stereotypy and other challenging behaviors as described above in general procedures. No prompting or feedback on the accuracy of the student's work was provided. After the student completed the worksheet, the teacher directed him to a preferred activity. Baseline sessions were alternated with pre-training sessions on the iPad (see below).

Student Pre-training on the iPad

At the request of the teacher, the researcher completed pre-training with the students. They were taught to use the VAS-VM to complete mastered tasks. Each VAS-VM for pre-training consisted of three video clips in which the adult modeled specific tasks (e.g., making patterns, verbally labeling images) and one VAS-VM was used per pre-training session. During these sessions, the instructor presented the VAS-VM to the student and provided most-to-least prompting if the student did not correctly imitate a step depicted in the video. After students independently navigated the pre-training VAS-VM and imitated all of the steps depicted in the videos for two out of three sessions, pre-training on the iPad was considered complete. The data sheet used for pre-training sessions is provided in Appendix F.

Pre-training lasted for four sessions for Zayne (10.5 minutes total), Samuel (9.5 minutes), and Mateo (12 minutes), 11 sessions for Aiden (29 minutes), and five sessions for Bennett (14.5 minutes). Aiden required more sessions in comparison to other participants because he did not initially vocally imitate the videos (e.g., he would arrange the patterns without labeling them aloud as depicted in the video).

VAS-VM Intervention

The teacher began each intervention session by presenting the participant with the materials, including the iPad with the appropriate VAS-VM open, and delivering the task direction. If the participant made an error, the teacher provided most-to-least prompting (i.e., provided a model prompt, gesture prompt, or verbal prompt). As in baseline, the teacher provided generic verbal praise, redirection for off-task behavior, and typical responses for other behaviors (e.g., stereotypy). The teacher also provided behavior specific praise (e.g., “Nice job counting”) one to two times per intervention session.

Withdrawal

After students demonstrated a stable improvement over baseline on their academic performance, the VAS-VM intervention was removed in order to determine if the student would continue to complete the academic skill independently. Procedures during the withdrawal phase were identical to those used during baseline.

Reintroduction of Intervention

For participants who did not continue to correctly perform the skill after intervention was withdrawn, an additional intervention phase was implemented in an effort to program for skill maintenance (Ledbetter-Cho et al., 2017a). This phase was implemented with Zayn and Samuel, using procedures identical to the original intervention phase.

Fading

After Zayn and Samuel demonstrated improved, stable performances during the reintroduction of intervention phase, the video schedules were faded, rather than abruptly removed. Specifically, the audio for the video models was turned off, requiring participants to count aloud and repeat totals without the verbal model.

Modification and Fading

Following discussions with the classroom teacher, sessions were discontinued with Zayn after the fading phase because it was believed that he was no longer attending to the video models and would also benefit from working on pre-requisite skills (e.g., counting more accurately and fluently).

Samuel participated in a final intervention phase in which his worksheet was modified to emphasize the concept of "part plus part equals whole." Specifically, the ten frame at the top of the worksheet was removed and frames were printed above both addends and the blank for the answer for each addition problem. The video models were also edited to reflect placing the bears above each addend and moving them all over to the frame above the blank when it was time to count the total. All other procedures were identical to typical intervention sessions.

Afterward, Samuel participated in two sessions in which the VAS-VM was faded (i.e., the audio for the video models was turned off). The school year ended shortly after and Samuel was not available to participate in additional sessions.

Generalization

Generalization sessions were designed to assess generalization across stimuli (i.e., untaught academic problems) and across contexts (i.e., a small group setting as opposed to one-on-one instruction). Academic problems selected to assess for generalization were probed in baseline but not utilized during intervention sessions. Probes for generalization to untaught academic problems were conducted during the return to baseline for students who demonstrated maintenance of targeted academic problems (i.e., Mateo, Aiden, and Bennett).

Given that sessions were conducted during one-to-one instruction with the classroom teacher, the teacher and researcher wished to evaluate the effectiveness of the intervention in a small group setting. Four participants (Zayn, Samuel, Mateo, and Aiden) regularly participated in small group work during the school day and their performance was evaluated in this setting during baseline and either intervention, the return to baseline, or both, depending on the classroom's schedule.

Follow-up

In order to assess longer-term maintenance of skill improvement, follow-up sessions were conducted with participants after the study had been discontinued for a minimum of 15 weeks. At follow-up, Zayn and Samuel had transitioned to another classroom in the school and Aiden had relocated to a different school. Therefore, follow-up sessions were conducted with Mateo and Bennett using the same procedures as in baseline. Because of Mateo's performance during the first follow-up session, the teacher reminded him, "Do it like the video taught you," prior the second follow-up session.

Social Validity

After the completion of the study, a questionnaire was provided to the classroom teacher to measure her opinions on the social validity of the intervention procedures, targeted academic skills, and the outcomes of the study. The survey contained eight statements with a Likert-type scale ranging from strongly agree to strongly disagree and provided space for comments.

In order to obtain a more unbiased opinion of the study's social validity, the researcher arranged for 13 master's students studying special education to view video clips from the study and complete a questionnaire. The master's students ranged in age from 22 to 36 years (M = 27.5 years) and had all completed foundational coursework in special education. The majority of the students (62%) had one or more years of teaching experience.

Video clips, each lasting 45 seconds, were chosen from baseline, intervention, and withdrawal of intervention sessions. The video clips were chosen because they were considered representative of the participants' typical performance throughout the study (i.e., neither their best nor their worst performance; Lancioni et al., 2006). The order of the clips was randomized and viewers were blind to the condition for each video clip. The questionnaire for each clip consisted of five statements with a Likert-type scale ranging from strongly agree to strongly disagree. Items were designed assess viewer's perceptions of participants' engagement with their work and how a teacher might perceive the effects of the intervention. Additionally, a statement regarding the feasibility and helpfulness of using pre-recorded videos in classrooms was listed at the end of the survey.

RESULTS

Performance on Academic Tasks

Figure 2 displays the percentage of task analysis steps that each participant independently completed for their academic skill across study phases. During baseline, Zayn completed an average of 4% of task analysis steps for addition with manipulatives. Following the introduction of the VAS-VM intervention, his performance immediately increased and he averaged 81% accuracy throughout the phase. When intervention was removed, Zayn's performance decreased to an average of 9% accuracy. His performance improved with the reintroduction of intervention, averaging 90% accuracy, and he continued to perform an average of 75% of steps after the audio was faded from the intervention package.

Samuel did not correctly complete any task analysis steps for addition with manipulatives during baseline. With the introduction of intervention, his performance increased to an average of 91% accuracy per session. When the VAS-VM was removed, Samuel's performance decreased to an average of 28% accuracy. With the reintroduction of intervention, he once again averaged 91% accuracy. Samuel continued to complete an average of 86% of steps when the audio was faded from the VAS-VM. With the modifications to the worksheet and videos (sessions 36 through 38), he completed an average of 97% of steps correctly and maintained an average of 81% accuracy when the audio was removed.

During baseline, Mateo accurately completed an average of 5% of steps for counting on. His performance increased to 98% accuracy during intervention and he continued to complete all task analysis steps correctly after intervention was removed. During follow-up sessions, Mateo completed an average of 76% of steps correctly (95% following the prime prior to follow-up session 2). Aiden completed an average of 1% of task analysis steps for counting on during baseline. With the introduction of the VAS-VM intervention, his performance increased to an average of 88% accuracy. His performance further increased after intervention was removed, averaging 93%. During baseline, Bennett did not complete any task analysis steps correctly. During intervention, he averaged 85% accuracy and his performance further improved after intervention was withdrawn, averaging 98%. At follow-up, Bennett averaged 94% accuracy on task analysis steps during each session.

Figure 3 depicts the percentage of task analysis steps completed independently as well as the number of problems that each participant answered correctly on their worksheets during each study phase. Zayne correctly answered an average of .2 problems (range 0-1) during baseline, 3 during intervention, .66 (range 0-1) during the return to baseline phase, and 3 during the reintroduction of intervention and fading. Samuel did not complete any problems correctly during baseline, averaged 3 correct problems during intervention, 1 when intervention was removed, and 3 throughout the reintroduction of intervention, fading, modification, and modification fading phases. Mateo did not complete any problems correctly during baseline sessions but he accurately completed all

5 problems on each worksheet he was given during the intervention and return to baseline phase. During the first follow-up session, Mateo did not answer any problems correctly. However, after the teacher's prime prior to the second follow-up session, Mateo answered an average of 4.8 problems (range 4-5) correctly on each worksheet.

During baseline sessions, Aiden did not correctly answer any problems on his worksheets. During intervention, he answered all 5 questions correctly on each worksheet and he continued to answer an average of 4.5 problems (range 4-5) correctly after intervention was withdrawn. Bennett did not mark the correct answer to any problems during baseline. He averaged 5.8 problems (range 5-6) correct on each worksheet during intervention, return to baseline, and follow-up sessions.

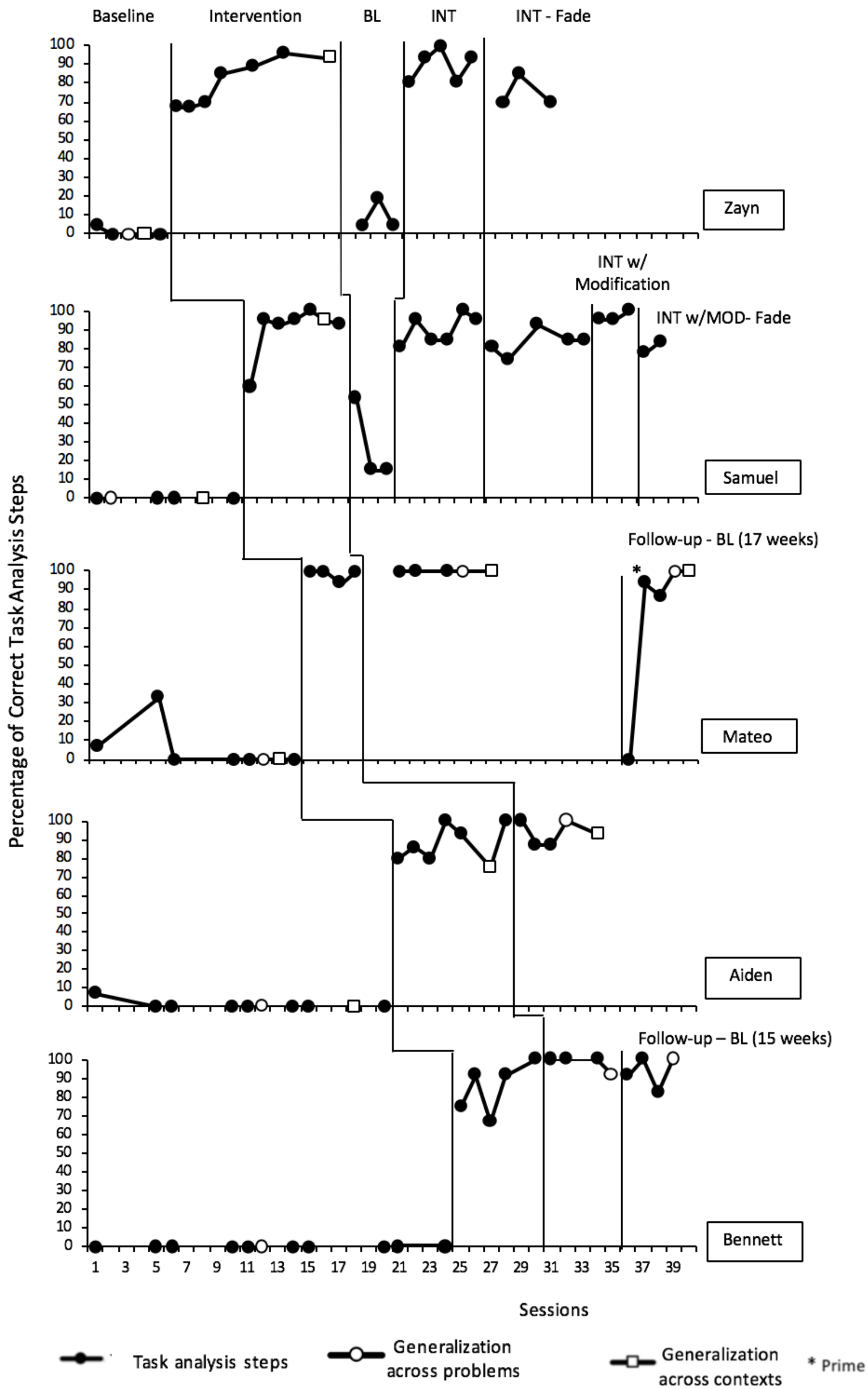

Figure 2: Percentage of task analysis steps completed independently.

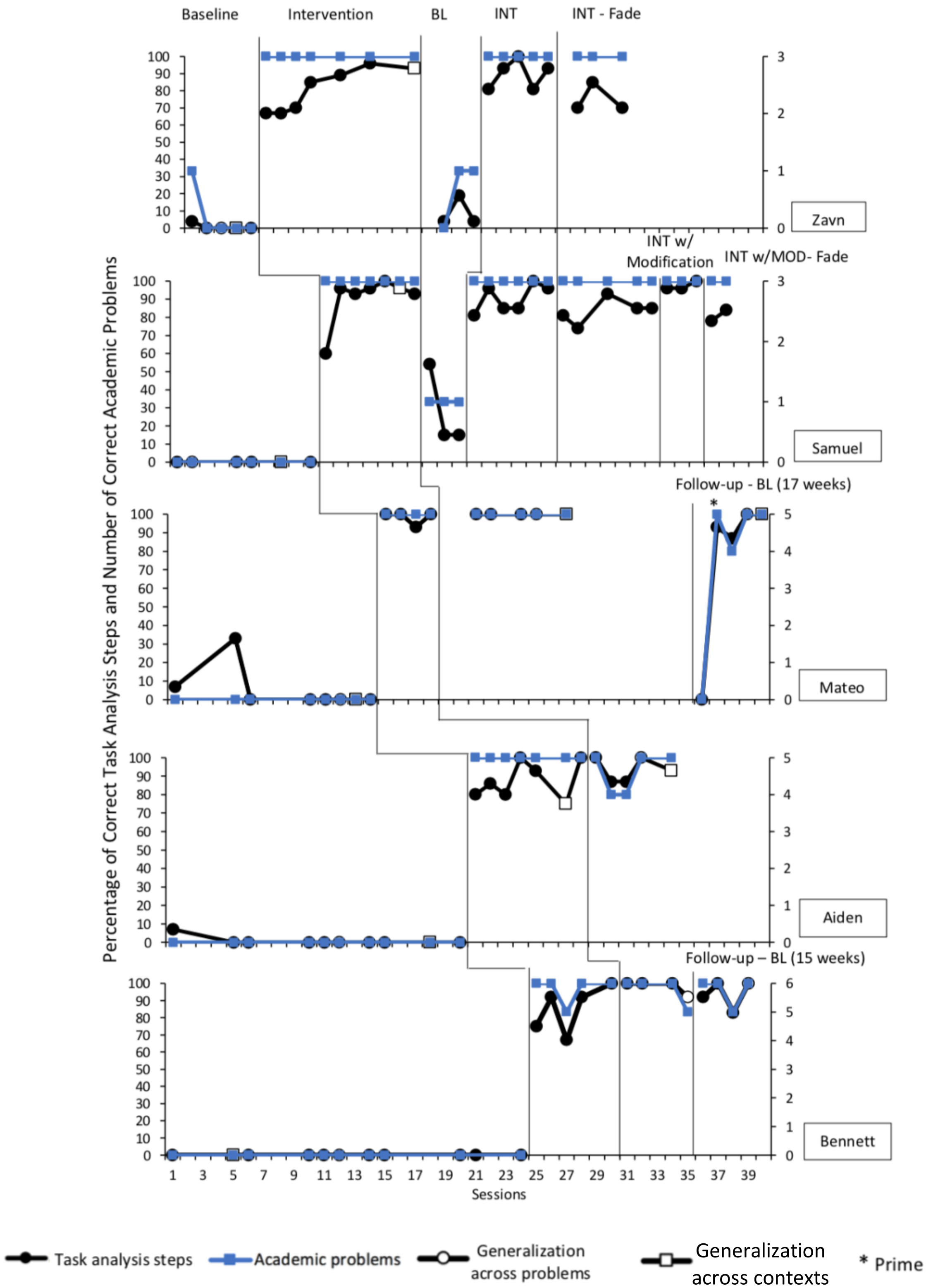

Figure 3: Percentage of task analysis steps completed independently and number of problems answered correctly across study phases.

Generalization

Participants' performance during generalization probes (both to untaught academic problems and to a small group setting) was consistently aligned with their performance during typical sessions. None of the participants completed any task analysis steps correctly during baseline generalization probes. During intervention, Zayne used the VAS-VM in a small group setting to correctly complete 93% of task analysis steps. Samuel completed 96% of steps accurately during the intervention session conducted in a small group (session 16). Zayn and Samuel's generalization to untaught academic problems was not evaluated because they did not demonstrate maintenance of the targeted problems after intervention was removed.

Mateo completed 100% of steps correctly during both generalization probes conducted during the return to baseline and at follow-up. Aiden completed 75% and 93% of steps correctly in a small group setting during intervention and return to baseline, respectively. He also completed the novel set of academic problems with 100% accuracy during the return to baseline (session 25). During the removal of intervention and follow-up phases, Bennett accurately completed 92% and 100% of steps correctly during probes for generalization to untaught problems.

Stereotypy and Other Challenging Behaviors

Figure 4 displays participants' performance on academic tasks as well as the percentage of intervals in which they engaged in stereotypy or other challenging behaviors during each session. Figure 5 presents the data on participants' stereotypy and challenging behavior as averages in each study phase. During baseline, Zayne's engagement in stereotypy was variable and averaged 77% of intervals per session. With the introduction of intervention, his stereotypy slightly decreased and became more stable, averaging 63% of intervals each session. Zayne's stereotypy returned to above baseline levels (an average of 86% of intervals) when intervention was removed. During the re-introduction of intervention and fading phases, his stereotypy once again decreased, occurring in an average 38% and 51% of intervals per session, respectively.

Samuel displayed variability during baseline and engaged in stereotypy for an average of 24% of intervals per session. During intervention, he engaged in slightly less stereotypy per session on average (21% of intervals) but his data remained variable. During the two return to baseline sessions in which stereotypy data were available, he engaged in high levels, averaging 67% of intervals per session. His stereotypy decreased during the reintroduction of intervention and fading phases, averaging 16% and 5% of intervals per session, respectively. During the modified intervention and fading phases, Samuel engaged in very little stereotypy, averaging 0% and 2% of intervals.

Mateo's engagement in challenging behavior during baseline was variable and averaged 41% of intervals each session. During intervention, his challenging behavior remained variable, although he averaged slightly less per session (34% of intervals). During the removal of intervention, his challenging behavior data displayed a decreasing trend and his average engagement was 50% of intervals per session. At follow-up, Mateo engaged in challenging behavior for an average of 61% of intervals per session. During baseline, Bennet engaged in challenging behavior for an average of 30% of intervals each session, with high variability and a decreasing trend. During intervention sessions, he engaged in challenging behavior for an average of 2% of intervals per session. Challenging behavior further decreased during the return to intervention and follow-up phases, averaging 0% and 2.5% of intervals each session, respectively.

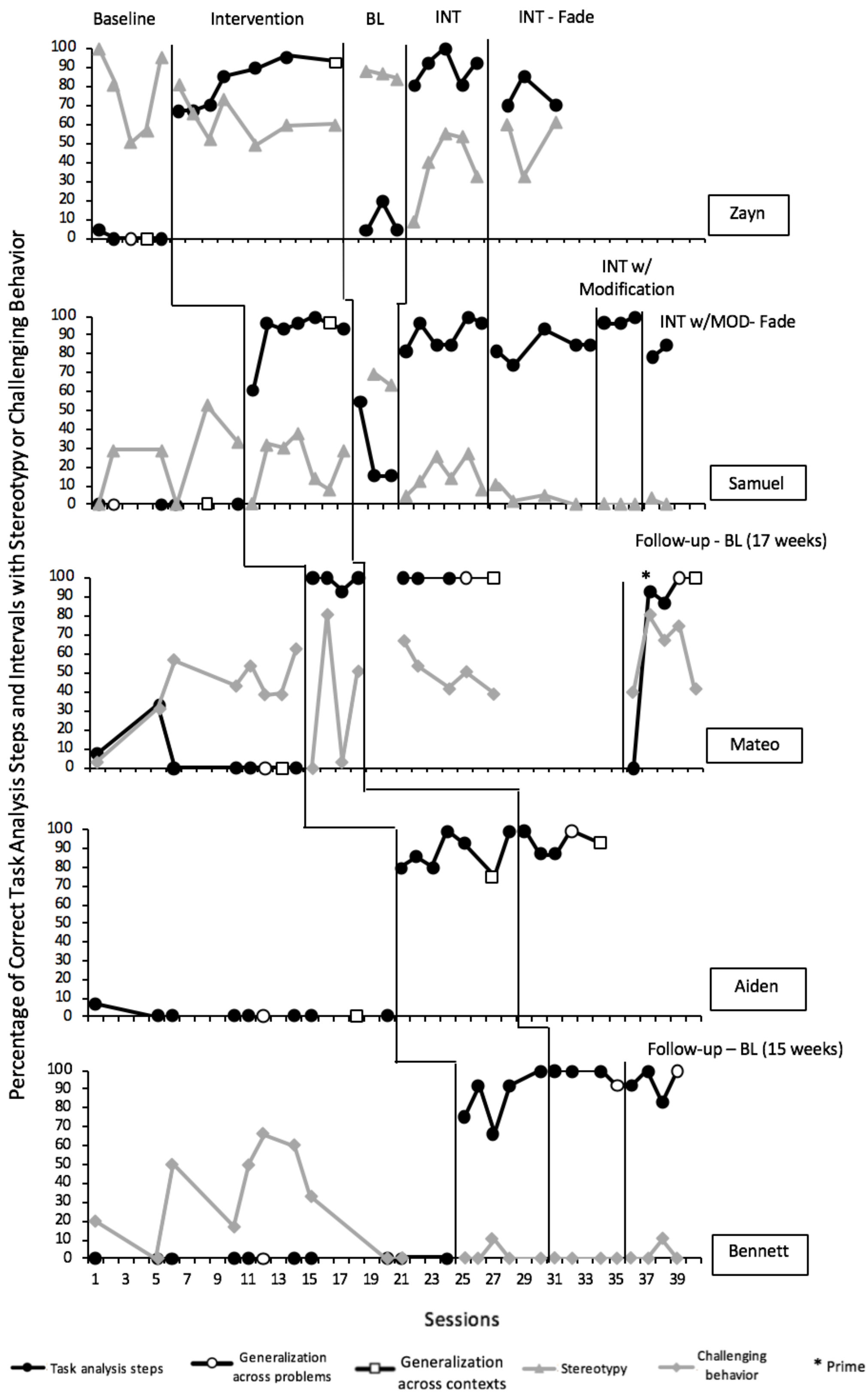

Figure 4: Percentage of task analysis steps completed independently and percentage of intervals with stereotypy or other challenging behaviors.

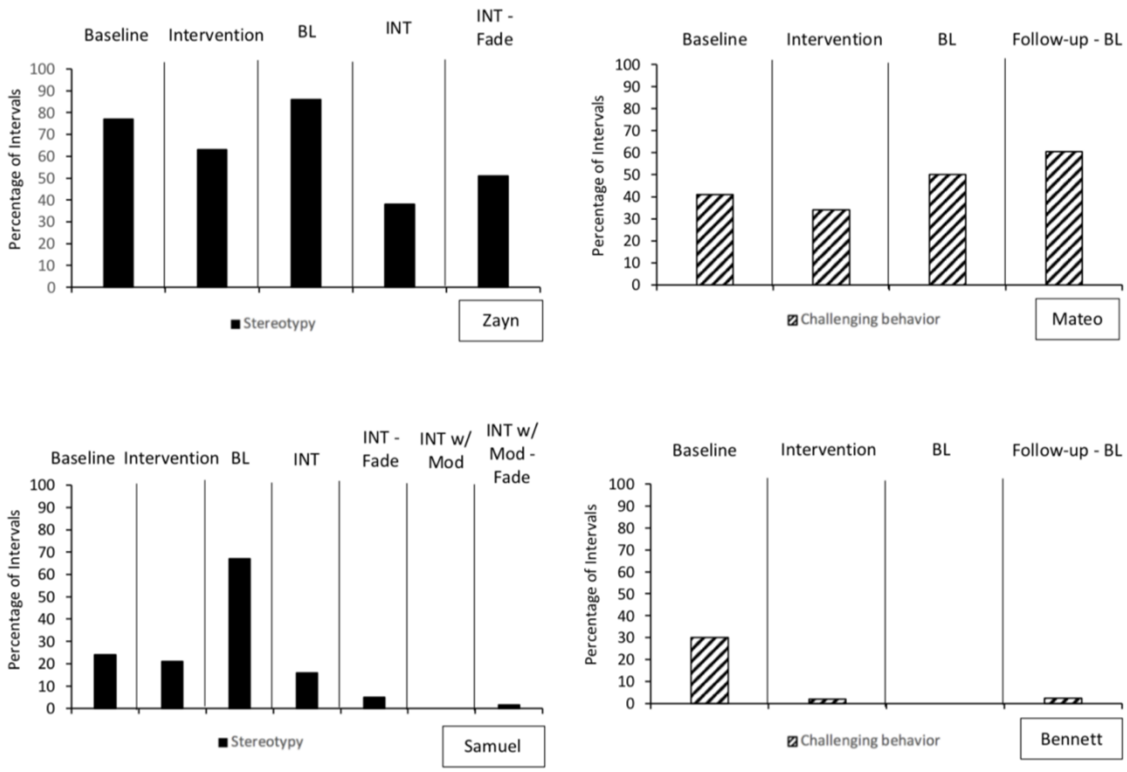

Figure 5: Average percentage of intervals with stereotypy or other challenging behaviors across study phases.

Social Validity

The survey returned by the classroom teacher indicated that she was highly satisfied with the study procedures and outcomes and intended to continue to use the intervention in her classroom. She strongly agreed that the teacher training was effective and efficient, noting that she felt "confident and ready" when it was time to implement the intervention with her students. The teacher also strongly agreed that the academic skills selected were important and that her students' performance on them had improved. She noted that two students had mastered their mathematics IEP goals during the study.

Finally, the teacher strongly agreed that the intervention was helpful in her classroom and that she planned to use it in the future. She indicated that she planned on creating video models for a variety of skills over the break in the school year.

Thirteen master's students studying special education returned the social validity survey after viewing video clips of the participants whose parents provided consent (Samuel, Mateo, and Bennett). Table 8 lists the survey items as well as the mean and standard deviation for each item across participants during baseline, intervention, and withdrawal conditions. Survey items were related to participant's engagement in their work and with materials, challenging behavior, accuracy, and whether or not a teacher would find their behavior agreeable. Higher scores indicate a more desirable performance.

Raters indicated that Samuel improved on all items during intervention (*M* = 4.81, range = 4.53 - 4.91) in comparison to baseline (*M* = 3.16, range = 1.84 - 4.53) and that these improvements were maintained after intervention was removed (*M* = 4.09, 3.30 – 4.69). Mateo's ratings were mixed, with viewers indicating that he displayed more accuracy and appropriate use of materials during intervention and withdrawal conditions in comparison to baseline. However, they indicated that his engagement in work and challenging behavior were most appropriate during baseline. On average, Mateo's scores were most positive during intervention (*M* = 3.24, range = 2.76 – 3.61), followed by baseline (*M* = 3.01, range = 2.00 – 415), and the withdrawal phase (*M* = 2.93, range = 2.23 – 3.76).

Viewers perceived Bennett as performing best during the withdrawal phase (M = 4.40, range = 3.84 – 4.76), followed by intervention (M = 4.26, range = 3.84 – 4.46), and baseline (M = 1.89, range = 1.23 – 2.69). On the general statement regarding the use of an iPad with pre-recorded videos in the classroom, raters provided an average score of 4.07 (range 3 - 5), indicating agreement that the intervention would likely be helpful and feasible in the classroom.

Table 8: Social validity questionnaire and results

1. The student is engaged with his work.
2. The student is not engaging in challenging behavior (e.g., yelling, crying, repeating phrases unrelated to work, drumming on the table).
3. A teacher would find the students' behavior agreeable/likeable.
4. The student is following the correct steps to complete his work.
5. The student is interacting with the materials in a manner similar to a typical peer.

General statement: Using an iPad with pre-recorded videos would be feasible and helpful in the classroom.

Participant	Item	Baseline *M SD*	Intervention *M SD*	Withdrawal *M SD*
Samuel	1	3.53 (1.33)	4.92 (0.26)	4.38 (0.92)
	2	4.53 (0.74)	4.92 (0.26)	4.69 (0.60)
	3	3.38 (1.21)	4.92 (0.26)	4.38 (0.83)
	4	1.84 (0.86)	4.76 (0.42)	3.30 (0.99)
	5	2.53 (1.00)	4.53 (0.63)	3.69 (1.20)
	average	3.16 (1.39)	4.81 (0.42)	4.09 (1.06)
Mateo	1	4.15 (0.36)	3.61 (1.00)	3.76 (1.24)
	2	3.23 (0.79)	3.15 (1.02)	2.38 (1.00)
	3	3.38 (0.50)	3.38 (0.96)	2.84 (1.06)
	4	2.61 (1.07)	3.30 (0.99)	3.46 (1.27)
	5	2.00 (0.55)	2.76 (1.12)	2.23 (0.97)
	average	3.07 (1.01)	3.24 (1.05)	2.93 (1.26)
Bennett				
	1	2.69 (1.20)	4.30 (0.82)	3.84 (0.76)
	2	2.30 (0.82)	4.46 (0.63)	4.76 (0.42)
	3	1.76 (0.42)	4.38 (0.83)	4.30 (0.91)
	4	1.23 (0.42)	4.30 (0.91)	4.61 (0.48)
	5	1.46 (0.49)	3.84 (0.76)	4.46 (0.49)
	average	1.89 (0.91)	4.26 (0.82)	4.40 (0.71)

General statement: *M* = 4.07 (*SD* = .79)

Statements were rated on a Likert-type scale which ranged from 1-5 (strongly disagree to strongly agree). Higher values represent more positive outcomes.

DISCUSSION

The purpose of this study was to evaluate the effects of a teacher-implemented video-schedule intervention on the academic skills and collateral behaviors of students with autism. One special education teacher and five of her students with autism participated in the study. During baseline sessions, in which no corrective feedback was provided, students completed very few to none of the steps necessary for the targeted academic skills. After students completed pre-training on how to use the video schedules, intervention was introduced by the classroom teacher. The intervention package consisted of an iPad-based VAS-VM schedule depicting the correct way to complete academic problems and teacher-delivered most-to-least prompts if the student made an error. During intervention, all students demonstrated an immediate increase in the number of steps completed independently and they correctly answered the majority of problems on their worksheets. Participants' performances after the intervention was removed were mixed. Additionally, participants engaged in lower levels of stereotypy or other challenging behaviors during the VAS-VM intervention. This intervention package is hypothesized to have been effective because participants may have preferred technology-based instruction and been more motivated to attend to and imitate the video models correctly.

This chapter will discuss the results of the study as they relate to the following research questions: a) Will BST be effective in training the classroom teacher to use VAS-VM with fidelity?; b) Will students with ASD demonstrate mastery and generalization of academic skills during the VAS-VM intervention and maintain these improvements after intervention is removed?; c) Will students with ASD demonstrate changes in challenging behavior or stereotypy following the introduction of the VAS-VM intervention?; and d) How will the classroom teacher and outside observers perceive the social validity of the intervention procedures and outcomes? Afterward, this chapter will address the limitations of the current study as well as identify directions for future research and implications for practitioners.

Effects of Teacher Training

A BST package, consisting of verbal and written rules, modeling, and role-play with feedback, was used to train the classroom teacher to implement the video-enhanced schedule intervention with her students. A total of one hour of training was provided and the teacher averaged 94% fidelity on intervention steps per session. This is the first study to utilize VAS-VM to target the academic skills of students with autism and describe a process for teacher training. The positive outcome is aligned with findings from previous research indicating that BST is effective in training practitioners to implement a variety of interventions with learners with autism (Brock et al., 2017). It is possible that the teacher in the current study learned to correctly implement the intervention in a relatively brief period of time because she expressed an interest in training and appeared motivated to learn to use the technology in her classroom (Clark et al., 2015; Lang & Page, 2011). Although the results are encouraging, future research should investigate effective ways to train additional intervention agents (e.g., teaching assistants, paraprofessionals), particularly those who may not have requested the training themselves.

Intervention Effects on Academic Performance

Participants' performance on academic skills from their IEPs (i.e., addition using manipulatives, counting on, and counting images) was evaluated prior to, during, and after the teacher-implemented VAS-VM intervention. Academic performance was measured according to task analysis steps for each skill. For example, counting on task analysis steps consisted of saying the first addend, counting the objects, and writing the correct answer. Additionally, the researcher recorded the number of problems for which participants wrote the correct answer on their worksheet. All participants demonstrated an immediate increase in the number of task analysis steps and problems answered correctly when intervention was introduced. Three participants (Mateo, Aiden, and Bennett) maintained the improvement in academic performance when intervention was removed. The remaining two participants (Zayn and Samuel) required additional intervention sessions and fading of intervention components; they did not demonstrate skill maintenance in the complete absence of intervention.

The positive results of the intervention support previous research demonstrating the effectiveness of tablet-mediated interventions targeting the academic skills of students with autism (Hong et al., 2017; Kagohara et al., 2013; Ledbetter-Cho et al., 2018). The current study also extends previous research on VAS-VM interventions by utilizing a classroom teacher as the interventionist, including younger participants who exhibited severe symptoms of autism, and evaluating their performance in the complete absence of intervention (c.f., Spriggs et al., 2015). The positive outcomes were likely due, in part, to the video modeling component of the intervention. Video modeling has been established as an evidence-based practice for teaching a variety of skils to individuals with autism (Bellini & Akullian, 2007) and was identified in Chapter 2 as an intervention component that produced significantly larger effect size estimates in comparison to other strategies. It has been hypothesized that video modeling aids learners with autism by emphasizing the salient aspects of the environment and capitalizing on the visual processing strengths often demonstrated by these individuals (Bellini & Akullian, 2007; Soulieres et al., 2009).

Additionally, the results support the findings from Chapter 2 that providing the participant with pre-training on the device and allowing them to operate the device during intervention both produced significantly improved outcomes. Requiring the participant to manipulate the device while they engage in an academic skill may increase their attention to the relevant stimuli, improving their accuracy and decreasing the need for adult-delivered prompts (Kimball et al., 2004). It is also possible that participants preferred the use of technology-based instruction and were motivated to attend to the video models (Kimball et al., 2004; Ledbetter-Cho et al., 2018). Finally, the presentation of shorter video clips, or “chunks,” has been found to be more effective than longer video models. It is possible that the brief videos promoted participants’ attending and acquisition of the academic skills. Overall, the results from the current study suggest that practitioners should incorporate evidence-based strategies (e.g., video modeling, prompting) into intervention packages that are delivered via electronic devices. Additionally, it is recommended that learners are taught to use the technology before intervention is introduced and that they continue to operate the device during intervention.

It is interesting that both Zayn and Samuel, who shared the academic goal of addition with manipulatives, did not demonstrate mastery of the skill in the absence of the intervention. Their skill required more steps in comparison to the other targeted skills (see Table 5) and may have been more difficult for them to acquire during the time frame of the study. Additionally, Zayn and Samuel both engaged in relatively high rates of stereotypy that were hypothesized to be maintained by automatic reinforcement. This may have interfered with their acquisition of the academic skill.

Generalization across contexts (i.e., one-to-one instruction versus small group) was observed for all participants for whom it was evaluated. Additionally, participants who maintained their targeted skill in the absence of intervention (i.e., Mateo, Aiden, and Bennett) each demonstrated generalization to untaught academic problems. It is possible that the use of multiple exemplars of video models and academic problems may have facilitated this generalization (Stokes & Baer, 1977). Additionally, participants were observed stating the steps to their work out loud after the video schedules were removed. Researchers have referred to this behavior as verbal rehearsal and verbal self-regulation and suggested that it may promote maintenance and generalization of correct responses (Flavell, 1970; Taylor & O’Reilly, 1997). These results suggest that, to maximize efficiency, teachers may only need to directly teach a small subset of academic problems and measure for generalization after the student demonstrates mastery. Additionally, students received pre-training and initial intervention sessions in a one-to-one context before demonstrating generalization to a small group setting. It is possible that teachers could (a) provide the initial instruction in a small group setting or (b) teach one academic skill via video-schedules in a one-to-one context and use the same intervention to target additional academic skills in a small group setting.

In an attempt to extend the literature, we collected long-term maintenance data (15-17 weeks) for participants who were available at follow-up. Bennett demonstrated maintenance of the targeted skill while Mateo required priming prior to one session to demonstrate skill mastery. Similarly to generalization, skill maintenance may have been promoted by the multiple exemplars provided during intervention or participants' engagement in verbal self-regulation. Alternatively, following the conclusion of the study, the teacher may have taught participants mathematics skills that included components of the skills targeted during the study. For example, at follow-up, the teacher reported that Mateo was beginning to work on addition using manipulatives.

Intervention Effects on Collateral Behaviors

Participants' engagement in stereotypy and other challenging behaviors was measured during all phases of the study using a 10-second partial interval system. Operational definitions were developed individually for each participant and can be found in Table 6. QABF scores suggested that Zayn and Samuel engaged in stereotypy that was automatically maintained while Mateo and Bennett engaged in challenging behaviors to escape non-preferred tasks.

With the exception of Mateo, participants engaged in lower levels of stereotypy and challenging behavior when intervention was in place. Participants may have displayed fewer undesirable collateral behaviors during intervention because they were required to engage in academic behaviors (i.e., manipulate the video schedules and complete the problems). Thus, the treatment package may have functioned as differential reinforcement of incompatible behavior (DRI; Cooper, Heron, & Heward, 2007). This hypothesis is supported by Zayn and Samuel's stereotypy data. Zayn, who engaged in vocal stereotypy, displayed higher levels of stereotypy throughout the study in comparison to Samuel, who engaged in motor stereotypy (tapping objects). It is likely that the steps required for completing the academic skill of counting with manipulatives were more incompatible with tapping objects than vocal stereotypy.

In addition to engaging in lower levels of escape-maintained challenging behavior during intervention, Bennett displayed very little challenging behavior immediately after the intervention was removed and during follow-up (see Figures 4 and 5). Acquiring the academic skill may have reduced the aversiveness of the task, serving as an abolishing operation for escape (Laraway, Snycerski, Michael, & Poling, 2003). However, conclusions regarding these positive results should be tempered by the fact that Mateo continued to exhibit challenging behavior during the return to baseline and follow-up phases.

These findings are aligned with the outcomes reported by previous studies which found collateral improvements in challenging behavior during tablet-mediated academic interventions (Lee et al., 2015; Neely et al., 2013; Zein et al., 2016). The current study is the second study to evaluate collateral effects arising specifically from the use of VAS-VM and extends previous research by including younger participants with autism in a public school setting (c.f., Ledbetter-Cho et al., 2017a). Although additional replication is warranted, results suggest that technology-based interventions that consist of evidence-based practices (e.g., video modeling, prompting) may not result in adverse collateral effects (c.f., Ramdoss et al., 2011) and, in some cases, may foster improvements in challenging behaviors after intervention is removed.

Social Validity

In order to add to the limited social validity data regarding technology-based academic interventions (Knight & Sartini, 2015; Lang et al., 2010), the current study sought feedback from the classroom teacher as well as outside observers. Specifically, the classroom teacher was provided with a survey measuring her opinions of the study's procedures and outcomes. She indicated that she was very satisfied with the training, intervention, and her students' performance throughout the study. It is possible that the teacher found the intervention appealing because it utilized materials already in the classroom and was conducted within the context of existing routines (Lang & Page, 2011). Additionally, the teacher was included in the intervention planning process (i.e., selection of academic targets, task analysis steps, and creation of the video models), which may have increased “buy in” and enthusiasm for the intervention. Because the survey was not returned anonymously, the teacher may have felt compelled to provide positive feedback. Nevertheless, her responses and high fidelity of intervention implementation indicate that this intervention may be socially valid and appropriate for use by teachers in public school classrooms. Additionally, she was informally observed using the intervention with students who did not participate in the study to teach them other skills from their IEPs.

In an attempt to provide a more unbiased assessment of social validity, master’s students in special education who were not involved in any aspect of the study completed questionnaires after viewing video clips from study sessions. Viewers indicated that all participants displayed better academic performance and appropriate use of materials following intervention. They also indicated an improvement in engagement and a decrease in challenging behavior for two of the three participants whom they viewed. Finally, the viewers noted that the intervention appeared to be helpful and feasible for use in the classroom. Given that the majority of the master’s students had previous experience teaching in public school classrooms, their feedback suggests that the intervention may be useful for classroom teachers targeting academics.

Limitations

Although all participants displayed improvements in academic performance and untargeted collateral behaviors, several limitations of the study warrant discussion. Only two of the five students who participated were available during follow-up. Therefore, only very limited conclusions regarding the long-term effects of the intervention can be drawn at this time. Additionally, the functional properties of participants' challenging behaviors were not empirically verified using functional analysis procedures. Therefore, this study cannot demonstrate that the intervention is effective in improving challenging behaviors maintained by specific functions. Future studies that evaluate collateral behaviors following the completion of a functional analysis would offer additional information for practitioners in the classroom.

Finally, although the intervention was implemented by a classroom teacher, she received training from the researcher, which may reduce the overall feasibility of the intervention. However, the total training time was only one hour and consisted of BST, a training approach with which many practitioners are familiar (Sarokoff & Sturmy, 2004).

Directions for Future Research

Given that two participants, Zayne and Samuel, did not demonstrate acquisition of the academic skills in the absence of intervention, future studies should investigate effective methods for gradually fading the intervention. For example, previous research targeting daily living skills demonstrated that students with autism learned to self-fade prompts when using a personal digital assistant (Mechling, Gast, & Seid, 2009). The effectiveness of this approach for teaching academics, as well as its feasibility in the classroom, seems an important direction for future research.

While the classroom teacher in the current study learned to implement the intervention with fidelity, additional teacher participants are necessary to demonstrate a functional relationship. Additionally, because other practitioners in the classroom provide instruction to students with autism, research should investigate the effectiveness of this intervention when implemented by individuals such as teaching assistants and paraprofessionals. Research that develops a method for training teachers to train classroom personnel in using technology-based interventions may further increase efficiency.

Conclusion

This study evaluated the effects of a teacher-implemented video-schedule intervention on the academic skills and untargeted challenging behaviors of elementary-school students with autism. Results indicated that the intervention was effective in improving participants' academic performance and a decrease in challenging behaviors and stereotypy was observed for three of participants following the introduction of intervention. Additionally, participants demonstrated generalization across academic problems and to a small group setting, suggesting that this technology-based intervention may be efficient and aid teachers in maximizing instructional time. Future research examining a variety of academic skills and intervention implementation by additional practitioners (e.g., teaching assistants) is warranted.

Appendix A

Data Sheet for Counting with Bears (Zayn and Samuel)

Participant: Date: Observer: Session: Instructor:

Directions: Mark the step as independent (I) or incorrect (-).

Step	Prompt Level	Step	Prompt Level
1. Say the first addend (**first** problem)	**I -**	15. Repeat the correct total	**I -**
2. Place that number of bears in boxes while counting aloud	**I -**	16. Find total on number chart and say	**I -**
3. Say the second addend	**I -**	17. Write the correct total	**I -**
4. Place that number of bears in boxes while counting aloud	**I -**	18. Clear bears	**I -**
5. Count the total number of bears	**I -**	19. Say the first addend (**third** problem)	**I -**
6. Repeat the correct total	**I -**	20. Place that number of bears in boxes while counting aloud	**I -**
7. Find total on number chart and say	**I -**	21. Say the second addend	**I -**
8. Write the correct total	**I -**	22. Place that number of bears in boxes while counting aloud	**I -**
9. Clear bears	**I -**	23. Count the total number of bears	**I -**
10. Say the first addend (**second** problem)	**I -**	24. Repeat the correct total	**I -**
11. Place that number of bears in boxes while counting aloud	**I -**	25. Find total on number chart and say	**I -**
12. Say the second addend	**I -**	26. Write the correct total	**I -**
13. Place that number of bears in boxes while counting aloud	**I -**	27. Clear bears	**I -**
14. Count the total number of bears	**I -**		

Total number of steps correct: _____ / 27 = _____ %

Key: I = independent (step initiated within 5 seconds of task direction and completed correctly; self-corrections count as independent); - = step not performed or performed incorrectly

Appendix B

Data Sheet for Counting On (Mateo and Aiden)

Participant: Date: Observer: Session: Instructor:

Directions: Mark the step as independent (I) or incorrect (-).

Step	Prompt Level	Step	Prompt Level
1. Say the first addend (**first** problem)	**I -**	11. Repeat the correct total	**I -**
2. Count the objects (correctly starting at one after the first addend)	**I -**	12. Write the correct total	**I -**
3. Repeat the correct total	**I -**	13. Say the first addend (**fourth** problem)	**I -**
4. Write the correct total	**I -**	14. Count the objects (correctly starting at one after the first addend)	**I -**
5. Say the first addend (**second** problem)	**I -**	15. Repeat the correct total	**I -**
6. Count the objects (correctly starting at one after the first addend)	**I -**	16. Write the correct total	**I -**
7. Repeat the correct total	**I -**	17. Say the first addend (**fifth** problem)	**I -**
8. Write the correct total	**I -**	18. Count the objects (correctly starting at one after the first addend)	**I -**
9. Say the first addend (**third** problem)	**I -**	19. Repeat the correct total	**I -**
10. Count the objects (correctly starting at one after the first addend)	**I -**	20. Write the correct total	**I -**

Total number of steps correct: _____ / 20 = _____ %

Key: I = independent (step initiated within 5 seconds of task direction and completed correctly; self-corrections count as independent); - = step not performed or performed incorrectly

Appendix C

Data Sheet for Counting Dice (Bennett)

Participant: Date: Observer: Session: Instructor:

Directions: Mark the step as independent (I) or incorrect (-).

Step	Prompt Level	Step	Prompt Level
1. Count all the dots	**I -**	11. Repeat the total	**I -**
2. Repeat the total	**I -**	12. Circle the total	**I -**
3. Circle the total	**I -**	13. Count all the dots	**I -**
4. Count all the dots	**I -**	14. Repeat the total	**I -**
5. Repeat the total	**I -**	15. Circle the total	**I -**
6. Circle the total	**I -**	16. Count all the dots	
7. Count all the dots	**I -**	17. Repeat the total	**I -**
8. Repeat the total	**I -**	18. Circle the total	**I -**
9. Circle the total	**I -**		
10. Count all the dots	**I -**		

Total number of steps correct: _____ / 18 = _____ %

Key: I = independent (step initiated within 5 seconds of task direction and completed correctly; self-corrections count as independent); - = step not performed or performed incorrectly

Appendix D
Data Sheet for Stereotypy (Samuel)

Stereotypy operational definition: Drumming - tapping an item (a pencil/pen or strip of paper) on a surface (e.g., the table, his knee) two or more times in a row; often (not always) done while holding item parallel to surface

Non-example: done off-camera (i.e., you can see his hand moving but not whether or not the object touches surface twice); tapping once and setting down or dropping his pencil; holding pencil vertical and wiggling it back and forth without tapping it down

Directions: Circle N if the behavior did not occur during the interval. Circle Y if the behavior occurred at any time during the interval.

Session/Observer:

Interval	Stereotypy?
0:00-0:10	Y N
0:11-0:21	Y N
0:22-0:32	Y N
0:33-0:43	Y N
0:44-0:54	Y N
0:55-1:05	Y N
1:06-1:16	Y N
1:17-1:27	Y N
1:28-1:38	Y N
1:39-1:49	Y N
1:50-2:00	Y N
2:01-2:11	Y N
2:12-2:22	Y N
2:23-2:33	Y N
2:34-2:44	Y N
2:45-2:55	Y N
2:56-3:06	Y N
3:07-3:17	Y N
3:18-3:28	Y N
3:29-3:39	Y N

Session/Observer:

Interval	Stereotypy?
0:00-0:10	Y N
0:11-0:21	Y N
0:22-0:32	Y N
0:33-0:43	Y N
0:44-0:54	Y N
0:55-1:05	Y N
1:06-1:16	Y N
1:17-1:27	Y N
1:28-1:38	Y N
1:39-1:49	Y N
1:50-2:00	Y N
2:01-2:11	Y N
2:12-2:22	Y N
2:23-2:33	Y N
2:34-2:44	Y N
2:45-2:55	Y N
2:56-3:06	Y N
3:07-3:17	Y N
3:18-3:28	Y N
3:29-3:39	Y N

Appendix E

Intervention Treatment Fidelity Checklist – Counting Images (Dice)

Participant: Date: Observer: Session: Instructor:

Teacher Behavior	Observed?	Student Behavior	Teacher Behavior	Observed?	Student Behavior
1. Set out iPad with VAS-VM open	**Y N**	NA	13. Prompt / don't interfere	**Y N**	Circle the total
2. Tell child it is time to do his work	**Y N**	NA	14. Prompt / don't interfere	**Y N**	Count all the dots
3. If student makes an error, provide prompt. Otherwise, do not interfere.	**Y N**	Count all the dots	15. Provide verbal praise for working.	**Y N**	NA
4. Prompt / don't interfere	**Y N**	Circle the total	**Notes:**		
5. Prompt / don't interfere	**Y N**	Count all the dots			
6. Prompt / don't interfere	**Y N**	Circle the total			
7. Prompt / don't interfere	**Y N**	Circle the total			
8. Prompt / don't interfere	**Y N**	Count all the dots			
9. Prompt / don't interfere	**Y N**	Circle the total			
10. Prompt / don't interfere	**Y N**	Count all the dots			
11. Prompt / don't interfere	**Y N**	Circle the total			
12. Prompt / don't interfere	**Y N**	Count all the dots			

Number of steps scored Y / Total number of steps x 100 = _____ / _______ = _______%

Appendix F
Pre-Training Data Sheet

Participant: Date: Observer: Session: Instructor:

Step	Prompt Level
1. Click first image	**I -**
2. Press play	**I -**
3. Imitate video one	**I -**
4. Click green arrow	**I -**
5. Press play	**I -**
6. Imitate video two	**I -**
7. Click green arrow	**I -**
8. Press play	**I -**
9. Imitate video three	**I -**

Total number of steps correct: _____ / 9 = _____ %

Key: I = independent (step initiated within 5 seconds of task direction and completed correctly; self-corrections count as independent); - = step not performed or performed incorrectly

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