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Effects Of A Teacher Versus Ipad-facilitated Intervention On The Vocabulary Of At-risk Preschool Children

Lindsay R. Dennis, Kelly Whalon, Lisa Kraut and Deborah Herron

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Effects of a Teacher vs. iPad Facilitated Intervention on the Vocabulary of Preschool Children
At-Risk for Reading Difficulties

Vocabulary knowledge is an essential component of both reading success and school achievement (Stahl & Nagy, 2006). Young children who fall behind their peers in developing the emergent literacy skills essential for future reading development, including vocabulary, are not only at an increased risk of experiencing reading and learning difficulties, but are also at a higher risk of qualifying for special education services (Lonigan, Anthony, Bloomfield, Dyer, & Samwel, 1999), as the majority of those referrals are related to unsatisfactory progress in reading (Lentz, 1988). Unfortunately, when children enter preschool with significant differences in vocabulary knowledge, these differences tend to grow throughout their schooling (Farkas & Beron, 2004), and become increasingly predictive of reading comprehension over time (Catts, Hogan, & Adolf, 2005; Vellutino, Tunmer, Jaccard, & Chen, 2007). Therefore, intervention must begin in preschool, when the highest rate of vocabulary growth occurs (Farkas & Beron, 2004), and must include strategies that reduce learning gaps in language development (National Association for the Education of Young Children [NAEYC], 2009).

Many young children at-risk (National Early Literacy Panel [NELP], 2008), including children served in programs specifically designed for at-risk populations (e.g., Title 1 preschool programs, many state funded pre-k programs, & Head Start; Carta et al., 2015) often score significantly below the mean on measures of vocabulary (e.g., Zill & Resnick, 2006). Research indicates that direct vocabulary instruction can make a substantial impact on the word knowledge, conceptual development, and comprehension of children at-risk for reading delays (Beck & McKeown, 2007; Coyne et al., 2010). Interventions that focus on explicit explanation of words, discussions of words in various contexts, and frequent review of these words improve

vocabulary development (Marulis & Newman, 2010). Therefore, children who attend early education programs targeting at-risk populations may benefit from opportunities to participate in intensive vocabulary instruction.

The types of words that are targeted for instruction should be given careful consideration. Biemiller (2005) suggests focusing on words that between 20% and 70% of children know because children can make the greatest gains on these words, these words are often found in grade level material, and can be easily explained. Beck and colleagues model of vocabulary instruction categorizes words into tiers of difficulty and frequency, describing tier 2 words as those that are more sophisticated or more refined labels for concepts with which young learners are already familiar (i.e., tier 1 words) (2007). Specifically, Tier 2 words are characterized as those that are of high utility, frequently encountered, likely unknown to young children, and appropriate for explicit instruction. Because of the role these words play in the verbal repertoire of the language user, knowledge of second tier words at a richer, deeper level could improve verbal functioning (Beck & McKeown, 2007; Kelley & Goldstein, 2015; Spencer et al., 2012).

Also, some children may require support when learning verbs, as these words may be more difficult than learning nouns (Ard & Beverly, 2004). Children preferentially attend to objects and prefer to map new names to objects, rather than the actions in which the objects are engaged. Second, objects are often stable in time and space, while actions are dynamic and more abstract. Finally, nouns tend to label objects that can generally stand alone, while the actions that verbs label require some agent to perform them. Thus, verb referents are often not as obvious as noun referents (McDonough, Song, Hirsh-Pasek, Golinkoff, & Lannon, 2011).

One method used to teach new vocabulary in preschool classrooms is storybook reading. Storybook reading allows an adult and child to participate in a shared context for word learning

and presents an opportunity to teach words and their meanings. Researchers have demonstrated that storybook readings that incorporate interactive vocabulary instruction promote vocabulary growth (Coyne, Simmons, Kame'enui, & Stoolmiller, 2004; Justice, Meier, & Walpole, 2005). Vocabulary instruction can be embedded within a storybook reading session as the adult teaches the meaning of novel words as they are encountered in text and within the context of the story. Explanations of the vocabulary words can consist of using a simpler synonym, role playing or acting out the word's meaning, or pointing to the picture in the book that illustrates the word's meaning (Penno et al., 2002). While vocabulary instruction presented during storybook readings may be time efficient, children who are at-risk may require a more intensive approach to affect learning outcomes (Vaughn, Gersten, & Chard, 2000).

One such approach is to provide extended instruction in word meanings, characterized by using both contextual and definitional information, giving multiple exposures to target words in varied contexts beyond the story, and providing opportunities to understand words at a richer, more complex level (McKeown & Beck, 2003; National Reading Panel, 2000). One way to extend instruction of target words is through technology. Young children are increasingly being exposed to electronic presentations of storybooks via a computer, tablet, smartphone, or other device, thereby offering varied, autonomous learning opportunities. One specific type of technology, the iPad, allows for physical manipulation that encourages curiosity, creativity, self-expression, and discovery (Plowman & Stephen, 2003). Further, apps made available on an iPad have the potential to target an array of functional skills necessary for effective communication including joint attention, turn-taking, vocabulary development, increasing length and complexity of language, and pre-literacy skills (DeCurtis & Ferrer, 2011).

Dennis (2015) found that children made gains in their expressive verb vocabulary, as well as definitions and examples of target verbs, when provided with an extended instruction intervention delivered via an iPad app called *Book Writer*. Similarly, Smeets and Bus (2012) designed a set of experiments in which vocabulary instruction was provided solely via electronic storybook, while also examining differences between instructed words in two conditions, hotspot and question. Hotspots were inserted on particular scenes within the storybook, and when clicked provided the definition of the object. In the question condition, children were asked multiple choice questions and were given individualized feedback. Results indicated that when children had some receptive knowledge of the word, hotspots and questions were equally effective. However, when words were completely unknown to participants, as indicated by receptive and expressive pretest scores, only questions promoted expressive word learning beyond merely repeating and defining a word through hotspots.

The current study expands the existing literature base by investigating whether children are better able to acquire verb knowledge through instruction facilitated by an adult or iPad. The following research question was addressed: What are the effects of a teacher facilitated versus iPad facilitated extended instruction on children's expressive and receptive verb learning?

Methods

Participants and Setting

Following human subjects approval, participants were recruited from Head Start preschool classrooms in the southeast. Head Start administrators identified classroom teachers of 4 and 5-year old children, who then nominated 7 children they perceived had a need for and would benefit from a language intervention, and who regularly attended school. After consent was obtained from caregivers, the Preschool Language Scale 5th Edition (PLS-5; Zimmerman,

Steiner, & Pond, 2011) was administered by the first two authors. Measures of oral language skills such as the PLS are strong predictors of future reading ability, and can potentially serve as good indicators of children who require targeted interventions (NELP, 2008). To participate, children had to: (1) score at least one standard deviation below the mean on the PLS-5 Expressive Communication or Auditory Comprehension subtests, and (2) demonstrate an ability to point to and label common objects during testing. Of 7 children screened, 5 met the inclusion criteria (see Table 1). Excluded children achieved PLS-5 subtest scores within the average range. All participating children were native English speakers, attended the same Head Start, and were taught by one of two teachers. The intervention occurred at a table in a workroom between classrooms. The room had two tables and chairs, and stored food, cots, and other materials. Doors separated the workroom from classrooms and were routinely closed to limit distractions.

Target Word Selection

Instructional targets included three verbs in each condition taken from age-appropriate storybooks. Intervention occurred for 7 weeks (i.e., 7 books per condition with 3 target words per book) resulting in 21 words in each condition or a total of 42 words. Vocabulary was selected based on the word tier system developed by Isabel Beck and colleagues (Beck, McKeown, & Kucan, 2002). Tier 2 words are of high utility, found across disciplines, and used in a variety of contexts (e.g., *dash*, *introduce*, *sob*). The authors, one faculty member, and two teachers of young children rated the appropriateness and utility of at least four verbs taken from each storybook using a Likert scale. Items asked reviewers to rate if the word was of high utility, if the provided definition was child-friendly, and if the word and definition were developmentally appropriate for preschool age children. Based on expert ratings, three Tier 2 verbs from each

storybook were selected. Selected verbs were different in sound and definition to limit confusion, and were contextualized in the story to illustrate the concept and enhance understanding.

Experimental Design

This study used an adapted alternating treatments design (AATD; Sindelar, Rosenberg, & Wilson, 1985). An AATD design is useful for comparing the impact of two or more interventions on different, non-reversible behavior response sets (i.e., target verbs; Wolery, Gast, & Ledford, 2014). Participants were taught one set of three verbs through teacher-facilitated instruction, and a second set of three verbs through an interactive iPad app. To ensure some participants learned a target word set through teacher-facilitated instruction and others through the iPad interactive app, target verb sets for each participant were randomly assigned to the teacher-facilitated or iPad condition prior to instruction. In addition, the order of instructional sessions (i.e., teacher facilitated and iPad interactive app) was counterbalanced each day to limit the effect of time of instruction (e.g., intervention delivered first) on outcome. That is, one participant was randomly assigned to either teacher-facilitated or iPad interactive app instruction each week. On each successive day, the condition received first was rotated. If any participant was randomly assigned to the same starting condition for 3 consecutive weeks, the following week began with the alternate condition.

Intervention Conditions

In both conditions the target vocabulary were taught over 4 days, and sessions lasted approximately 10 minutes. Regardless of condition, Day 1 instructional procedures were identical. On each successive day (i.e., Days 2-4), both conditions consisted of the same teaching procedures, but one set of words was taught using teacher-facilitated instruction, and the other set via an iPad interactive app, with the sessions delivered back to back each day.

Day 1 instruction. In both conditions, the interventionist taught the two sets of three target words by reading the storybook once aloud to a group of 2-3 children, and stopping at marked pages to introduce the target verbs. The interventionist began by labeling the verb and describing the action in the illustration (e.g., “*The frog leaped.*” while pointing to the illustration). Then, the interventionist defined the target verb in child friendly terms (e.g., “*To leap means to jump off the ground.*”), and asked participants to repeat the word (e.g., “*Say leap.*”). Next, the interventionist provided an example from the text (“*Here we see the frog leap to catch the butterfly.*”), followed by a real-world example (e.g., “*If you saw a puddle of water on the ground, you might leap over it so your shoes don’t get wet.*”). Last, the interventionist modeled the action and asked participants to imitate the model (e.g., “*Let’s pretend this blue piece of paper is a puddle. I am going to leap over it [demonstrates]. Your turn.*”).

Days 2-4 instruction. On each consecutive day, lessons occurred one to one, and began with a summary of the target words from the storybook. Each page containing a target verb was shown, and participants were asked to: (1) label the action verb (i.e., “*What is the frog doing?*”), (2) provide a definition (e.g., “*What does leap mean?*”), (3) explain when/how/why the action is performed (e.g., “*Why would you leap?*”), and (4) give a real word example (“*Remember when we read the story, we pretended to leap over a big puddle of water. What else might leap?*”). In both conditions, corrective feedback was provided. Correct responses were praised and confirmed by repeating the target word in context (e.g., “*Good, a bunny is something else that leaps.*”). Corrective feedback included limiting possible visual response options (i.e., Google images). Google images were consistent across conditions, but in the teacher-facilitated condition they were presented on paper, and in the interactive app condition on the iPad.

Teacher facilitated instruction. Sessions started with the interventionist sharing the cover of the book, and summarizing the target verbs learned on Day 1 (e.g., “Remember in this book we saw the 3 frogs **quarrel** with each other. Next we see one of the frogs **leap** up to catch a butterfly. Then a storm comes and the scared frogs **tremble**.”). The interventionist turned to marked pages in the storybook depicting the target verbs, and asked the series of questions described in Days 2-4 instruction while displaying 3 Google images. Following an incorrect or no response, the interventionist initiated a prompting hierarchy by pointing to and labeling each picture (“Does leap mean to play, jump, or skip?”). If the child answered incorrectly or failed to respond, the interventionist covered one option and provided a binary choice (e.g., *Does leap mean to jump or skip?*). If the child responded incorrectly or failed to respond again, the interventionist pointed to the correct picture, and modeled the correct response (e.g., “*To leap means to jump off of the ground.*”). Prior to the interventionist labeling the visual response options, if a child responded by pointing to a visual without verbalizing, the interventionist prompted the child for a verbal response (e.g., “*What is that?*”) to ensure the child understood the action. At any point, if the child answered correctly, the interventionist confirmed the response and praised (e.g., “*Yes! To leap means to jump off of the ground. Great job!*”).

iPad interactive app. AutisMate™ was used to create an interactive instructional sequence that mirrored teacher-facilitated instruction. Pictures of each page of the storybook containing the target words were taken with the iPad, and loaded into AutisMate™. Hotspots were created on each page illustrating the target verb. The interventionist recorded her voice to read all target word summaries, questions, and response options. A hotspot in the shape of a large yellow arrow allowed participants to independently turn to the next picture.

For each word set, the first page included a picture of the book cover, and a hotspot in the shape of a star. When pressed, a summary of target verbs learned on Day 1 was provided (following the same format as previously described for teacher facilitated instruction). On each additional page, hotspots were numbered from 1 to 4 for each of the 4 question types described under Days 2-4 instruction. When participants clicked on a hotspot, a window opened and the iPad verbalized the question (e.g., “*What does leap mean?*”), and presented 3 visual response options (e.g., *play, jump, skip*). See Figure 1 for examples. If the child responded correctly, the iPad verbally confirmed the correct response and provided praise (“*Yes, to leap means to jump off the ground. Great job!*”). If incorrect, the iPad provided corrective feedback (“*No, leap does not mean to skip. Choose a different picture.*”). The app was programmed so that participants were unable to move on to the next item until the correct response was chosen.

Prior to intervening, a sample book was created in AutisMate™ to teach participants how to navigate the app. The interventionist walked participants through the app in one 10-minute session. During intervention, the interventionist only provided assistance related to the app, and did not respond to questions about target verbs.

Interventionists and training. Two master’s degree seeking students served as the intervention agents. Both were former teachers attending graduate school full time, and each had prior experience working with preschoolers. Training involved direct instruction covering teacher-facilitated or iPad procedures and role-play practice. Both interventionists practiced delivering iPad or teacher-facilitated instruction until they reached 80% or higher on a treatment integrity checklist over 3 consecutive sessions. The target goal was reached in 3 sessions.

Dependent Measures

Vocabulary probes were developed to assess participant understanding of the target words prior to (i.e., immediately before instruction on day 1) and following instruction (i.e., immediately after instruction on day 4). Probes assessed expressive and receptive understanding of the target verbs. The same items were included on pre- and post-test for all participants. Vocabulary probes were administered by the interventionists. Participants received no feedback on their performance, but received praise for staying on-task (e.g., “*Good job, keep working!*”).

To measure expressive understanding, participants were asked to define the target verb (e.g., “*What does X mean?*”). Responses were coded using a rating scale of 0-2 (no knowledge, partial knowledge, complete knowledge; Spencer et al., 2012). A total of 2 points could be awarded for each target word. An accurate verbal definition of the target word resulted in two points, a partial definition or clear example was given 1 point, and an incorrect or no response resulted in no points. See Table 2 for the scoring criteria.

To measure receptive understanding, children completed two tasks. First, children were asked to identify a Google image representing the target verb from an array of four color pictures (i.e., “*Which picture shows slumber?*”) displayed on a single Power Point slide. Correct responses were awarded one point. All images (i.e., target verb and 3 distractors) were randomly assigned to one of the four positions on the paper, and were different than those used during instruction. Second, participants were asked to receptively identify a target verb definition (see Beck & McKeown, 2007; Coyne, McCoach, Loftus, Zipoli, & Kapp, 2009). Specifically, participants were asked two yes/no questions including a correct and incorrect definition of the word. For example, “*Does fling mean to throw or push?*” and “*Does fling mean to carefully put something away?*” Children received 1 point if they answered “yes” to the correct definition and “no” to the incorrect definition. No points were awarded for correctly responding to 1 or no

questions. Therefore, the receptive probe included a total of 2 points for each target verb (1 point for receptive picture identification and 1 point for correct receptive definition).

Maintenance

One and two weeks following intervention, vocabulary probes were administered. Probes were individualized to include a randomly selected 18 words for each participant based on a gain of at least 1 point from pre- to post- test on the expressive language probe. One participant (participant 5) showed an increase of 1 point on only 12 words. All 12 words were included on her maintenance probe along with 6 randomly selected words learned (i.e., a gain of at least one point at post-test) on the receptive probes. Maintenance data were collected in the same location as probe data and were administered over a 2-day period.

Social Validity

Social validity data were gathered from participating children and their two teachers. Participant's teachers were asked to rate the importance of the target verbs for children entering kindergarten. In addition, participating children were asked whether the teacher or iPad helped them learn better, and which was more enjoyable.

Treatment Integrity

All sessions were videotaped, and a randomly selected 30% of Day 1, teacher-facilitated, and iPad interactive app sessions for each participant were coded for fidelity using a researcher developed checklist. Day 1 and the teacher-facilitated checklist included a task-analysis of instructional procedures for each of the three target words. Items on the iPad checklist monitored the extent to which the adult limited her feedback to iPad navigation, and provided no feedback on vocabulary. Treatment integrity data indicate that the interventionists adhered to all procedures. Mean fidelity was 99% for teacher facilitated (94-100%), 97% for iPad app (91-

100%), and 96% for Day 1 (88-100%) instruction. Interobserver agreement was conducted by a second observer on 30% of the sessions and was 99% across conditions (91-100%).

Reliability

Interventionists recorded all oral responses on probes in real time. Probes were also videotaped, and a randomly selected 30% of the probes were reviewed for accuracy by a second coder, and accuracy was 100%. The first two authors double-scored all probes, and scores on each item were compared and designated as an agreement if the first and second rater recorded the same score. There were no disagreements.

Data Analysis

Figures 2 and 3 present gain scores on expressive and receptive probes across conditions and participants. Gain scores represent the difference between pre- and post- test expressive and receptive probes. Data were analyzed visually by comparing level, trend, and variability across conditions. That is, patterns in gain scores by condition were analyzed to determine whether gains were consistently higher (level difference), or evidenced a greater increase over time (trend) in either condition. To ascertain whether growth in verb learning was higher in the teacher- or iPad- facilitated condition, we reported whether participants increased their knowledge of a word. Increased knowledge of a word was defined as the frequency and percentage of target word improvement or a 1-point gain (i.e., 0 to 1, 1 to 2 or 0 to 2) from the pre- to post- on the expressive and receptive probe. A percentage was calculated by dividing the number of verbs demonstrating an increase from pre-test by the number of verbs not mastered at pre-test (scored below a 2) and multiplying by 100.

Results

Gain scores on expressive probes are presented in Figure 2. Table 3 provides the number of words with a gain in word knowledge (0 to 1, 1-2, 0-2) on the expressive scoring rubric.

Expressive Vocabulary

Participant 1. Participant 1 scored a 0 on the majority of words (38/42 or 90%) and below a 2 on all words at pre-test. Figure 2 shows some variability in performance on the expressive probes in both conditions with Participant 1 gaining 1-4 points in teacher-facilitated and 1-3 points in the iPad condition. Participant 1 experienced higher gain scores more consistently in the teacher-facilitated condition. He increased his knowledge of 16 words (76%) in the teacher-facilitated and 9 (43%) in the iPad condition. On average, Participant 1 demonstrated increased knowledge of 2.29 (1-3) and 1.29 (1-3) words a week in the teacher-facilitated and iPad conditions respectively. Table 3 indicates that gains reflect an increase from 0 to 1 on the scoring rubric for 11 words in the teacher-facilitated and 7 in the iPad condition, and an increase of 0 to 2 on 5 words in the teacher-facilitated and 2 in the iPad condition.

Participant 2. Participant 2 scored a zero on 67% of words (28/42), and below a 2 on 95% (40/42) of the target verbs at pre-test. Figure 2 shows variability across conditions with gain scores ranging from 0-4 in the teacher-facilitated and 0-3 in the iPad condition. Participant 2 increased knowledge of 9 (53%) words in the teacher-facilitated, and 8 (53%) in the iPad condition. On average, Participant 2 made at least a one-point gain on 1.29 (0-2) verbs a week in the teacher-facilitated and 1.14 (0-2) in the iPad app condition suggesting a very limited difference between conditions. Table 3 indicates Participant 2 verbally defined more words in the teacher-facilitated than the iPad condition (teacher-facilitated = 4 words; iPad = 2 words).

Participant 3. Participant 3 scored a 0 on 64% (27/42) and below a 2 on 90% (38/42) of target verbs at pre-test. Following intervention, Participant 3's gain scores ranged from 1-5 in the

teacher-facilitated and 0-4 in the iPad condition. Participant 3 increased knowledge of 10 words in both the teacher-facilitated (53%) and iPad (55%) conditions, or a mean of 1.43 (1-3) words per week in each condition. Table 3 shows that gain scores were higher in the teacher-facilitated condition as Participant 3 gained 2 points (increased from 0-2) more frequently in the teacher-facilitated condition (6 words) than in the iPad condition (2 words), suggesting a greater ability to verbally define target verbs learned following teacher-facilitated instruction.

Participant 4. Participant 4 scored a 0 on 83% (35/42) and below a 2 on 95% (40/42) of the target verbs at pre-test. Figure 2 indicates some variability with gain score increases ranging from 0-5 in the teacher-facilitated and 0-3 in the iPad condition. Participant 4 increased knowledge of 13 (65%) words in the teacher-facilitated and 11 (52%) in the iPad app condition with an average of 1.86 (1-3) words and 1.57 (1-3) words per week in the teacher-facilitated and iPad conditions respectively. Table 3 shows that following intervention, Participant 4 verbally defined the target verb (i.e., an increase of 0-2 on the scoring rubric) more frequently in the teacher-facilitated (i.e., 10 words) than the iPad (i.e., 7 words) condition.

Participant 5. Participant 5 scored a zero on 93% (39/42) and below a 2 on all target verbs at pre-test. Figure 2 shows variability across conditions with gain scores ranging from 0-5 in the teacher-facilitated and 0-3 in the iPad condition. Participant 5 increased knowledge of 7 (33.33%) words in the teacher-facilitated and 5 (23.8%) words in the iPad condition averaging 1 word (0-3) a week in the teacher-facilitated condition and less than 1 (.71; 0-2) in the iPad condition. Table 3 indicates little difference in performance on the scoring rubric across conditions. In general, participant 5's performance was highly variable across conditions.

Receptive Vocabulary

Figure 3 presents gain scores on the receptive vocabulary probes across conditions. Table 4 presents the number of words with a change in score from 0 to 1 on the receptive picture identification and receptive definition items. Percentages were calculated by dividing the number of words scored a 1 at post-test by the number of words scored a 0 at pre-test.

Participant 1. Participant 1 scored a zero on 24% (10/42) and below a 2 on 86% (36/42) of the receptive probes at pre-test. At pre-test, Participant 1 scored a 1 on the majority picture identification items (n=33; 79%), but few receptive definitions (n=10; 24%). Gain scores were variable ranging from 0-2 in both conditions. Visual analysis indicates initial improvement in the iPad condition with a declining trend, and consistent variability in the teacher-facilitated condition. Participant 1 increased knowledge of 7 (33%) verbs in the teacher-facilitated and 4 (22%) verbs in the iPad condition with increases on 1 and less than 1 (.57) verbs weekly in the teacher-facilitated and iPad conditions respectively. Table 4 indicates that Participant 1 experienced greater gains on picture identification in the iPad condition (teacher facilitated = 3 words; iPad = 5 words), and greater gains on the receptive definition items in the teacher facilitated condition (i.e., teacher-facilitated = 6 words; iPad = 1 word).

Participant 2. Participant 2 scored a 0 on 38% (16/42) and below a 2 on 81% (34/40) of the verbs on the receptive probes at pre-test. At pre-test, Participant 2 scored a 0 on 17 (40%) picture identification items, and a 0 on 33 (79%) receptive definition items. Gain scores were highly variable across both conditions with scores ranging from 0-3 in the teacher-facilitated and 0-2 in the iPad condition. Participant 2 increased her knowledge of more words in the teacher-facilitated (9 words; 50%) than in the iPad (6 words; 38%) condition with increases averaging 1.29 (0-3) and .86 (0-2) verbs a week in the teacher-facilitated and iPad conditions respectively. Table 4 shows similar progress on picture identification items in both the teacher- and iPad

facilitated conditions (teacher = 5 words; iPad = 4 words), but gains were higher in the teacher-facilitated (10 words) than the iPad condition (2 words) on receptive definition items.

Participant 3. Participant 3 scored a zero on 31% (13/42) and below a 2 on 79% (33/42) of the receptive probes at pre-test. Participant 3 scored a 0 on 15 (36%) of the picture identification, and a 0 on 31 (74%) on the receptive definition items at pre-test. Gain scores indicate variable performance across conditions ranging from 0-3 in the teacher-facilitated and 0-2 in the iPad condition. Participant 3 increased knowledge of 10 words (55%) in the teacher-facilitated condition and 9 words (56%) in the iPad condition averaging gains on 1.43 (0-3) and 1.29 (0-2) verbs a week in the teacher-facilitated and iPad conditions. As shown in Table 4, Participant 3 experienced greater gains on picture identification items in the teacher-facilitated (9 words) than the iPad condition (1 word). In contrast, on the receptive definition items, gains were slightly higher in the iPad (6 words) than the teacher-facilitated (4 words) condition.

Participant 4. Participant 4 scored a 0 on 36% (15/42) below a 2 on 83% (35/42) of the verbs on the pre-test receptive probes. Participant 4 scored a 0 on 24 (57%) of the picture identification items, and 26 (62%) of the receptive definition items at post-test. Participant 4 showed improvement on receptive probes in both conditions with gain scores ranging from 1-5 in the teacher-facilitated and 0-4 in the iPad condition. Participant 4 increased knowledge of 13 (68%) words in the teacher-facilitated and 12 (75%) verbs in the iPad condition averaging increases on 1.86 (1-3) and 1.71 (1-3) verbs in the teacher-facilitated and iPad conditions respectively. Table 4 indicates that gains on all receptive items were similar across conditions.

Participant 5. Participant 5 scored a 0 on 48% (20/42) and below a 2 on 98% (41/42) of the target verbs on the receptive probe pre-tests. Participant 5 scored a 0 on 20 (50%) of the picture identification, and 40 (91%) of the receptive definition items at pre-test. Gain scores

ranged from 0-4 in the teacher-facilitated and 0-2 in the iPad condition. Although variable, Participant 5 showed a steady increase across conditions in weeks 4 through 7 with increased knowledge of 11 (52%) verbs in the teacher-facilitated and 10 (50%) in the iPad condition averaging increases on 1.57 (1-3) and 1.43 (0-2) verbs per week in the teacher-facilitated and iPad conditions respectively. As shown in Table 4, Participant 5 experienced greater gains in the teacher-facilitated (9 words) than iPad (4 words) condition on picture identification items, and scored similarly on receptive definition items (teacher-facilitated = 4 words; iPad = 5 words).

Maintenance

Probes consisted of a randomly selected 18 verbs learned (i.e., a gain of at least 1 point) on the expressive and receptive probes from both the teacher-facilitated and iPad conditions. Table 5 provides maintenance data for each participant. Data indicate that all participants maintained their increased knowledge of at least 80% of verbs learned on the receptive probe. Maintenance data on the expressive probes were more variable ranging from 6% to 83%.

Social validity

Teachers were asked whether they believed the target verbs were important for children to know before entering Kindergarten, and one teacher indicated “no” for two verbs, *pluck* and *quarrel*. All 5 participating indicated the iPad was more helpful than the teacher when learning the verbs, and 4 rated the iPad condition as more enjoyable.

Discussion

This study compared 10-minute extended instruction sessions facilitated by an adult or iPad app. The five participants were provided instruction on 6 verbs per week across 7 weeks. In both conditions, instruction included repeated exposure to target verbs, use of definitional and contextual information, and real world applications. Participants were scored on the depth of

knowledge about the target verbs similar to previous vocabulary studies (see Coyne et al., 2010; Spencer et al., 2012). The results suggest that participants demonstrated knowledge of target words in both conditions. This finding is consistent with previous studies indicating children can learn the meanings of sophisticated vocabulary through direct, extended instruction (Beck & McKeown, 2007; Biemiller & Boote, 2006; Coyne et al., 2009; Silverman, 2007).

Overall, data indicate gains in verb knowledge across participants and conditions; however, variability on both the expressive and receptive measures suggest further research is needed to determine the optimal learning conditions necessary to facilitate vocabulary development for young children. The stimulus presentation in the teacher facilitated condition (i.e., repeating the stimulus and visual reduction of choice stimuli) may explain some variability. We also recognize that iPad applications do not allow the same flexibility as teacher facilitated instruction. Questions still remain as to the extent of the limitations of instructional technology, as well as the particular nuances that teachers need to be aware of when delivering technology facilitated instruction versus teacher facilitated instruction.

Another possible explanation for the modest impact is that the storybook was read in its entirety only on day 1 of instruction, and each subsequent day of instruction (i.e., days 2-4) provided only the storybook illustration of the target word. Coyne and colleagues (2010) designed and implemented an intervention that included 2 storybook reading sessions focused on definitional and contextual information, paired with 2 post-reading activities focused on decontextualized information, resulting in large effect sizes. A combination of teacher-facilitated intervention focused on contextualized and definitional information during storybook reading sessions, followed by independent extended instruction focused on decontextualized information is worthy of further examination.

It was noteworthy that participants independently engaged with the iPad, with limited teacher facilitation (e.g., redirection of attention, reminders to touch all hot spots, etc.) suggesting the iPad may be a helpful tool for providing children with additional opportunities to learn new vocabulary. Instructional apps are relatively new, and although the AutisMate app allowed for customization, the functions failed to completely mirror teacher-facilitated instruction. In the teacher-facilitated condition, the teacher covered up incorrect responses and restated the remaining options. It was not possible to remove an option and restate options on the app. Instead, if the participant selected the incorrect option, the iPad stated the response was incorrect and prompted the participant to select another option. Once prompted, participants consistently chose an alternate option and did not repeat errors. As iPad apps become more customizable for instruction, it is possible to provide children with increased opportunities for repeated practice and feedback that will reinforce correct responses.

Limitations

Study data report the gain scores from a pre-test probe taken prior to instruction and a post-test probe following 4 days of target word instruction. It would strengthen the study to include a baseline assessment of target verbs. Another limitation of this study is the number and difficulty of the target words. Participants in this study were asked to learn 6 new verbs each week, over the course of the 7 week intervention. Although the target verbs were randomized across conditions, it is possible that either the number or complexity of some verbs was too challenging for some participants. The ordinal scale also confounds interpretation. That is, although the data reflect a change from pre- to post- test, the extent of verb learning in each condition is unclear as score increases from 0 to 1 or 1 to 2 are not equivalent. In addition, the purpose of this study was to determine whether children would experience greater growth in verb

learning when extended instruction was delivered via teacher or iPad. As such, participants only experienced each condition daily for approximately 10 minutes. It is likely that many children require more time and opportunities to use target words in a variety of contexts.

Implications for Practice and Research

Within the broad domain of oral language, vocabulary knowledge has been linked to reading success, with the National Early Literacy Panel concluding that instruction that enhances oral language skills is likely to positively impact future reading outcomes (2008). To prevent future reading disabilities, there is a need for interventions that improve the oral language skills of preschool children (Spencer et al., 2012), particularly for those who may be at-risk. Yet, much is still to be learned about the appropriate number and complexity of target vocabulary words for preschool children (Beck & McKeown, 2007; Beck, McKeown, & Kucan, 2002; Biemiller & Boote, 2006). Future studies may consider comparing the impact of similar supplemental interventions on different word sets (e.g., nouns, verbs, adjectives), and/or combining easier to learn concepts with more challenging or complex words, so that children feel successful and enjoy the process of learning new vocabulary (Kelley & Goldstein, 2015).

Future research also should address levels of intensity necessary for learning new words. For example, research suggests that children make greater gains when explicit instruction is paired with ongoing opportunities to use newly acquired words in a variety of contexts (e.g., shared reading, play, problem solving tasks) that promote word knowledge as well as a broader conceptual understanding (Neuman, 2011). Future studies can investigate the number of opportunities to engage with target words in differing instructional configurations (e.g., direct instruction, embedded instruction).

Table 1

Characteristics of Participants

<u>Child</u>	<u>Age</u>	<u>Gender</u>	<u>PLS-5 Auditory Comprehension</u>	<u>PLS-5 Expressive Communication</u>	<u>PLS-5 Total Language Score</u>
EA	5:1	F	69	85	76
EI	5:1	F	86	74	78
J	4:7	M	96	84	89
A	5:4	M	76	83	78
L	4:6	F	87	83	84

Note: PLS-5 = Preschool Language Scales – 5th ed. (Zimmerman, Steiner, & Pond, 2011); Age is reported in years: months, and is the child’s age at the beginning of the study

Table 2

Expressive Vocabulary Scoring Rubric with Example

Points	Criterion	Sample Responses for Leap
2	Complete knowledge: <ul style="list-style-type: none"> • Provides definition from intervention • Provides another definition or synonym • Provides a definition and example 	<ul style="list-style-type: none"> • <i>Jump high in the air</i> • <i>Jumps up; hops</i> • <i>Jump over a puddle</i>
1	Partial knowledge: <ul style="list-style-type: none"> • Provides partial definition • Provides meaningful use of the word in a phrase or sentence • Uses word in story context or gives a specific example 	<ul style="list-style-type: none"> • <i>Go over something</i> • <i>You leap over a puddle</i> • <i>The frog leaped</i>
0	No knowledge: <ul style="list-style-type: none"> • Incorrect, no response, or repeats the word • Related but inadequate response 	<ul style="list-style-type: none"> • <i>Run; leap</i> • <i>They leap</i>

Directions: “*What does X mean?*”

Table 3

Expressive Probe Gain Scores by Condition

Participant	Teacher-Facilitated Condition			iPad-Facilitated Condition		
	0-1	1-2	0-2	0-1	1-2	0-2
1	11 (55%)	0	5 (25%)	7 (39%)	0	2 (11%)
2	4 (33%)	1 (14%)	4 (33%)	6 (38%)	0	2 (11%)
3	3 (21%)	1 (14%)	6 (43%)	8 (67%)	0	2 (17%)
4	2 (12%)	1 (33%)	10 (59%)	4 (22%)	0	7 (39%)
5	2 (10%)	1 (100%)	4 (20%)	2 (11%)	0	3 (16%)

Percentages were based on the number of opportunities for an increase from pre-test (words scored a zero [increases of 0-1 and 0-2] or words scored a 1 [increases of 1-2]).

Table 4

Receptive Probe Gain Scores (0-1) by Item Type and Condition

Participant	Picture Identification		Receptive Definition	
	Teacher-Facilitated	iPad – Facilitated	Teacher-Facilitated	iPad – Facilitated
Participant 1	3 (75%)	5 (100%)	6 (40%)	1 (6%)
Participant 2	5 (63%)	4 (44%)	10 (56%)	2 (13%)
Participant 3	9 (90%)	1 (20%)	4 (27%)	6 (38%)
Participant 4	9 (82%)	10 (77%)	8 (50%)	7 (70%)
Participant 5	9 (75%)	4 (44%)	4 (20%)	5 (25%)

Table 5

Maintenance Data

Participant	Expressive Week 1	Expressive Week 2	Receptive Week 1	Receptive Week 2
1	83% (15/18)	78% (14/18)	89% (16/18)	100% (18/18)
2	56% (10/18)	72% (13/18)	94% (16/17)*	100% (18/18)
3	61% (11/18)	83% (15/18)	83% (15/18)	89% (16/18)
4	67% (12/18)	61% (11/18)	100% (18/18)	83% (15/18)
5	11% (2/18)	6% (1/18)	83% (15/18)	83% (15/18)

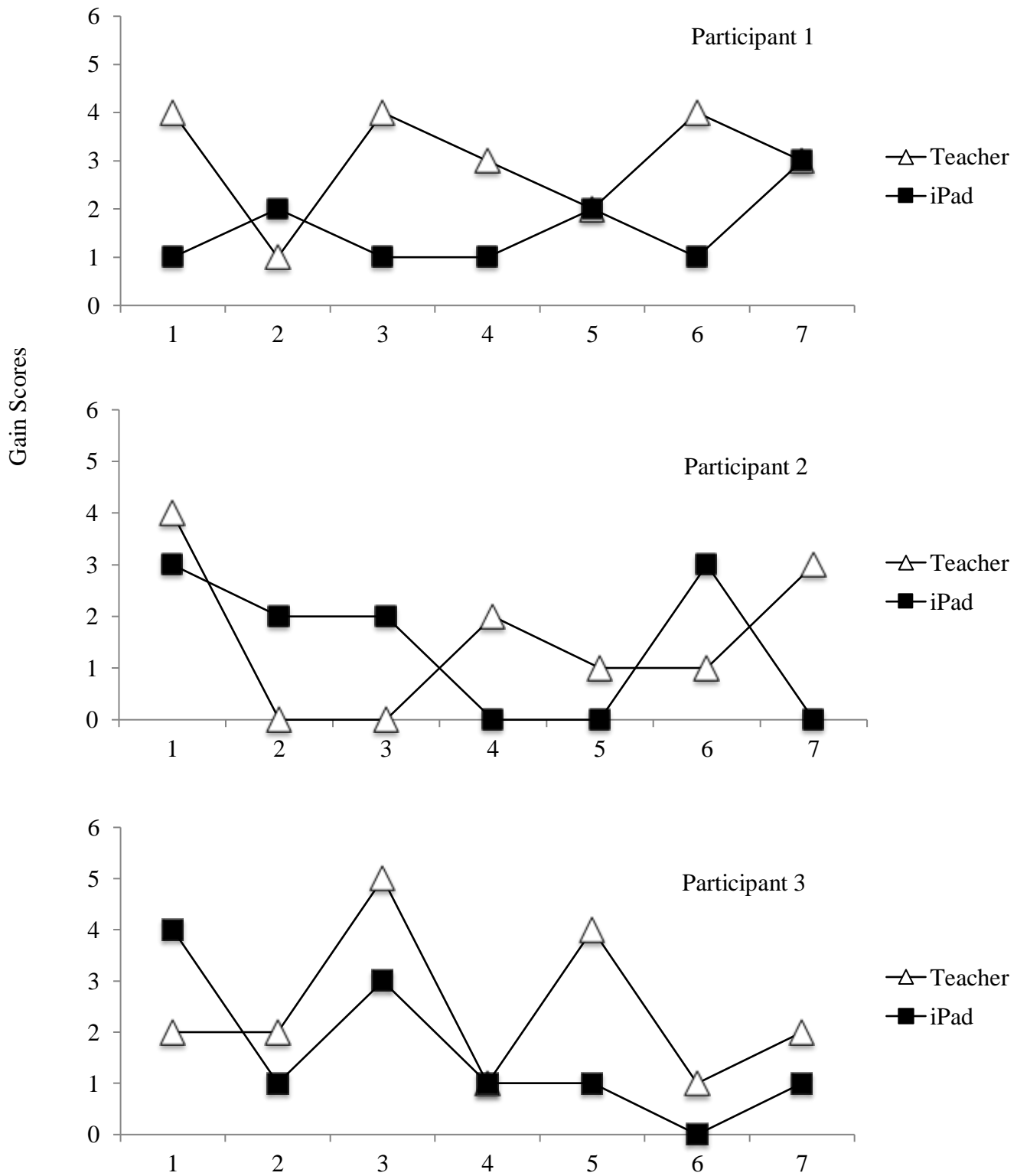
**Note:* One word in the receptive probe was overlooked for participant 2; her score was determined based on 17 instead of 18 words

Figure 1

AutisMate™ Sample Picture



Figure 2

Expressive Probe Gain Scores by Participant and Condition

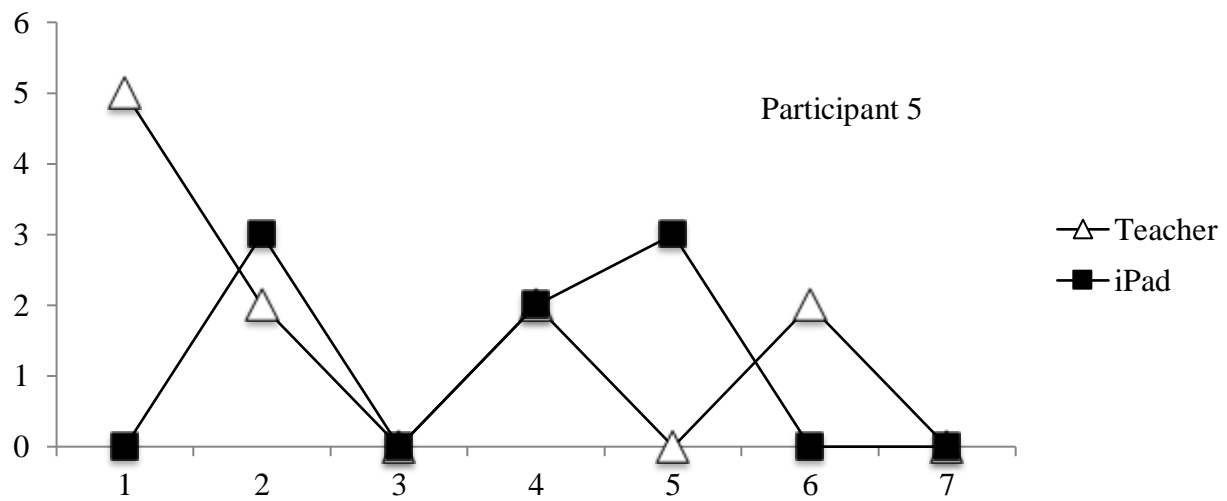
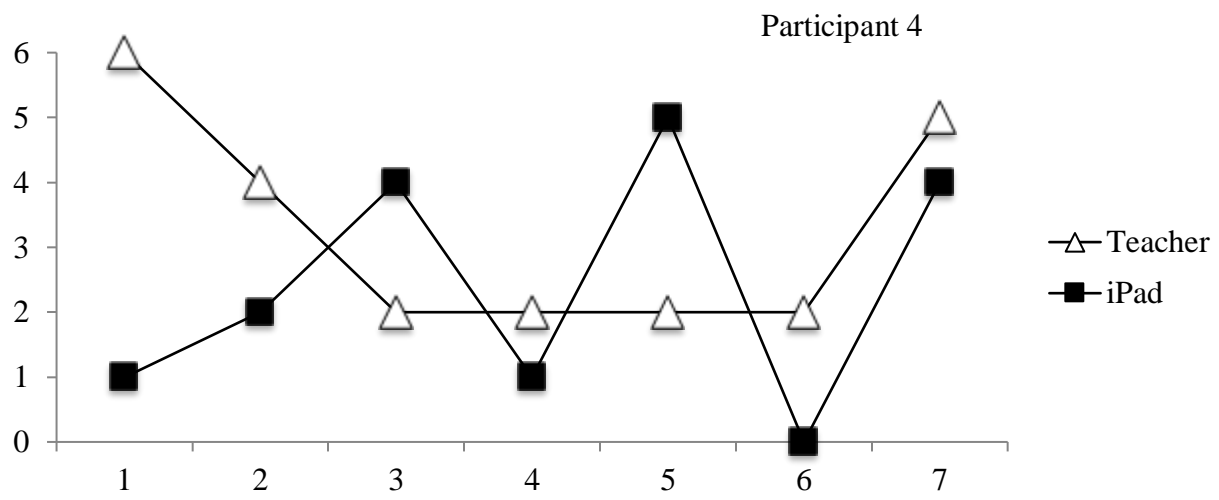
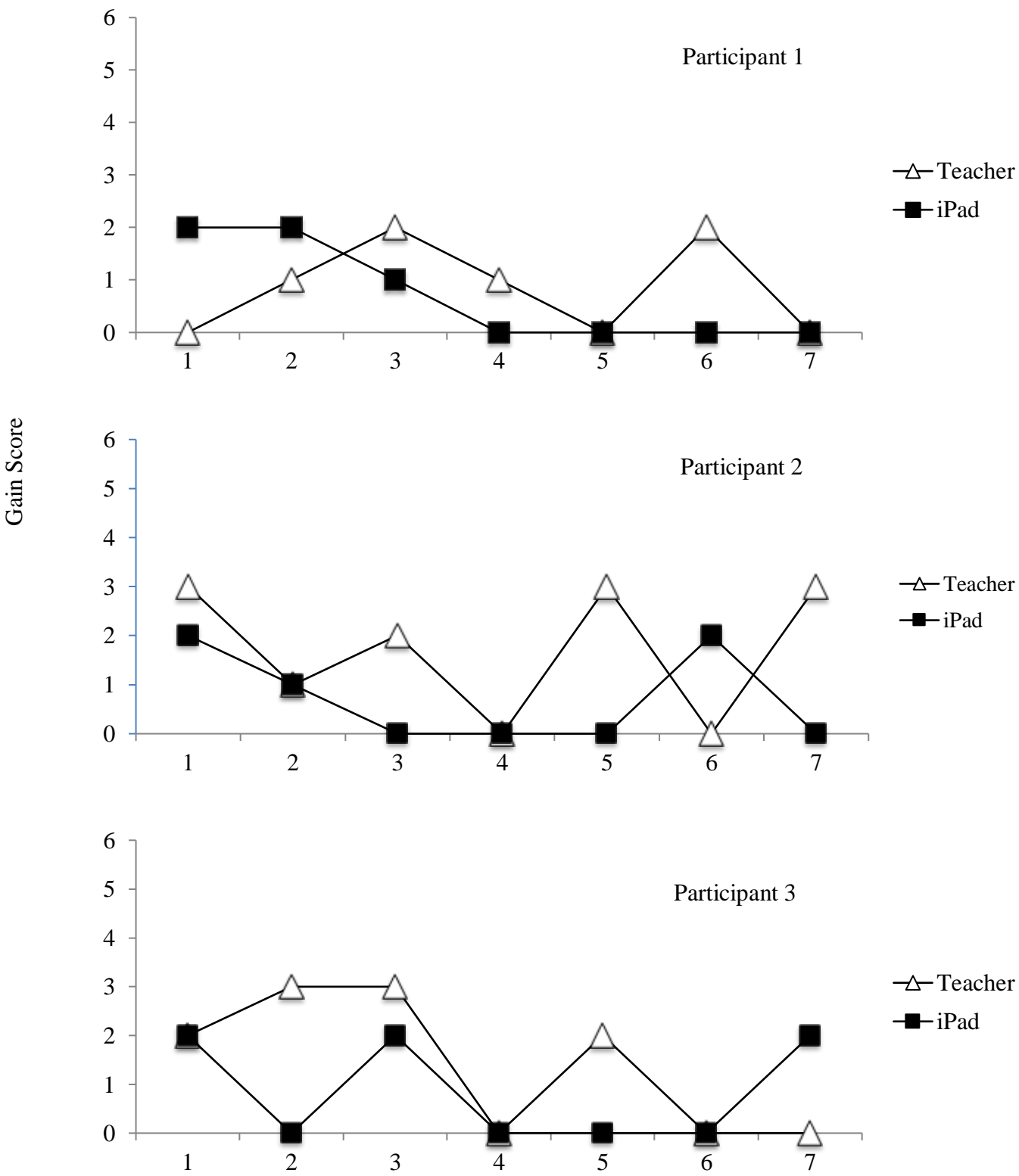
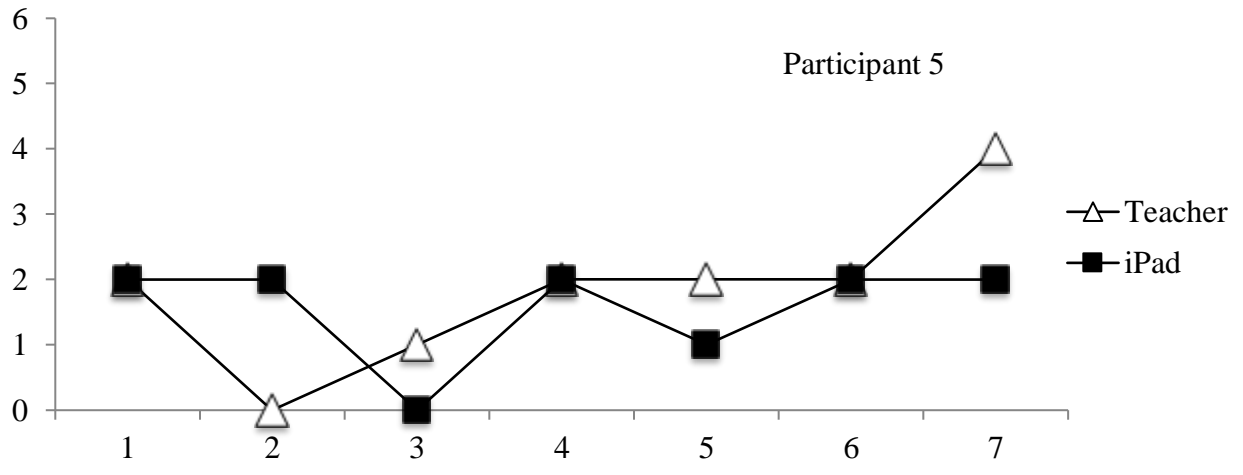
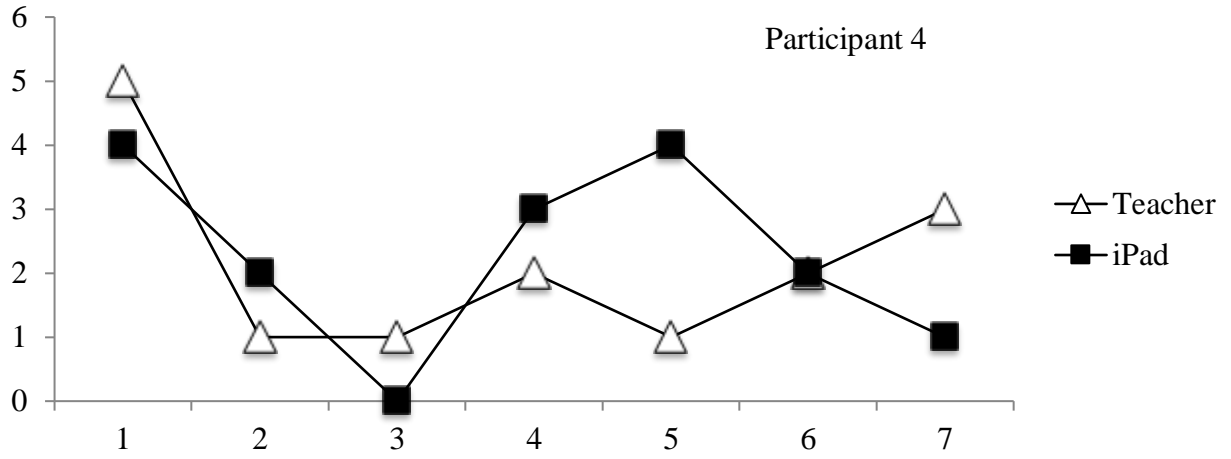


Figure 3

Receptive Probe Gain Scores by Participant and Condition





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