Effects of Using an iPad to Teach Early Literacy Skills to Elementary Students with Intellectual Disability

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Abstract

The purpose of this study was to investigate the effects of using an iPad to teach early literacy skills to students with intellectual disability (ID). Three elementary students with mild to moderate ID participated in the study. We used a multiple-probe design across students to examine a functional relation between using an iPad providing visual supports and the acquisition of phonemic segmentation skills. Results indicated that using visual supports via an iPad was an effective method to teach phonemic segmentation fluency to these three students with ID. We also discussed implications and suggestions for future research.

Keywords: intellectual disability, iPad, portable smart devices, early literacy skills

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Early literacy skills, such as sound blending and segmentation, are fundamental skills needed for children to develop reading skills required throughout their school years (Snyder & Golightly, 2011). These skills also increase individuals' independence, which is necessary to succeed in their schools, workplaces, and eventually, in their lives (Allor, Gifford, Otaiba, Miller, & Cheatham, 2013). Failure to develop early literacy skills may result in life-long reading problems (Otto, 2008). Therefore, the development of such skills has been an important educational goal that students, including students with disabilities, achieve at school (Browder, Ahlgrim-Delzell, Courtade, Gibbs, & Flowers, 2008). As a result, special educators have strived to teach these skills to students with intellectual disability (ID).

Researchers recently have reported that students with ID can learn various early literacy skills (e.g., phonemic awareness and phonics) if they are taught explicitly and carefully (Allor, Mathes, Roberts, Jones, & Champlin, 2010). For example, Conners, Rosenquist, Sligh, Atwell, and Kiser (2006) conducted a group study to investigate the effects of phonological reading instruction. 40 children with ID, whose age ranged between 7 and 12 years, took park in the study. The researchers taught a series of phonological reading lessons to the experimental group, but did not teach the lessons to the control group. Results of the study demonstrated that children with ID were able to learn phonological reading skills through intense and well-targeted instruction. Allor and colleagues (2010) examined the effects of using a comprehensive intervention for teaching early literacy skills. They divided 24 students with ID into experimental and control groups and taught early literacy skills including phonemic awareness. Results indicated that students with ID clearly showed improvement in the acquisition of early literacy skills.

Various interventions were used to teach literacy skills to students with ID. One promising intervention was visual supports. For instance, Shurr and Taber-Doughty (2012) investigated the effects of using visual supports. They taught reading comprehension to three middle school students with ID using a combination of discussion and visual supports (a picture symbol strip containing five photos). Results of the study demonstrated positive effects on using visual supports in improving reading comprehension skills of students with ID. Shurr andTaber-Doughty (2017) conducted another study to examine if visual supports are an effective method. In this study, they used the same method (i.e., discussion and visual supports) as in their previous study (Shurr & Taber-Doughty, 2012) to teach reading comprehension to high school students with ID. Findings demonstrated that the use of visual supports was effective in increasing text access for this population. Another promising intervention found in the body of the literature is the use of technology (e.g., desktop/laptop computers and tablet computers) for teaching students with ID. A number of studies investigated the effects of using technologies and indicate that it was an effective method to teach students with ID various skills: living skills (Ayres & Cihak, 2010; Ayres, Langone, Boon, & Norman, 2006; Hanson & Morgan, 2008; Mechling & O'Brien, 2010), job skills (Larson, Juszczak, & Engel, 2016; Mechling & Ortega-Hurndon, 2008), and academic skills (Bouck, Bassette, Taber-Doughty, Flanagan, & Szwed, 2009; Tyler, Hughes, Wilson, Beverley, Hastings & Williams, 2015). As technology has advanced, portable smart devices (PSD), such as iPads and iPods, have received increasing attention from researchers in special education. Research indicates that using PSDs can benefit all students, including students with disabilities, by providing multiple forms of text (Lorah & Parnell, 2014), communication options (Xin & Leonard, 2015), and digital video and audio-recording functions (Hammond, Whatley, Ayres, & Gast, 2010).

PSDs, especially, can be useful tools to teach students with ID various functional skills, such as domestic skills, academic behavior, community skills, and job skills. To date, four studies have investigated the effects of using PSDs in teaching students with ID domestic skills (e.g., food preparation). Taber-Doughty et al. (2011) used three iPod Nanos to teach food preparation skills (i.e., 12 recipes) to middle school students with ID. The researchers used the devices to show the students video modeling (VM) demonstrating making 12 recipes. Payne, Cannella-Malone, Tullis, & Sabielny (2012) taught making microwave popcorn and preparing soup to two secondary-age students with ID and ASD. They utilized an iPod Touch for self-video prompting (SVP). Johnson and colleagues (2013) also taught another food preparation skill to two high school students with ID and ASD. The students learned how to make fruit smoothies, macaroni and cheese, and frozen pizza through an iPad Touch being used for video prompting (VP). Gardner and Wolfe (2015) evaluated the effects of using an iPad in teaching washing dishes to four middle school students with ID. They used an iPad as a tool to deliver VM and VP to teach the skill. These studies indicated positive effects on using PSDs to teach home skills to students with ID.

Researchers also examined PSDs as tools to increase or decrease academic behavior skills (e.g., on-task behaviors). So far, three studies have investigated the effects of using PSDs on academic behaviors and indicated that the use of PSDs was an effective method to teach such behaviors to students with ID. Hart and Whalon (2012) used an iPad to teach how to respond to teachers' questions in science class to secondary students with moderate ID and Autism Spectrum Disorder (ASD). In the study, an iPad was used to deliver self-video modeling (SVM).

Kim, Blair, and Lim (2014) also conducted a study on utilizing a tablet computer to increase academic behavior (e.g., on-task behaviors) and decrease disruptive behavior (e.g., disturbing classmates and making noises). A *Samsung Galaxy Tab* was used to present a social story to teach three secondary school students with ID desirable academic behaviors. Douglas and Uphold (2014) also used one iPad and one iPod in their study to improve a skill for scheduling school activities. Five high school students learned scheduling school activities using an app (*First Then Visual Schedule*). The studies reported that the academic behaviors of the students were increased when PSDs were used.

In addition, six studies have investigated using PSDs to teach various community skills (e.g., pedestrian navigation, using an ATM, and grocery shopping). Kelley and colleagues (2013) conducted a study teaching pedestrian navigation skills to four college students with mild to moderate ID. One iPod Classic and one iPod Touch showing the photographs of landmarks were used for the students to navigate to destinations. Similarly, McMahon, Smith, Cihak, Wright, and Gibbons (2015) and Smith et al. (2017) taught the same skills using iPads and/or iPhones to college students with ID. Unlike Kelley et al., they used an app, *Heads Up Navigator: 3D,* to simulate Augmented Reality (AR) for students to locate destinations. Another study (Taber-Doughty et al., 2008) investigated the effectiveness of using PSDs to teach locating books or DVDs at a public library to three middle school students with moderate ID. The researchers used an iPod Classic for simultaneous and delayed VM. PSDs were also utilized to teach using an ATM card to three college-aged students with ID (Scott et al., 2013). In the study, an iPod Classic was used to present a video podcast to the students to learn the skills. The video podcast played a role in VM. Douglas, Ayres, and Langone (2015) taught another skill to four high school students with moderate ID. They taught the location of grocery items using an iPhone which provided visual supports. They compared different visual supports (i.e., text only, audio and text, and picture and text) and reported that the picture and text were the most effective. The results of all the studies indicated that although there were some variations, PSDs were effective tools for students with ID to use for acquiring community skills.

Lastly, job skills can be taught using PSDs. Five studies have investigated the effects of using PSDs in teaching job skills to students with ID. Laarhoven and colleagues (2009) conducted a study on effects of using PSDs in teaching one high school-aged student four different job skills (e.g., cleaning bathroom, mopping floors, taking out garbage, and cleaning kennels). The researchers used an iPod Classic, and this was used to present video prompts of each step to complete the three tasks. Cannella-Malone, Wheaton, Wu, Tullis, and Park (2012) taught sweeping and washing tables to three adolescents with moderate to profound ID using an iPod Touch. They delivered VP through the iPod Touch with or without error correction. Cannella-Malone et al. (2013) conducted a similar study to Cannella-Malone et al. (2012). They taught washing tables and vacuuming to four adolescents with moderate to severe ID. An iPod was used with an app (*inPromptu*) to show self-directed VP to the students. Wu, Cannella-Malone, Wheaton, and Tullis (2016) taught similar skills (i.e., washing tables and windows) to two middle school students with ID. To teach these skills, the researchers used VP presented via an iPod Touch with error correction. All of the studies demonstrated positive effects of using these devices to teach job skills to students with ID.

The literature shows that a number of studies have examined the effects of using PSDs to teach various functional skills to students with ID. However, it also indicates that there are two areas that have not been addressed yet. One is the effects of using PSDs in teaching elementary level students with ID. All students who participated in the studies in the literature were secondary or post-secondary level students with ID. Also, no studies in the literature directly addressed the effectiveness of using PSDs in teaching academic skills (e.g., reading and math skills) to this population. In addition, many of the studies in the literature examined PSDs as tools for video technology (i.e., VP and VM), but only a few studies (see Douglas et al., 2015; Kelley et al., 2013) examined the potential of using PSDs as tools to provide visual supports (e.g., text, picture, and audio). Researchers accordingly should investigate areas which have not been explored.

Therefore, the purpose of the current study was to examine if using the iPad to provide visual supports was effective in teaching phonemic segmentation to elementary students with mild to moderate ID. In addition, the first author proposed and used the 7Cs strategy (Table 2) to create visual supports, which was delivered through an iPad, for the study. The strategy may help special educators create visual supports and use them with PSDs for the students.

Research Questions:

- Is using the iPad providing visual supports effective in teaching phonemic segmentation to elementary school students with ID?
- Is the 7Cs strategy applicable in the classroom setting as perceived by the special educator?

Method

Participants

Three students with mild to moderate ID at a suburban public elementary school in the South Central United States participated in the study. The second author sent an email to graduate students, most of whom were general or special education teachers, to find a teacher who taught students with ID. One teacher replied to express his interest in this study. The first author then contacted the teacher to recruit participants. In recruiting participants, we used predetermined inclusion criteria: (a) students who were diagnosed as having ID; (b) students who needed to acquire early literacy skills; and (c) students, whose IEP goals included the needs of acquiring early literacy skills. The teacher was a male with 3 years of experience as a resource teacher at potential participants' school. He has taught various skills (e.g., reading and math) to students with ID, autism, learning disabilities (LD), and emotional and behavior disorders (EBD). His resource room used a school district developed curriculum, which was aligned with the state academic standards. With the criteria, the teacher nominated four potential participants. The potential participants were mainly in general education classrooms and came to the teacher's resource room in reading and math all most everyday day. Except for these periods, they were educated alongside classmates without disabilities. Based on a discussion with the teacher and the potential participants' IEP goals, we (i.e., the research team) selected phonemic segmentation skills as target academic skills for the study. After obtaining parental consent, we assessed participants' present levels of phonemic segmentation fluency (PSF) using *Dynamic Indicators of Basic Early Literacy Skills* (*DIBELS*) 6th Edition probes (Kindergartner level). Based on the students' scores on PSF (i.e., below grade level), three students were selected for participation.

Jill. Jill was a Caucasian female student in second grade (7 years 8 months) diagnosed with mild ID (WISC-IV: IQ = 70). She liked to play with her classmates, and eagerly share information about her school work and her family with teachers and classmates. Academically, her reading was at the kindergarten level (Developmental Reading Assessment-2: 0.4). She was able to name every letter of the alphabet and produce 15 sounds of the letters,", but she had difficulty in decoding words. She was able to perform rote counting to 10, but struggled with single digit addition. She had a very short attention span and was easily distracted by other people (e.g., other students or para-professionals). Although she had difficulty in pronouncing some sounds (e.g., '-ing'), this did not interfere with her speech comprehensibility so she was able to articulate her needs and engage in conversations.

Parker. Parker was a Hispanic male student in fourth grade (8 years 2 months) diagnosed as having mild ID (WISC-IV: IQ = 70). He was a very introverted student. Academically, his reading was at the first-grade level (Developmental Reading Assessment-2: 1.0). He knew every letter and letter sound, but struggled with decoding similar words. He could rote count to 200. Also, he could calculate single digit addition, but was not fluent. He rarely initiated conversations with adults, but liked to make conversations with his classmates. Although he demonstrated some speech errors, he could clearly articulate his needs.

Don. Don was an Asian male student in fifth grade (10 years 9 months) diagnosed as having moderate ID (WISC-IV: IQ = 57) with communication difficulties. He was a happy and energetic student and loved to share stories about his family with his teachers. Academically, his reading was at the first-grade level (Developmental Reading Assessment-2: 1.4). He knew every letter and letter sound, but had difficulty decoding unfamiliar words, such as those ending with "-ought" and "–ight". He was able to count to 100 and compute single digit addition problems. He struggled to speak clearly if he was excited or nervous. He often refused to work on tasks when he was confused and he did not like to work with unfamiliar people.

Instructional Settings

Approximately 800 students (Early Childhood to 5th) attended the participants' elementary school, and approximately 80 of them received special education services. The study primarily took place in an assessment room at the participants' school to avoid interruptions by other students and staff. Also, the teacher's preparation room and the school counselor's room were used to accommodate school and classroom schedules on two occasions. The size of the assessment room was approximately 8ft. by 12 ft. It had approximately 10 student desks and chairs. During the study, a student desk and chair were located in the middle of the room, and chairs for the researchers were next to the student desk.

Materials

10-word probe. A 10-word probe was developed to teach the target skills to the students. The probe included 10 words that the students could not break down into individual sounds (Table 1). In order to identify these 10 words, two *easyCBM* Phoneme Segmenting (Kindergartner level) and one *DIBELS* PSF probe (Kindergartner level) were randomly selected and administered to the students. After scoring the probes, words that the students were not able to break down correctly were analyzed. If a word was broken down correctly fewer than 50% of the total possible points across at least two students, the word was included in the 10-word probe. For instance, if two of the students obtained one point (33.3%) for a word, which had three possible points, and the other student obtained two points (66.6%) for the word, the word was included in the probe. But, if two of the students obtained two points for the word (66.6%), and the other student obtained one point (33.3%) for the word, the word was not included in the probe. Using this process, 10 words with three to five syllables were identified and included in the probe. These words were randomly ordered in the probe with their phonemes (e.g., shine /sh/ /ie/ /n/) to score (Table 1). In addition to the words and phonemes, the probe included directions for the researchers to consistently administer the probe (e.g., “After I say the word, you will tell me all the sounds you heard in the word”) on the top of it. This 10-word probe was used in baseline, intervention, and 1-week maintenance sessions. The *easyCBM* and *DIBELS* probes used to develop the probe were excluded from assessments during pre- and post-tests.

Visual support materials. The first author developed visual support materials to deliver via an iPad by using the 10-word probe and the 7Cs strategy (Table 2). An Apple iPad® (first generation) and two iPad applications (i.e., MS PointPoint® and Voice Recorder®) were used to create the materials. MS PointPoint® was used to create text and slides, and Voice Recorder® was used to record auditory directions (e.g., "Listen to the word and sounds carefully") and sounds (e.g., the 10 words and the words' phonemes) embedded in the materials. The materials consisted of 32 PowerPoint slides. The first slide showed the title ("Let's Learn How to Make All the Sounds in the Words"), and the second slide provided the students with a general direction (e.g., how to manipulate the visual support materials) with auditory recordings (e.g., "To move on to the next slide, you need to swipe the slide from right to left"). Beginning with the third slide, instruction on phonemic segmentation was provided. Each of the words in the 10 word-probe was taught with three slides. The first slide (phase 1) for each word provided the students with (a) a visual presentation for the word (e.g., the word "loaf"), (b) auditory directions (e.g., "Listen to the word and sounds in the word carefully"), and (c) sounds for the word and each phoneme (e.g., "/Loaf/" and "/l/-/o/-/f/"). The second slide (phase 2) for each word provided the students with the same visual presentation used in the first slide; however, a different auditory direction was provided (e.g., "Repeat after me"). Sounds for each word and each phoneme in the word were provided with a short time delay (approximately 2s) to allow the students to repeat the sounds (e.g., "/loaf/" followed by a time delay for the students, then "/l/" followed by a time delay for the students, then "/o/" followed by a time delay for the students, then "/f/" followed by a time delay for the students). The third slide (phase 3) for each word provided the students with the same visual presentation used in the first slide, but a different auditory direction from the first and second slides was provided (e.g., "Read the word and make sounds for the word by yourself"). No word or phoneme sounds were provided for the students. The slides for each instructional phase had a different background color so that the students could know what phase they were in (e.g., the background color for the first phase was yellow).

7Cs Strategy

The first author proposed the 7Cs strategy (Table 2) to guide educators to developing iPad instructional materials, and it was used in the study. In Step 1, we (i.e., the researcher team) consulted with the special education teacher to identify a skill to teach based on the IEP goals of the participants (Step 1). In Step 2, we measured the current level of performance on the chosen skill for each student and analyzed data that were collected through this measurement. Based on our analysis, we selected the 10 words to teach and developed the 10-word probe. In Step 3, based on the 10-word probe, we created auditory recordings (e.g., word and word phoneme sounds) using an iPad App. In Step 4, we combined the audio recordings with text (e.g., words in the 10-word probe) using MS PowerPoint® App to present. In Step 5, we created a data collection sheet (i.e., the 10-word probe) based on the 10 words chosen in Step 2. In Step 6, we created directions for our doctoral student researcher (i.e., DSR) to assure consistency in implementing the intervention. In Step 7, we inserted an auditory direction in the second slide of the materials (e.g., "To move on to the next slide, you need to swipe the slide from right to left") as a means to coach the students on how to use the iPad instructional materials. Also, the DSR provided verbal direction to the students when they were unable to move to the next slide (e.g., "swipe the slide"). All the steps took place before pre-test session.

Experimental Design

A multiple probe design across students (Kazdin, 1982) was used in this study to investigate evidence for a functional relation between the visual supports on an iPad and the students' performance in phonemic segmentation. Unlike a multiple-baseline design across students, the multiple probe design provided a means to reduce potential carryover effects and therefore enhanced the internal validity of the study. The study was comprised of five phases: pre-test, baseline, intervention, maintenance, and post-test. The pre- and post-test phases were used to examine the generalizability of the skills acquired through the iPad visual supports. To evaluate the students' performance level during the pre- and post-test phases, students were presented with randomly selected words which had not been taught. The pre-test phase took place before the baseline phase, and the post-test phase took place after the maintenance phase. The purpose of the baseline phase was to evaluate the students' current performance level using the 10-word probe. The purpose of intervention phase occurred to evaluate the students' progress during implementation of the intervention. After the intervention phase, a 1-week maintenance session took place to examine the extent to which the skills acquired during intervention were maintained. During the maintenance phase, the 10-word probe was used to measure the students' performance level in the same manner as during the baseline phase.

Dependent Variables

Two dependent variables were collected in the study. The first dependent variable was the participant's *DIBELS* PSF scores during the pre- and post-test phases. The second dependent variable was the participant's scores on the 10-word probe during the baseline and intervention phases and the one-week maintenance phase. The students could score up to 36 points in each 10-word probe. The scores were converted to percentages, and the percentages were plotted on a graph for visual analysis (Figure 1).

Procedures

Pre- and post-test phases. One pre-test session occurred in the assessment room before the intervention phase. Prior to the study, the first author trained the DSR to implement the intervention and collect data. The DSR worked as a bilingual teacher and educational diagnostician over 18 years and was adept at teaching literacy skills to both students with and without disabilities. During the pre-test session, the DSR administered a *DIBELS* PSF probe to each student in a one-on-one setting. The DSR sat by the first student and administered the PSF probe which had randomly selected from 19 *DIBELS* Kindergarten probes. Once one minute had passed, the DSR stopped the student and praised the student (e.g., "good job"), and provided a sticker (the same reward regularly use by the student's special education teacher). The DIBELS standard directions for PSF probes were used to administer (e.g., reading words aloud) and score the probe. The pre-test session lasted approximately 5 min for each student. One post-test session took place. The same procedure was used in the post-test session, however, a randomly selected PSF probe was administered (thus, words in the post-test probe were equivalent in difficulty, but were different, from words used in the pre-test probe).

Baseline phase. During the baseline phase, no intervention was implemented; the 10-word probe was administered to each student in a one-on-one setting by the DSR until baseline data became stable. In order to ensure stability of baseline data prior to introducing the intervention, baseline data were collected until low variability with at least three data points was demonstrated (Figure 1). Unlike the pre-test phase, this assessment was not timed; all of the 10 words in the probe were administered. The DSR sat by the first student and read aloud the directions on the 10-word probe. The DSR then read aloud the first word on the probe and waited for the student's response. Sufficient time for a response was given to the student. If the student responded, his or her response was recorded as it was spoken regardless of the correctness, and the DSR prompted the student move to the next word. If the student could not respond, the DSR also prompted the student to move to the next word. No error corrections were provided during this phase. General praise (e.g., "good job") was provided after the last word was administered. The same procedure was used across the remaining students. Baseline sessions occurred three or four times a week, and each session lasted approximately 10 minutes. The DSR also intermittently collected baseline data the remaining students until they began their intervention phase.

Material customization session. The first student took part in a session to customize the visual support materials. When the first student began the intervention phase, the initial visual support materials were used to teach phonemic segmentation for the 10 words. The total amount of time for the intervention was measured by the researchers to adjust the total number of slides. After this session, to reduce the time to deliver the intervention (from 40 minutes to 20 minutes), the researchers reduced the total number of slides (from 152 to 32 slides) by condensing the content and then used the adjusted visual support materials during the intervention phase. The student's responses during the customization session were scored but were not considered as experimental data to determine the effects of the intervention.

Intervention phase. The intervention was implemented in a one-on-one setting. The DSR loaded the adjusted visual support materials onto an iPad and placed the iPad on the desk in the assessment room prior to each intervention session. A short directive (e.g., "Today, you are going to learn how to make sounds in words. Let's get started") was given to the student. After the directive, the student swiped from right to left to move to the second slide providing auditory directions about how to use the visual support materials. Then, the student advanced to the first slide of the first word. In the first slide, the student listened to an auditory direction (i.e., "*Listen* *to the word and sounds in the word carefully*"); looked at the slide presenting the first word (e.g., "loaf") while the iPad read the word (e.g., "loaf"); and then made the phonemic sounds (e.g., "/l/-/o/-/f/") in the word. In the second slide, the student listened to an auditory direction (i.e., "*Repeat the word and sounds in the word after me*"); listened to the word and the phonemic sounds in the word; and then repeated these sounds. In the third slide, the student listened to an auditory direction (i.e., "*Read the word and make sounds in the word by yourself*") and was prompted to read the word and make the phonemic sounds in the word. After the third slide for the first word, the student advanced to the first slide for the second word. The same procedures were used for the remaining words. If the student did not follow the auditory directions (e.g., the student did not repeat the words or phonemic sounds in the second slide), the doctoral student verbally promoted the student to repeat the words or phonemic sounds. If the student repeated the words or phonemic sounds incorrectly, the doctoral student corrected the sounds by modeling them (e.g., "the correct sound is /ai/") and gave the student another opportunity to read the words or make the phonemic sounds. When the student read the words or made the phonemic sounds correctly, general verbal praise was provided to the student. The student went through all the 32 slides twice in each session. After the intervention, the student's progress was evaluated using the 10-word probe. The same evaluation procedure used in the baseline phase was used in this evaluation (i.e., no error corrections were provided during the evaluation). The intervention sessions occurred three to four times a week and continued until the student met the mastery criterion (i.e., 80% correct or above). Each intervention session lasted approximately 20 minutes.

One-week maintenance phase. One week after the intervention phase ended, a maintenance session took place to measure participants' maintenance of the acquired skills. The same procedure used in the baseline phase was used, and each probe lasted about 10 minutes.

There were no maintenance data for the third student because the school year ended before the maintenance session for the student occurred.

Inter-Observer Agreement

Inter-observer agreement data were collected during the intervention phase to ensure that measurement was accurate. The first author trained the special education teacher to be the second observer. Both observers counted the students' total number of phonemes pronounced correctly (out of 36) in the intervention session. Inter-observer agreement was calculated by dividing the number of agreed-upon scores by 36 and multiplying by 100. Inter-observer data were collected for 78.5% of the intervention sessions across the students; a mean of inter-observer agreement was 92.3% (range = 72.2 – 100%).

Procedural Fidelity

The special education teacher collected data on procedural fidelity during the intervention delivery. Using a data collection sheet, the special education teacher measured and scored six steps for implementing the intervention. Procedural fidelity data were calculated by dividing the number of correct steps by 6 and multiplying by 100. These data were collected in 57.1% of the intervention sessions across the students; a mean of procedural fidelity was 100%.

Social Validity

After the study, an email survey including five multiple-choice questions (e.g., I believe that the intervention was appropriate for teaching the target skills to the students) using a Likert scale (5 points) and one open-ended question were given to the special education teacher to assess social validity of the intervention. The teacher reported that all students expressed that the intervention was fun and helped them learn the skill. The teacher also indicated that the students' decoding skills improved (e.g., self-correction for unfamiliar words); their academic engagement increased; and the acquired skills were used in other areas (e.g., understanding directions).

Results

Figure 1 shows the percentage of correct responses for phonemic segmentations. The data clearly shows changes in student performance between the baseline and intervention phases, both in terms of trend and level. Changes in trend and level are key indicators of behavioral change (e.g., see Ledford & Gast, 2018; Maggin, Briesch, & Chafoleas, 2013). When the intervention was introduced, all students' performance improved over the baseline phase. Moreover, there was no overlapping data between the baseline and intervention phases across all students. Although Don did not meet the mastery criterion, his data during the intervention phase clearly showed an upward trend. Jill and Parker met the mastery criterion and maintained the skill. Overall, results of the study established a functional relation between using visual supports presented through an iPad and the improvement of phonemic segmentation for students with ID. However, the findings in regard to generalization (34.2% – 44.7%) of the acquired skills were inconclusive.

Jill

Jill had a score of 35% on the pre-test. During the baseline phase, three sessions took place. The mean score of the baseline data was 36.1% (range 30.6% - 47.2%). She consistently struggled with the words including vowel sounds (e.g., /ai/, /ie/, and /ir/) and consonant sounds right after the vowel sounds (e.g., /k/, /l/, and /t/). When the intervention started, Jill's scores rapidly increased during her first and second intervention sessions. Jill finally met the mastery criterion (i.e., 80.0%) in her third intervention session and continued to meet the criterion in two subsequent sessions. She scored 86.1% in the fourth session and 88.9% in the fifth intervention session. The mean score of her intervention data were 77.8% (range 52.8% - 88.9%). Unlike the baseline phase, she struggled with only one vowel sound (i.e., /ai/) consistently and some ending consonant sounds inconsistently (e.g., /k/, /n/, and /r/). There was a clear change in performance level between Jill's baseline and intervention phases (36.1% to 77.8%) with no overlapping data points. Jill then scored 90% in a one-week maintenance session. However, her post-test score was the same as her pre-test score (i.e., 34.2%).

Parker

Parker had a score of 20% on the pre-test. During the baseline phase, five data points were collected. The mean score of the baseline data was 35.6% (range 33.3% - 38.9%). He also consistently struggled with the words including vowel sounds (e.g, /ie/, /ai/, and /ir/) and consonant sounds right after the vowel sounds (e.g., /n/, /k/, and /t/). After the intervention was implemented, Parker's scores immediately increased, and he met the mastery criterion in three consecutive sessions. The mean score of the intervention data was 87.0% (range 83.3% - 88.9%). After the implementation of the intervention, he no longer struggled with any vowel sounds but struggled with some consonant sounds inconsistently (e.g., /k/, /n/, and /r/). Visual analysis of the data indicated a clear separation in performance level between Parker's baseline and intervention phases (35.6% to 87.0%), with no overlapping data points. Parker maintained the acquired skills during the one-week maintenance phase. His score in the maintenance session was 90%. During the post-test phase, he scored 44.7%. This performance level was somewhat higher than the level in the pre-test phase.

Don

In the pre-test session, Don scored 15%. Six baseline data points were collected where the mean score was 38.4% (range 27.8% - 44.4%). Like the other two students, he consistently struggled with the words including vowel sounds (e.g, /ie/, /ai/, and /ir/) and consonant sounds right after the vowel sounds (e.g., /k/, /n/, and /t/). His scores immediately increased when the intervention was introduced. The mean score of the intervention data was 63.9%. But, the researchers could not continue to collect data on the intervention and post-test due to the beginning of summer break. During the intervention, Don did not struggled with any vowel sounds but produced some consonant sounds inconsistently (e.g., /g/, /k/, and /n/). Although he did not reach the mastery criterion, visual analysis of his data indicates an immediate upward trend; a clear separation in level between Don's baseline and intervention phases (38.4% to 63.9%); and an upward trend during the intervention phase with no overlapping data points.

Discussion

The current study investigated the effects of using visual supports presented via an iPad to teach phonemic segmentation to students with ID. Results of the study indicate that using the iPad to provide visual supports is overall an effective tool to teach phonemic segmentation to elementary students with mild and moderate ID. Although early literacy skills are crucial for learners' school and community success, no prior study was found which investigated the effects of using PSDs to teach phonemic segmentation skills to students with ID (Goo, Maurer, & Wehmeyer, 2019). The results from this investigation add new findings to the literature base on the effects of using an iPad in teaching academic skills to students with ID. In our study, all students showed improved phonemic segmentation skills after the implementation of the intervention. Jill's performance gradually improved; she met the criterion in the third session during intervention phase and maintained the skills in two successive sessions. Parker's performance immediately met the criterion in the first session during the intervention phase and maintained the skills in two subsequent sessions. Although Don did not meet the criterion, his performance immediately improved and was maintained at a similar level.

With respect to generalizability (i.e., reading novel words which were not taught through the visual support materials), our findings did not provide conclusive results. Although Parker showed improvement from the pre-test to the post-test, Jill did not show improvement from the pre-test to the post-test, and Don was not able to have the post-test because summer break began. Therefore, the findings did not provide clear evidence supporting the generalizability of the acquired skills to novel words.

The results also suggest that using multimedia (e.g., visual and auditory prompts via PSDs) is an effective method. This finding is consistent with previous research on the effectiveness of using multimedia to teach skills to students with ID (Cannella-Malone et al., 2013; Douglas et al., 2015; Gardner & Wolfe, 2015; Kelley et al., 2013; Scott et al., 2013). It is hard to pinpoint which component of PSDs affected the students' performance; however, it is evident that PSDs can be effective tools to teach various skills to students with ID (Goo et al., 2019). The visual support materials used in the study provided the students with various visual prompts (e.g., text, different background color) and auditory prompts (e.g., auditory directions, sounds for each word, and phonemic sounds for the words). In studies by Gardner et al. (2015) and Scott et al. (2013), when multimedia materials were presented via an iPad or an iPod, the performance of the participants immediately improved. Similarly, in the present study, when the visual support materials were presented via the iPad to the students, their performance improved immediately.

Another possible factor that may have affected participants' skill acquisition was the interactive components (e.g., swiping and responding to visual and auditory prompts) of the visual support materials via the iPad. Researchers reported that interaction with multimedia materials may have facilitated students' engagement, thus leading to better outcomes (Goo, Therrien, & Hua, 2016; Mechling, Gast, & Langone, 2002). Similarly, the visual support materials used in the study allowed the students to interact with the materials by listening to auditory directions, looking at visual prompts, and responding to directions or prompts (e.g., making phonemic sounds; reading words, swiping the screen to move to the next slide). The iPad may have held the students' attention and increased their engagement, which facilitated the skill acquisition.

Lastly, the first author proposed the 7Cs strategy, and it was used to create the iPad materials for the study. This strategy guided the researchers to creating the materials using the iPad and instructing the students during the study. This may also help special educators create iPad (or PSD) materials for their instruction. One study is certainly insufficient to provide evidence of the effects of using this strategy; however, additional research on using it can provide more evidence of how the 7Cs strategy can help special educators with using PSDs more effectively when teaching their students.

Limitations

Although the findings of the study indicate that using PSDs can be effective when teaching phonemic segmentation to students with ID, there are two limitations to consider when interpreting the study findings. The first limitation was that the improvement of all students was limited to the 10-words taught via the iPad visual supports. Although all the students attained and maintained scores above the mastery criterion or showed improvement during the intervention phase, two of them were not able to generalize the skills to novel words or displayed only slightly better performance in the post-test session, and the last student was not even able to have the post-test session. One possible reason why the students were not able to generalize the skills was that although the words for the 10-word probe were identified carefully, the 10 selected words may not have given the students sufficient variations to generalize the skills to novel words. For instance, although the words in the 10-word probe were selected using a semi-random process, three of them started with the same letter (i.e., “w”). A short duration of delivering the intervention may also have affected the generalization of the skill. The second limitation was that the researchers could not continue to collect data on the last student because the students’ school began the summer break. As stated earlier, Don showed improvement during the intervention phase; however, he was not able to meet the mastery criterion and was not evaluated for post-test data. Although this does not pose a threat to the internal validity of this study, it does impact the external validity of the study (i.e., the generalizability of the results).

Implications and Suggestions for Future Research

The findings of this study suggest that this type of intervention could be an effective way to teach early literacy skills to students with mild to moderate ID. Teachers are likely to use technology in their classrooms if the technology is easy to use and is associated with immediate effects on student learning. Using PSDs to present visual supports can also promote inclusion for students with ID because of the ubiquitous nature of PSDs, which draw little attention and may be less stigmatizing than other interventions (McMahon et al., 2015; Taber-Doughty et al., 2011).

In addition to early literacy skills, researchers should continue to investigate the effects of using PSDs and strategies like the 7Cs to teach students with ID other academic skills (e.g., adding, subtracting, word identification, shape identification), social skills (e.g., introducing yourself, saying “please” and “thank you,” waiting your turn), and life skills (e.g., brushing teeth, getting dressed, making the bed). The effects of the intervention increase its appeal to special educators, who could develop multiple materials and use them across learners as appropriate.

Conclusion

Overall, the study added new findings to the literature on the effects of using visual supports via PSDs in teaching early literacy skills to students with ID. The results of the study suggested that using an iPad was an effective method to teach phonemic segmentation to elementary school students with ID. However, the results also indicated that its effects on generalizing the skills was inconclusive. Therefore, more research on the functional relation between PSDs and teaching early literacy skills to students with ID should be conducted to ensure the effectiveness of this method.

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Table 1

Words in the 10-Word Probe and Possible Points for Each Word

No.	Word	Sounds	Possible Points
1	shine	/sh/ /ie/ /n/	3
2	clink	/c/ /l/ /i/ /n/ /k/	5
3	grabbed	/g/ /r/ /a/ /b/ /d/	5
4	pouch	/p/ /ow/ /ch/	3
5	whale	/w/ /ai/ /l/	3
6	broke	/b/ /r/ /oa/ /k/	4
7	meet	/m/ /ea/ /t/	3
8	worth	/w/ /ir/ /th/	3
9	worked	/w/ /ir/ /k/ /t/	4
10	loaf	/l/ /oa/ /f/	3

Table 2

7Cs Strategy

Step 1	*Choose a skill to teach.*
Step 2	*Conduct an analysis (task analysis) for the chosen skill (if needed).*
Step 3	*Create video clips/photographs/text using a PSD*
Step 4	*Combine the video clips/photographs/text using a presentation application.*
Step 5	*Construct a data collection sheet/tool aligned with the analysis or task analysis*
Step 6	*Craft simple lesson plans (if needed).*
Step 7	*Coach students on how to use the material (if needed).*

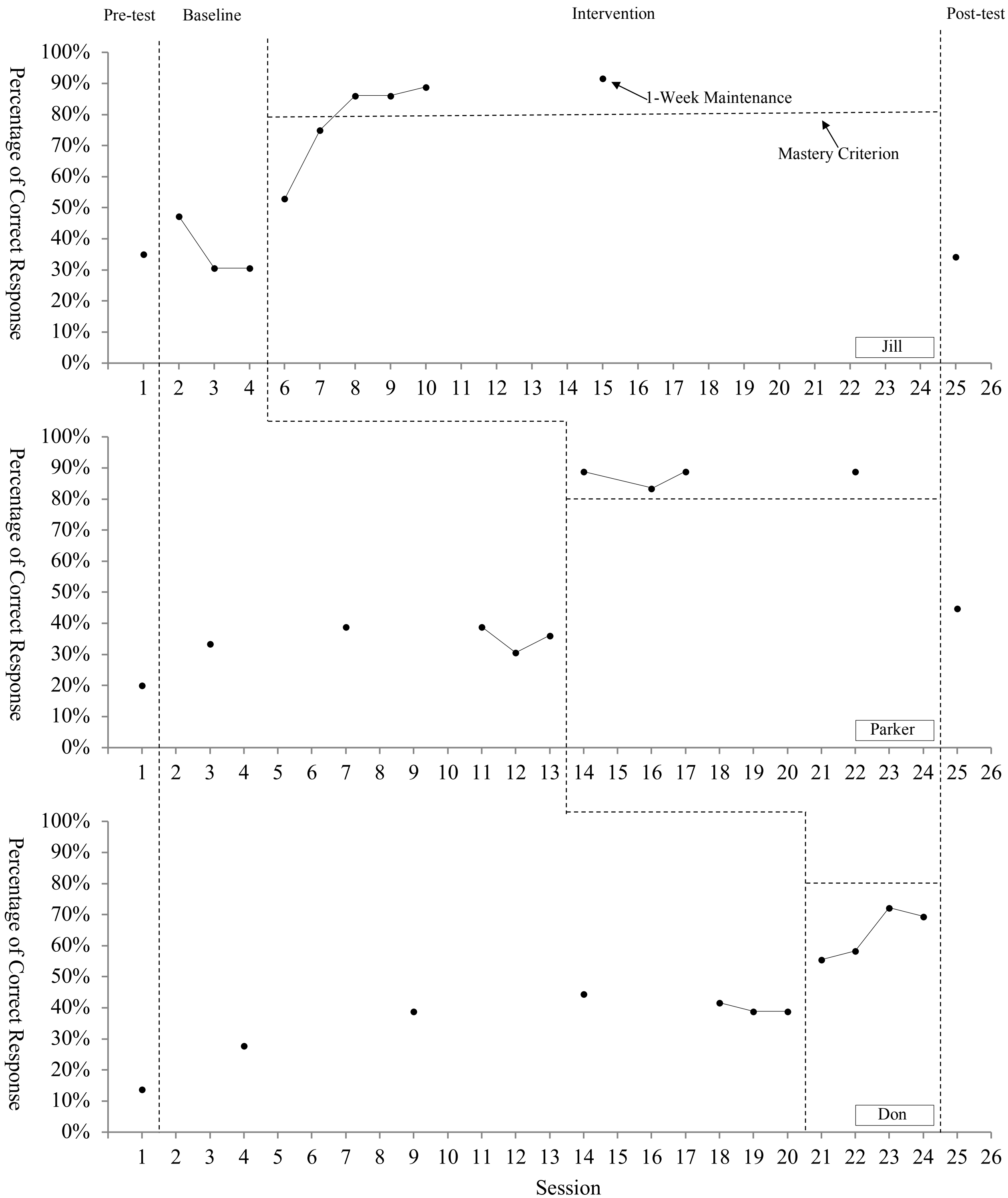
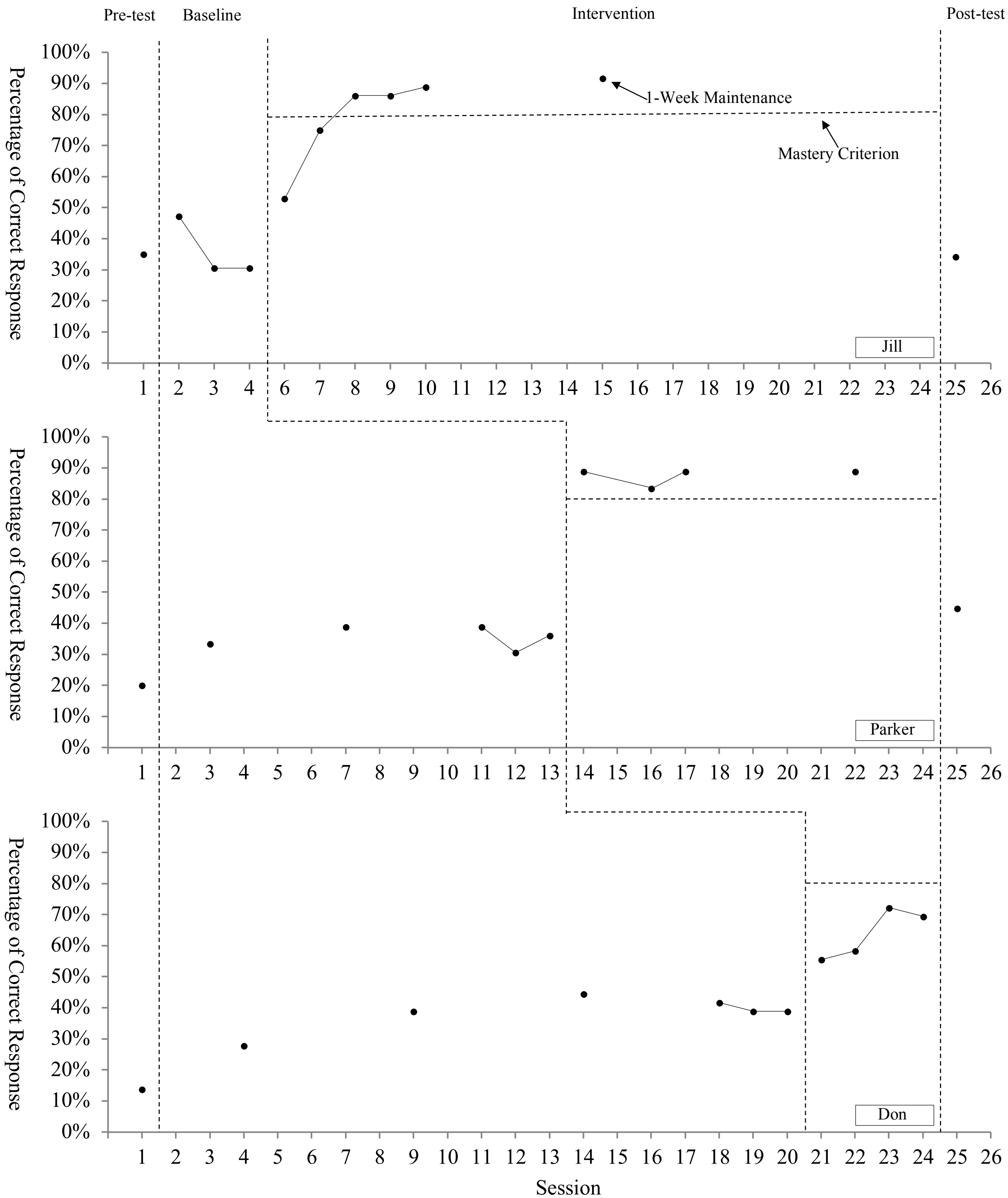


Figure 1. *Students' Performance on Phonemic Segmentation Fluency*



Pre-test
Baseline
Intervention
Post-test
1-Week Maintenance
Mastery Criterion
Percentage of Correct Response
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Jill
Parker
Don
Session