


A Comparison of the Effects of Reading Interventions on Engagement and Performance for Fourth-Grade Students With Learning Disabilities

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Abstract

Inexpensive software applications designed to teach reading, writing, mathematics, and other academic areas have become increasingly popular. Although previous research has demonstrated the potential efficacy of such applications, there is a paucity of research that compares applications instruction (AI) with traditional teacher-directed instruction (TDI), and the relative effectiveness and efficiency of these instructional approaches remains largely unknown. This study used an alternating treatment design to compare academic engagement and outcomes (i.e., word identification and reading fluency) during an AI condition and a TDI condition for four students with learning disabilities (LD) attending a charter school. Instructional conditions (i.e., TDI, AI) were randomly alternated 7 times each, for a total

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of 14 instructional sessions. Results indicated that both approaches fostered high levels of engagement although students were more engaged during AI. With regard to academic performance, visual and quantitative analysis suggest that TDI was more effective than AI in terms of passage fluency and word identification. Students completed social validity rating scales to examine instructional preference. Results indicated that both approaches, TDI and AI, were popular with the students.

Keywords

reading, learning disabilities, technology, iPads

The report of the National Assessment of Educational Progress (NAEP; 2013) noted that fourth- and eighth-grade students in the United States score poorly on standardized reading tests, with only 35% and 36%, respectively, showing at or above proficient. For students with disabilities, the statistics are even more disturbing, with 11% scoring at or above proficient in fourth grade and only 9% in eighth grade. Research has demonstrated, however, that students with reading learning disabilities (LD) can learn to read, provided they are engaged when given evidence-based interventions that combine systematic and explicit instruction with strategic instruction (Swanson, Hoskyn, & Lee, 1999). Specifically, strategy instruction is critical for students with LD for learning reading skills such as phonological awareness (Mathes, Torgesen, & Allor, 2001), word study (Fuchs, & Fuchs, 2005), fluency (Kuhn & Stahl, 2003), vocabulary (Mastropieri, Scruggs, & Fulk, 1990), and comprehension (Vaughn et al., 2011). Yet research has demonstrated, for example, that readers who are not engaged are less motivated and use fewer strategies to comprehend text (Wigfield et al., 2008). According to Alvermann (2002), “the level of student engagement (including its sustainability over time) is the mediating factor, or avenue, through which classroom instruction influences student outcomes” (p. 192).

Singh, Granville, and Dika (2002) described academic engagement as “active involvement, commitment, and attention as opposed to apathy and lack of interest” (p. 324). The importance of engagement during instructional activities cannot be overstated. Peverly, Marcelin, and Kern (2014) noted this simple truth: “If students do not attend to instruction, they cannot learn from instruction” (p. 405). Research has long noted that low levels of academic engagement produce low academic achievement (Fredricks, Blumenfeld, & Paris, 2004; Voelkl, 1997). For struggling students at the middle elementary level, engagement is particularly important because reading interventions

typically focus on skills that students failed to learn earlier in their academic lives. Students are behind their typically achieving peers in one or more of the five areas of reading designated by the National Reading Panel (National Institute of Child Health and Human Development, 2000): phonological awareness, word study/phonics, fluency, vocabulary, and comprehension. To close the achievement gap, struggling students must progress at a rapid rate. Thus, every day of intervention is critical, and teachers must use the most advanced techniques and tools available.

Technology devices have been demonstrated to enhance individuals' functional skills (Bryant & Bryant, 2011), including improving the reading performance of students with LD (Hall, Hughes, & Filbert, 2000). Previous research also suggests that the mere use of technology may facilitate an increase in student motivation (e.g., Okolo, 1992), a critical factor relating to student engagement. Motivation, in this sense, has been measured in terms of attention in learning (Fisher, 1983), time on task (Okolo, Bahr, & Rieth, 1993), and independence (Manset-Williamson, Dunn, Hinshaw, & Nelson, 2008).

Over the past 30 years, computer-assisted instruction (CAI), a precursor to current apps, has been identified as a promising method for teaching reading to students with disabilities, including those with LD (Ramdoss et al., 2011). Like apps, CAI uses computer software programs to offer instructional content to enhance students' skills, knowledge, and academic achievement, whether used in isolation or as a supplemental tool that is combined with traditional teacher-directed instruction (TDI; Okolo et al., 1993). CAI is commonly delivered as (a) drill and practice, (b) tutorials, (c) games, (d) simulations, (e) problem solving, and/or (f) computer-managed instruction (Mechling, 2011). As technology has evolved, mobile devices have supplemented, or in some cases, supplanted desktops or laptops as a means to help deliver instruction. Smartphones, tablets, and the like have gained in popularity in the past 5 years and typically have touch screen displays, provide Internet access, and promote easy device operation and fast access to information. With their built-in accessibility options and customization abilities, mobile devices can be useful tools for students with disabilities (Douglas, Wojcik, & Thompson, 2011).

Given the influx of CAI apps for mobile devices, we sought to examine the potential utility of the use of this Application Instruction (AI) and to expand the research base by applying AI to reading instruction. The purpose of this study was to examine the extent to which student engagement differed when AI versus TDI was used to teach word identification and passage fluency to fourth-grade students with reading LD. We were also interested in the effects of each instructional approach on student performance. Finally, we

sought to gather social validity data from the students themselves regarding their perceptions of each approach. Four research questions were posed:

Research Question 1 (RQ1): Which instructional procedure, TDI or AI, is associated with higher levels of student engagement during reading instruction?

Research Question 2 (RQ2): Which instructional procedure, TDI or AI, is more effective in teaching word identification to students with reading LD?

Research Question 3 (RQ3): Which instructional procedure, TDI or AI, is more effective in improving reading fluency to students with reading LD?

Research Question 4 (RQ4): What are the postintervention perceptions of students toward TDI or AI?

Method

Setting

The study took place during students' 30-min reading period in a special education classroom in an urban charter school in Central Texas. The school serves approximately 600 students in Grades Pre-K through 5. The school predominately served students from low-income households. Approximately 66% of the students were Hispanic, 17% Caucasian, 10% African American, 5% mixed race, 1% Asian, and less than 1% Native American. There were equal percentages of males and females enrolled. The school had consistently received at least an Acceptable rating from the Texas Education Agency in all academic areas tested.

Each intervention (TDI and AI) was conducted at the charter school in the special education classroom. The classroom was divided into two areas of arranged desks and chairs. The interventionists and two participants were seated facing each other at each desk.

Participants

Criteria for participation in this study included (a) a diagnosis of LD, (b) below average performance on school-administered standardized tests of reading (i.e., had standard scores less than 90 on either the *Woodcock-Johnson III Tests of Achievement* [WJ III ACH; Woodcock, McGrew, & Mather, 2001] or *Wechsler Individual Achievement Test 2nd Edition* [WIAT II; Wechsler, 2005]), and (c) had Individualized Education Program (IEP)

Table 1. Participant Demographic Information.

Student ^a	Gender	Age (years.	Race/ethnicity	Grade	Disability	Free/reduced		Math	Reading	Writing
		months)		level		lunch status	ELL			
1	F	9.5	Hispanic	4	LD	Y	N	86 ^b	83 ^b	100 ^b
2	F	9.10	Hispanic	4	LD	N	N	76 ^c	64 ^c	77 ^c
3	M	9.10	Mixed race	4	LD	Y	N	90 ^b	77 ^b	12 ^d
4	M	9.10	Hispanic	4	LD	Y	N	82 ^c	71 ^c	76 ^c

Note. ELL = English language learner; LD = learning disabilities.

^aStudent groupings: 1 and 2, 3 and 4, 5 and 6.

^bWoodcock-Johnson III.

^cWechsler Individual Achievement Test.

^dTest of Written Language.

goals in reading. Four students (two boys and two girls) attending the charter school met these criteria and participated in this study. Student demographic information is provided in Table 1, including various test scores provided by the school. All were English-proficient fourth graders and were receiving pullout reading instruction per their IEP. These four students were randomly assigned to two-student pairs.

Research Design

A single-subject alternating treatment design was used to examine the effects of TDI and AI on student engagement and on word identification and fluency. Data collection on student engagement began on the first day of intervention, as a baseline phase is not required to demonstrate experimental control in the comparison of interventions in an alternating treatments design (Cooper, Heron, & Heward, 2007). However, data on word identification and fluency were evaluated across three study phases including baseline, alternating treatments, and maintenance. TDI and AI conditions were conducted 7 times each within a randomly determined sequence for a total of 14 sessions.

Data analysis procedures. Visual analysis supplemented by calculation of Nonoverlap of All Pairs, (NAP; Parker & Vannest, 2009) to measure effect sizes was used to evaluate the effects of AI and TDI on each dependent variable (NAP; Parker & Vannest, 2009). Within NAP, all data points during the intervention are compared with all baseline data points for overlap to provide a valid effect size. For example, each baseline score is compared with each intervention score. If the intervention score is higher, a 1 is awarded; if lower, 0; if the same, .5. After all comparisons are made, the point values are summed and divided by the total number of comparisons. The resulting quotient is multiplied by 100 to derive a NAP percentage. For the word fluency

and word identification, effects were calculated between baseline and intervention for each intervention.

To examine effect size for engagement, we contacted one of the authors who helped develop NAP to find out whether it would be appropriate to use the technique to compare engagements across types of intervention. In a personal communication, the researcher shared that colleagues were finding new ways to apply NAP, and our approach seemed reasonable, as long as results were interpreted with caution (K. Vannest, personal communication, April 12, 2014). For student engagement, effect sizes were calculated between the two intervention conditions.

Data Collection Measures and Procedures

Pretest. Prior to the baseline phase of the alternating treatment design, students were administered easyCBM Passage Reading Fluency (PRF) probes (University of Oregon, 2006) to identify their instructional reading level (highest level passage read with 90% or above accuracy); this testing was used to determine the level of passages used during baseline, intervention, and maintenance.

Dependent variable engagement form. A researcher-designed Student Engagement Form was created to examine student engagement throughout the intervention via momentary time sampling at 30 s intervals. The engagement form was designed to be used with mathematics studies (Bryant & Bryant, 2010) in which students are considered engaged when the (a) student's eyes are on the activity or teacher, (b) student is silent (on-task talking acceptable), (c) student's hands are to self, (d) student is listening, and (e) student is ready to learn (i.e., attending to instruction).

Engagement observation procedures. During the observation of each lesson, each observer set a timer for 30 s, after which time the timer vibrated. At the 30-s mark, the observer monitored student engagement for both students in the observer's assigned pair. Student engagement was scored as 1 (if all engagement criteria were met) or 0 (if any engagement criteria were not present). For 9 of the study's 14 days, one observer was assigned to one student pair, the second observer monitored engagement for the second pair of students. On the other five occasions, only a single observer was available. In these instances, both student pairs were observed in 30-s alternate intervals. Thus, engagement was observed for only half the time (30 s for 12-min intervals, 6 min for each instructional component, Word Reading Fluency [WRF] and PRF).

At the end of each day, observers summed the number of 1 s recorded and divided by the number of 30-s segments observed to compute an Engagement Percentage. Each Engagement Percentage (Word Identification and Fluency) was then recorded and plotted, and a notation was made as to the type of intervention delivered (i.e., TDI or AI).

An interrater reliability analysis was conducted using the engagement form. Interrater reliability was computed between two observers 3 times (21.4% of the 14 observations), with an average agreement of 96.5% across sessions.

Dependent variable reading probes. EasyCBM 1-min WRF and PRF probes (University of Oregon, 2006) were used as the dependent measure for reading data collection. The easyCBM WRF probe has increasingly difficult unrelated words that begin at the primer level and progress toward increasingly difficult levels. Students are given 1 min to read as many words as they can. The total score is the number of words attempted minus the number of words pronounced incorrectly. All probes were audiotaped to facilitate confirmation of scores by the interventionists. Based on the pretest results of the PRF probe, we used Level 3 of the WRF probe.

The easyCBM PRF probe we used for the study has narrative stories at the third-grade reading level, the Instructional Reading Level of the students identified by the pretest. Eight alternate forms of the probe were administered from Forms 1 through 8. With each PRF probe, students are given 1 min to read as many words of continuous print as they can. The total score is the number of words attempted minus the number of words pronounced incorrectly. Again, all assessments were audiotaped for later scoring by two interventionists.

In the Technical Manual of the easyCBM, alternate forms reliability coefficients for Level 3 are reported from .87 to .93 (median = .91) for the WRF probes and .94 through .95 (median = .94) for the PRF probes. For this study, two interventionists listened to and scored 14 auditory tapes of student performance in WRF and PRF. Their scorings were intercorrelated, and inter-scoring agreement was .87 for WRF and .98 for PRF.

Fidelity of Implementation

Both interventionists were observed by the engagement observers on each of the 14 days of intervention to assess adherence to protocol (i.e., fidelity) of specific implementation performance indicators. (Engagement observers observed for fidelity in the 30-s intervals between engagement checks.) Quality of Implementation (QoI) indicators included the degree to which the interventionist adhered to scripted procedures throughout the lesson sections. For the TDI approach, script adherence was examined for each segment of

the lesson: Engage Prior/Informal Knowledge, Modeled Practice, Practice 1, Practice 2, and Independent Practice, and Overall Fidelity. Performance for each lesson segment (i.e., Engage Prior/Informal Knowledge, Modeled Practice, Practice 1, Practice 2, and Independent Practice) was rated on a 1- to 4-point scale:

1. Interventionist did not follow the script at all.
2. Interventionist somewhat followed the script (more than one deviation observed).
3. Interventionist closely followed the script (one deviation observed).
4. Interventionist followed the script exactly.

The Overall Fidelity rating ranged from 1 (*poor*) to 4 (*excellent*).

For AI, fidelity was assessed (using the same 4-point Likert-type system above), for the following areas:

- The interventionist provided a review to the students on how to use the iPad and the application.
- The interventionist let students review previous skill sets from the previous lesson (e.g., The teacher set up the application on skill sets learned in the previous session to let students practice at the beginning of the lesson).
- The interventionist kept monitoring students' use of the iPad and their work.
- The interventionist provided appropriate support and feedback (no teaching) when students had questions or problems.
- The interventionist administered the probe and followed the written administration procedures.

An overall rating was also provided, ranging from 1 (*poor*) to 4 (*excellent*).

In all cases, scores of 3 or 4 points were awarded in each of the categories. The maximum possible fidelity score was 20 points for both TDI and AI. The average fidelity rating for TDI was 19.3 (96.5%) and for AI, 19.5 (97.5%), out of 20. Thus, observations across interventionists and instructional procedures showed a high degree of fidelity in the implementation of the two instructional procedures.

Social Validity Interview

To gather information about student perceptions relating to the two instructional approaches used in this study, AI and TDI, we designed an interview

that was conducted with each student after the intervention. Seven questions composed the interview.

1. "Which method of instruction did you prefer?"
2. "Why do you prefer that method?"
3. "What do you think about the other method? What factors made you not choose the other method as the better one?"
4. "Which method do you think helped you learn better?"
5. "Which method do you think you were more engaged and motivated to learn?"
6. "Which method do you think you were more focused on the task?"
7. "Do you have any other comments regarding the two methods of teaching that you would like to share?"

Student responses were audio recorded for later playback and reporting.

Training of Interventionists, Observers, and Students

Three doctoral students with teaching experience served as interventionists in this study and completed a 3-hr training session in the two instructional approaches: TDI and AI. They were taught to administer the TDI and AI lessons and conduct after-lesson, one-on-one probe assessments by strictly following the intervention and assessment scripts. They were also provided with instructions for using the iPad apps.

Engagement observers, who also administered the after-lesson probes to one of the students, participated in the assessment training, as well as a 30-min training session on observing for engagement. Both student pairs then practiced WRF and PRF probe administration and were observed by the lead researcher and provided with corrective feedback until all were able to administer the lessons and probes with fidelity. The probes were practiced and scored until at least 90% agreement was reached on scoring.

Prior to the study, the interventionists met with the students for 2 hr to discuss the study and introduce the iPad and apps to the students. After seeing the interventionists' model application procedures, students practiced logging in, moving to the correct introduction page, and beginning and ending each application activity, which included saving the results of their work. The interventionist helped students with any problems that arose, including making transitions from one activity to another. At the end of the training session, the interventionists answered any questions and thanked the students for their participation.

During the intervention, two interventionists delivered the lesson. For 9 of the 14 lessons, the same interventionists did the teaching; but for 5 days, the

third interventionist who participated in the training substituted for one of the absent interventionists.

Intervention Materials

iPad application only instruction (AI). For AI, three reading iPad applications were used: *K12 Timed Reading Practice* (K12, 2010) for passage reading, and *Howie Finding Vowel* (PlaySmart-Kids, 2012) and *ABC Phonics Word Family Writing* (Hien Ton, 2011) for word reading. *K12 Timed Reading Practice* is an application that allows students who are in Grades K to 4 practice fluency by reading short, timed stories. The application includes more than 250 short stories and poems grouped by grade and Flesh-Kincaid reading levels (between 0.0 and 4.7). The application allows users to keep track of the stories read and how many words per minute (WPM) the students achieved.

ABC Phonics Word Family Writing focuses on word families (similar phonics spelling patterns). Students use the application to learn to read by finding common sounds among a set of presented words. For purposes of this study, the focus was on two syllable patterns, the vowel-consonant-e pattern (i.e., ake, -ale, -ame, -ape-, -ate, -ice, -ide, -ine, -oke) and vowel pair pattern (i.e., -ail, -ain, -eat, -eel, -een, -eep, -eet, -oat, -oot). A word list appears on the left side of the screen, with a blank section on the right side on which students can write words. Students write each word with their finger and moved on to the next word. If they need to have the word pronounced, they can click “speak” at the top of the screen. When they finished the last word, they move to the next pattern.

The other application used for word identification, *Howie Finding Vowel*, focused on two different syllable patterns, the closed pattern (vowel-consonant or consonant-vowel-consonant, where the vowel makes its common, short sound), and r-controlled vowels (e.g., ur, ar, where the vowel-r combination results in an uncommon but consistent sound). In the app, students select a missing vowel in each word by listening to the word spoken by the program, finding the correct vowel sound(s) from among four response choices, and “feeding” a monster (i.e., Howie) a hotdog. The application included a self-correction that allowed students to find the correct answer in their second try.

TDI. The TDI intervention involved learning and applying the SPLIT strategy (Bryant, Bryant, Kim, Baker, & Simon, 2001), a multisyllabic word identification strategy, using scripted lessons. SPLIT calls for students to See the syllable patterns in words, Place a line between each syllable, Look at each

syllable, Identify the syllable sounds, and Try to say the word by blending the syllable sounds together. Each SPLIT lesson includes elements of effective instruction, similar to those proposed by Madeline Hunter (1993), including Preview (providing an advance organizer), Engage Prior/Informal Knowledge (reviewing syllable patterns taught in the previous session), Demonstrate (making a slash mark [/] between the syllables and identifying each syllable pattern of a supplied word list), Practice (practicing on identifying words on the word list), and Independent Practice (reading an 1-min probe).

Fluency activities included Partner Reading. Each lesson consisted of a Preview, Engage Prior/Informal Knowledge (reading high frequency sight words), Practice (reading a passage for 3 min using Partner Reading), followed by Independent Practice (reading the same passage for 1 min). In Partner Reading, Partner 1 (the more advanced reader) reads a passage aloud for 3 min and Partner 2 (the less advanced reader) follows along on his or her copy of the passage. Partner 2 then reads aloud the same passage for 3 min as Partner 1 follows along. Then Partner 1 reads aloud again for 1 min as the interventionist monitors time and counts the number of words correct per minute (wcpm). Partner 2 follows.

Intervention Procedures

Prior to collecting baseline data, tests of pseudowords and PRF passages were administered. The researcher-created pseudoword test was used to identify phonics strengths and struggles. The PRF passages were administered to identify the Independent, Instructional, and Frustration levels for each student, and thus identify proper passages to be used during the intervention.

Baseline testing then began. Students were individually administered the WRF and PRF tests to identify and chart words correct per minute for individual words and words correct per minute for continuous text. Testing continued for 7 consecutive days until stable baselines for each dependent variable were obtained. Each probe was scored immediately after the intervention by two researchers (double-checking). In the rare instances when the results differed, the researchers reconciled scoring by listening to the student's reading and agreeing on the total number of words read correctly; the raw scores were plotted. Total numbers of words correct per minute for individual words and continuous text served as the raw scores that were plotted for each student.

After baseline was established, interventions took place with homogeneous student pairs (all four students' Instructional Level was at the easyCBM third Level for both measures) for 30 min per day for 14 days over a 3-week period, divided into four waves. Waves 1 and 3 were intervention

periods; Waves 2 and 4 probe administration periods. Wave 1 involved 12 min of phonics instruction (syllable patterns) administered either in TDI or AI by project Interventionists. Wave 2 involved the administration of a 1-min word easyCBM WRF probe by the interventionists and observers. Wave 3 involved either Partner Reading, the TDI activity, or a fluency-building AI. Wave 4 involved the administration of a 1-min timed reading using easyCBM's PRF.

During Wave 1, the TDI the SPLIT activity focused on four syllable patterns: closed syllable (e.g., at, -og), vowel pairs syllable (e.g., eat, -ain), vowel-r syllable (e.g., or, -ir), and vowel-consonant-e syllable (e.g., ace, -ite). These were selected because the same patterns were available on the Applications used in the intervention.

During Wave 3, Partner Reading was used for the TDI activity. The interventionist timed the reading, and assisted with unknown words, and counted the wcpm; students then graphed their performance. Narrative passages were selected from Project Aim (<http://terpconnect.umd.edu/~dlspeece/cbmreading/studentmat/grade3/>) and were used with permission from the lead principal investigator. All passages were examined for readability levels using the Flesch-Kincaid method in Microsoft Word.

Throughout Waves 1 and 3, engagement observers set the timer for 30 s, after which the timer vibrated. The observers noted whether each student was exhibiting all Reading Ready behaviors, and marked the observation form accordingly (1 for yes, 0 for no). This was done throughout the 12-min time period for each intervention, word identification, and fluency. During Waves 2 and 4, the engagement observers assisted in administering the probes to the students. Maintenance testing for WRF and PRF took place during Weeks 5 and 6. Interventionists assessed their students 4 times over the 2-week period.

Results

In this study, we examined the extent to which student engagement and performance differed when AI and TDI were used to teach word identification and passage fluency to fourth-grade students with reading LD. We also asked students social validity questions to identify the perceptions toward the two instructional approaches. Four research questions were proposed: First, "Which instructional procedure, TDI or AI, is more conducive to promoting student engagement during reading instruction?" Second, "Which instructional procedure, TDI or AI, is more effective in teaching word identification to students with reading LD?" Third, "Which instructional procedure, TDI or AI, is more effective in improving reading fluency to students with reading LD?" Finally, "What are the perceptions of students and interventionists toward TDI or AI after the intervention?"

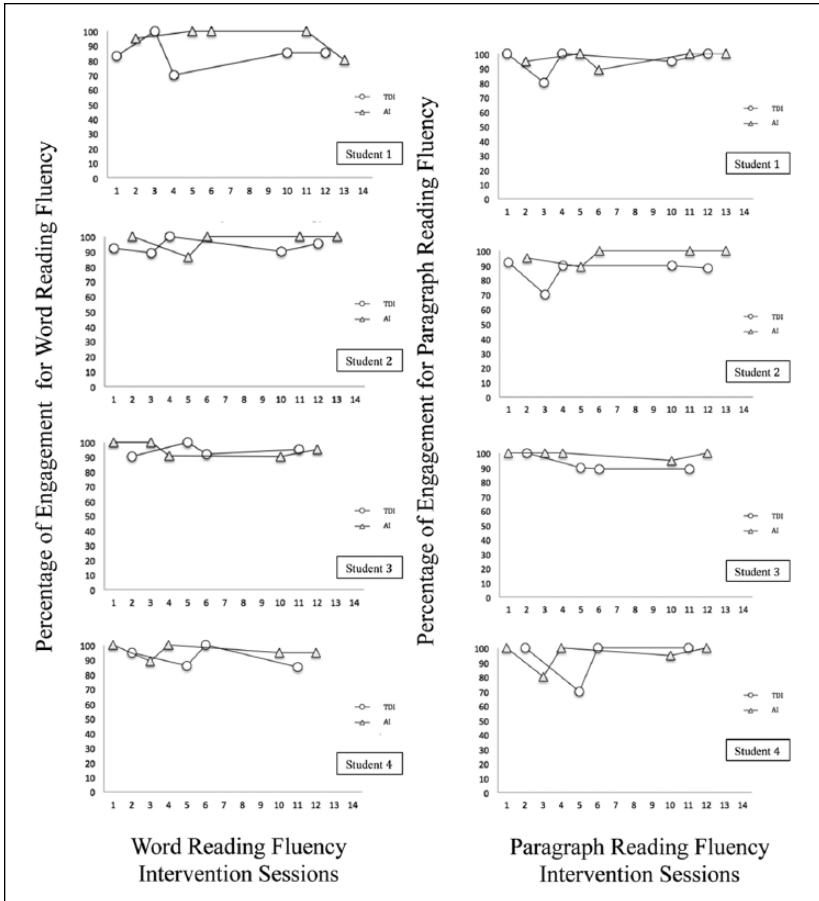


Figure 1. Visual depiction of performance for students' engagement during teacher-directed instruction and applications instruction.

RQ1: Comparison of Instructional Approaches' Effects on Engagement

Visual analyses of the data. For WRF and PRF, visual inspection of the engagement data (see Figure 1) demonstrates a consistent preference in favor of AI over TDI. Across all students, engagement was consistently high for both instructional approaches for both the WRF and PRF interventions, often approaching or reaching 100%.

Table 2. Means (Standard Deviations) for Each Student's Engagement During Word Reading and Paragraph Reading for Two Intervention Approaches.

Student	Word reading instruction		Paragraph reading instruction	
	TDI	AI	TDI	AI
1	84.6 (10.6)	95.0 (8.7)	95.0 (8.7)	96.8 (4.9)
2	93.2 (4.4)	97.2 (6.3)	86.0 (9.1)	96.8 (4.9)
3	94.3 (4.3)	95.2 (4.8)	92.0 (5.4)	99.0 (2.2)
4 ^a	91.5 (7.2)	95.8 (4.5)	92.5 (15)	95 (8.7)
T	90.7 (7.7)	95.8 (5.8)	91.3 (9.7)	96.9 (5.4)

Note. TDI = teacher-directed instruction; AI = application instruction.

^aSignified student absence on 2 days of instruction.

Table 2 provides means and standard deviations across the observations for students. The average across all students are reported for each instructional approach (again, the asterisk for one student indicates 2 days of absence). Engagement was high for all students for both approaches, but they consistently were more engaged during the AI condition.

Effect size. We computed NAP (Parker & Vannest, 2009) to check for engagement effect size. Our engagement NAP results were consistent with our visual analysis of the data. That is, NAP data showed that students were engaged more often when AI was being implemented. Comparison percentages for Students 1 through 4 for WRF (TDI reported first, followed by AI) were as follows: Student 1 (22% to 78%), Student 2 (28% to 72%), Student 3 (30% to 70%), and Student 4 (32.4% to 67.5%). Percentages for Students 1 through 4 for PRF (again, TDI reported first, followed by AI) were as follows: Student 1 (40% to 60%), Student 2 (12% to 88%), Student 3 (17.5% to 82.5%), and Student 4 (60% to 40%). Thus, all students during word identification intervention had higher effect sizes with AI; three of the four students had a higher effect size with AI than TDI for PRF intervention, and the fourth student's engagement favoring TDI, but the results were fairly close (60% to 40%).

RQ2 and 3: Comparison of Instructional Approaches' Effects on Reading Performance

In this section, we report on the visual analysis of the data (see Figure 2). WRF (RQ2) is reported first, followed by PRF (RQ3). We then provide information about procedures run to examine effect size for both areas.

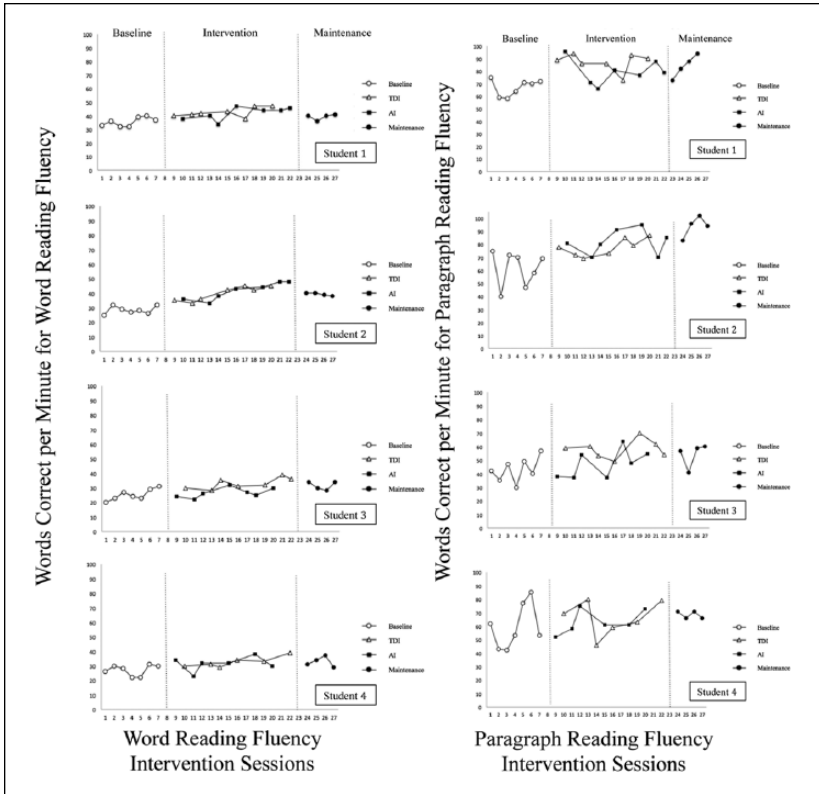


Figure 2. Visual depiction of performance for students' WRF and PRF performance during TDI and AI. Note. WRF = Word Reading Fluency; PRF = Passage Reading Fluency; TDI = teacher-direct instruction; AI = applications instruction.

WRF

Student 1's scores (Figure 2, upper left panel) were initially low during baseline and continued at low and stable levels throughout the baseline condition ($M = 35.6$; $SD = 3.3$). Student 1's scores for both approaches exceeded the average baseline score on the implementation of the intervention (TDI = 40, AI = 38) and continued at moderate and increasing levels throughout the remainder of the intervention condition. The average intervention score for TDI (42.6) exceeded AI (41.9) by 0.7 points. Responding remained relatively stable following the removal of the intervention during maintenance ($M = 39.3$; $SD = 2.2$).

Student 2's scores (Figure 2, second row of left panel) were initially low during baseline and continued at low and stable levels throughout the baseline condition ($M = 28.4$; $SD = 2.8$). Student 2's scores for both approaches exceeded the average baseline score on the implementation of the intervention (TDI = 35, AI = 36) and improved at moderate and increasing levels throughout the remainder of the intervention condition. The average intervention score for AI (41.4) exceeded TDI (39.7). Again, responding remained relatively stable following the removal of the intervention during maintenance ($M = 39.3$; $SD = 1.0$).

Student 3's scores (Figure 2, third row of left panel) were the lowest of the four students during baseline and continued at low and stable levels throughout the baseline condition ($M = 25.3$; $SD = 2.8$). Student 3's initial score for TDI (30) exceeded the average baseline score on the implementation of the intervention, but TDI (24) did not; for both approaches, scores remained fairly flat and stable throughout the remainder of the intervention condition. The average intervention score for TDI (33.0) substantially exceeded AI (26.6), while showing considerably larger gains over baseline. Again, responding remained relatively stable following the removal of the intervention during maintenance ($M = 31.5$; $SD = 3.0$).

Student 4's scores (Figure 2, bottom left panel) were initially low during baseline and continued at low and stable levels throughout the baseline condition ($M = 27.0$; $SD = 3.8$). Student 4's initial scores for TDI (30) and AI (34) both exceeded the average baseline score on the implementation of the intervention. Like Student 3, both approaches' scores remained fairly flat and stable throughout the remainder of the intervention condition. The average intervention score for TDI (32.7) exceeded AI (31.5). As with the other three students, responding remained relatively stable following the removal of the intervention during maintenance ($M = 31.5$; $SD = 5.0$).

PRF

Student 1's scores (Figure 2, upper right panel) were initially low during baseline and continued at low and stable levels throughout the baseline condition ($M = 67.0$; $SD = 6.7$). Student 1's scores for both approaches substantially exceeded the average baseline score on the implementation of the intervention (TDI = 89, AI = 96), yet declined at moderate and decreasing levels throughout the remainder of the intervention condition. The average intervention score for TDI (87.3) exceeded AI (79.1), yet even with the steady decline across the intervention, both average scores exceeded the average baseline score by substantial margins. Responding remained relatively stable following the removal of the intervention during maintenance ($M = 84.3$; $SD = 9.0$).

Student 2's scores (Figure 2, second row of right panel) were initially low during baseline and continued at low and stable levels throughout the baseline condition ($M = 61.6$; $SD = 13.6$). Student 2's scores for both approaches exceeded the average baseline score on the implementation of the intervention (TDI = 78, AI = 81) and improved at moderate and increasing levels (with some exceptions for both approaches) throughout the remainder of the intervention condition. The average intervention score for AI (81.7) exceeded TDI (77.6). Responding actually increased following the removal of the intervention during maintenance ($M = 93.8$; $SD = 7.9$).

Student 3's scores (Figure 2, third row of right panel) again were the lowest of the four students during baseline and continued at low yet fluctuating levels throughout the baseline condition ($M = 42.9$; $SD = 9.0$). As with WRF, Student 3's initial score for TDI (59) exceeded the average baseline score on the implementation of the intervention, but TDI (38) did not. For both approaches, scores fluctuated throughout the remainder of the intervention condition; but the average intervention score for TDI (58.1) substantially exceeded AI (47.6) and showed considerably larger gains than AI over baseline. As has been the case consistently, responding remained relatively stable following the removal of the intervention during maintenance ($M = 54.3$; $SD = 8.9$).

Student 4's scores (Figure 2, bottom right panel) were initially low during baseline and, like Student 3, had scores that fluctuated throughout the baseline condition ($M = 66.0$; $SD = 12.9$). As with Student 3, Student 4's initial score for TDI (69) exceeded the average baseline score on the implementation of the intervention, but TDI (52) did not. Also like Student 3, both approaches' scores fluctuated throughout the remainder of the intervention condition. The average intervention score for TDI (66.0) exceeded AI (63.3), with neither approach showing gains over baseline. As with the other three students, responding remained relatively stable following the removal of the intervention during maintenance ($M = 68.5$; $SD = 2.9$).

Effect size. To examine effect size, we used the NAP (Parker & Vannest, 2009) procedure. We computed percentages of nonoverlapping data for both interventions, TDI and AI, and in most cases TDI proved more effective than AI. For Student 1 WRF, the level of nonoverlap for TDI was greater than AI, 94.9% to 86.7%. For PRF, the percentages were 98% to 88.8%. For Student 2, the levels of engagement were the same for across both interventions, 100% each for WRF and 89.8% each for PRF. For Student 3, TDI surpassed AI 92.9% to 62.1% for WRF, and the same occurred for PRF, 92.8% to 63.2%. For Student 4 WRF, the average level of nonoverlap for TDI was greater than AI, 86.9% to 83.3%. For PRF, the percentages were 66.7% to 57.1%.

RQ4: Social Validity of Instructional Approaches

We collected social validity data to determine student perceptions on the instructional approach administered.

The student interviews asked them to respond to several questions. In response to “Which method of instruction did you prefer?” all four students preferred the AI. When asked, “Why do you prefer that method?” Student 1 responded, “I like the AI because using the iPad is always fun.” Student 2 stated, “I found the *Howie Finding Vowel*, one of the word reading applications, very fun.” Student 3 noted that the *Howie Finding Vowel* was fun so it helped him with the word reading and kept him motivated. Student 4 offered that the iPad helped his reading and writing, and especially, the *ABC Writing* was a little bit hard but helpful. To the next question, “What do you think about the other method? What factors made you not choose the other method as the better one?” with regard to the TDI, Students 1 and 2 both stated the TDI was also fun but AI was more fun. They added that they liked completing the My Fluency Chart in the TDI. Students 3 and 4 noted that the SPLIT strategy of the TDI was helpful for both of them. When asked, “Which method do you think helped you learn better?” all four students responded that they thought TDI helped them learn better. For “Which method do you think you were more engaged and motivated to learn?” the results were mixed; three students (Students 1, 2, and 4) selected the AI approach, and only Student 3 responded in favor of the both approaches. For “Which method do you think you were more focused on the task?” results were two-fold; Students 1 and 2 responded that AI helped them stay more focused on the task because repetitive practices helped them stay quiet. However, Students 3 and 4 noted that the TDI was the method that they were more focused with. Finally, the students were asked if they had any other comments regarding the two methods of teaching that they experienced. Students 1 and 2 stated they thought using the iPad in class was very cool and fun because their parents never allowed them to use iPad at home. Students 3 and 4 provided no additional response.

Discussion

Students with reading LD face challenges accessing information provided in print. Previous research suggests some students with reading LD have experienced success with remedial interventions that combine explicit, systematic instruction with the teaching of reading strategies (Swanson et al., 1999) and through the use of CAI (Hall et al., 2000). The purpose of this study was to examine the extent to which student engagement and performance differed

when AI and TDI were used to teach word identification and passage fluency to fourth-grade students with reading LD. An additional purpose of the study was to examine student perceptions of the two interventions.

Results showed that student engagement was high under both interventions, but highest with AI. Not surprisingly, students noted that the applications in the AI intervention were more fun than TDI. With regard to academic performance, students tended to perform better with TDI than they did with AI. However, when considered as a whole, students showed intervention progress over baseline for both approaches, and those gains were maintained to some extent over time.

It is important to note that we investigated three specific reading instruction apps (i.e., *K12 Timed Reading Practice*, *Howie Finding Vowel*, *ABC Phonics Word Family Writing*) and, although the single case design utilized offers strong internal validity regarding the influence of these apps on the reading skills of these participants, these results should not be considered evidence that all instructional apps would have the same effect on other participants. It seems likely that the effectiveness of the iPad (or AI condition) is bound to (a) the software's ability to deliver research-based instruction and exercises and (b) the individual student's idiosyncratic preferences and familiarity with the iPad. Additional research investigating apps with notably different features remains warranted until the parameters defining best practice for CAI can be further elucidated.

We hypothesize that the advantage that TDI offers over AI lies in its use of the elements of effective instruction. The TDI lessons used in this study contained critical elements of effective instruction including explicit, systematic, and strategic instruction (Swanson et al., 1999), yet the applications did not and instead focused on drill-and-practice. Although providing multiple opportunities to practice is an element of effective instruction, practice by itself is insufficient in skill building. It appears that there exists an opportunity for application developers and educators to collaborate to develop a series of tablet applications that incorporate key elements of effective practice, such as modeling, examples and think alouds, checking for understanding, error correction and feedback, and so forth. Because applications have the potential to enhance academic engagement, it stands to reason that pedagogically sound instructional applications can also, perhaps, rival TDI in their instructional effectiveness as well.

Limitations and Future Research

There are four particular limitations in this study that deal with the academic information and warrant examination. The primary limitation to this study

was the potential carryover effects of reading performance across the two conditions. Students who learn one day using one instructional approach undoubtedly carryover that learning to the next day/instructional approach. The extent to which carryover affects experimental control can be problematic in academic instruction using an alternating treatment design. Carryover is a greater problem when examining student achievement than engagement. For engagement, the degree of overlap simply points to the degree of both approaches to be effective in fostering engagement. For the reading comparisons, it is likely the case that carryover effects contributed to this issue (Barlow & Hayes, 1979) and future research comparing these two instructional formats should target substantially different skills and counterbalance those skills across conditions to help control for this potential confound.

Second, 3 weeks is a short time to provide academic instruction, especially for students with reading LD. Future research should investigate whether increased intervention duration may improve students' reading skills to even greater extents than were demonstrated in the current study. It is noteworthy that, despite the small dosage of intervention, improvements in student engagement and performance were detected. As such, these data must be seen as promising, and these data suggest that future research involving longer duration is indeed warranted.

Third, the applications did not teach identical skills to the TDI condition. For example, the TDI word identification intervention taught syllable patterns to help students identify multisyllable words. We could find no applications that specifically focused on syllable patterns, so we selected apps that taught similar letter-sound associations as the syllable patterns (e.g., short vowel sounds sound in closed syllables, vowel pairs found in vowel team syllables). Also, the fluency intervention involved partner reading, and the applications were designed to reinforce silent reading rate, a skill associated with reading fluency, yet without the partner feature. We did this intentionally because we wanted to use the apps "as intended," that is, as they are written, not adapted by teachers. Future research could include an intervention where teachers adapted the apps to more closely align with the TDI intervention and are adapted by the teacher to support the TDI.

Fourth, we found it interesting, but not surprising, that the maintenance scores for WRF and PRF sometimes dipped below the later scores during the intervention. Alberto and Troutman (2012) noted that maintenance, that is, the ability to respond over time without reteaching, best occurs when overlearning and distributed practice occurs during instruction. We built neither into the interventions; researchers would be well advised to build these important factors into their interventions by providing repeated opportunities to review and practice previously learned skills (overlearning) while also spreading such practice opportunities over time (distributed practice).

In conclusion, a sense of urgency is needed to help struggling students at the elementary level catch up academically to their peers before they enter middle school, where academic rigor increases substantially as states implement the Common Core State Standards (Council of Chief State School Officers & National Governors' Association, 2010). Promoting student engagement in the learning process is critically important; educators would be well served to include instructional methods that promote and maintain student engagement. The results of the current study attests to the potential of instructional apps to foster such engagement in small group reading interventions, particularly when such apps include key elements of effective instruction.

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