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Effects of Computer-Assisted and Teacher-Led Fluency Instruction on Students At Risk for Reading Failure

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A quasi-experimental pretest/posttest group design was used to determine whether computer-assisted fluency instruction is as effective as print-based, teacher-led fluency instruction in improving fluency, vocabulary, and comprehension skills in third grade students experiencing delayed fluency development. Fifty participants were randomly assigned to 1 of 3 conditions: a teacher-led group, a computer-assisted text-equivalent group, or a computer-assisted time-equivalent group. The same fluency program was used for all three groups. An analysis of covariance (ANCOVA) revealed no significant differences across groups on 2 of the 3 outcome measures (i.e., fluency and comprehension), but significant differences between the text equivalent and time equivalent treatment groups occurred in the area of vocabulary. Limitations and recommendations for research and practice are discussed.

Keywords: Computer-assisted fluency instruction, teacher-led fluency instruction, reading fluency, reading comprehension, reading problems

Introduction

Over 70% of students who drop out of school report difficulties with reading (Joshi et al., 2009). Seventy-five percent of all students recommended for special education services are recommended because of poor reading skills (National Center for Education Statistics, 2012). These students, especially those in the upper elementary grades and beyond, often struggle with one or more components of reading such as fluency, vocabulary, and comprehension (King-Sears & Bowman-Kruhm, 2010; Malmgren & Trezek, 2009). There is clear evidence that reading fluency, vocabulary, and comprehension are strongly associated with each other (Rasinski, Rikli, & Johnston, 2009; Stahl, 2003) and some evidence suggests that when instruction in fluency is targeted, systematic, and explicit it can positively impact achievement in vocabulary and comprehension (Neddenriep, Fritz, Carrier, 2011; Pagan & Senechal, 2014; Pikulsi & Chard, 2005).

Computer-assisted instruction (CAI) has emerged in recent decades as an option for supporting student access to targeted, systematic, and explicit reading instruction. Some researchers have found that because traditional teacher-led instruction often occurs in small groups and involves turn taking, those readers experiencing the most significant reading deficits receive less direct practice with text which may hinder reading achievement (Sorrell, Bell, & McCallum, 2007). Because computers

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have become ubiquitous in today's schools (Meyen, 2015; Regan, Berkeley, Hughes, & Kirby, 2014) there is a high likelihood that they can be used to provide students with increased opportunities to interact with text in meaningful ways.

Cognitive learning theory posits that components of effective instruction such as active involvement in learning and immediate feedback while learning encourage deeper information processing and subsequently promote higher levels of information retention (Craik & Lockhart, 1972; Norton, 1983; Williams & Brown, 1990). This theory provides an important framework by suggesting that CAI incorporates interactivity (e.g., learner control and feedback) into learning resulting in increased information transfer and subsequent understanding of information (Mayer, 2009; Renkl & Atkinson, 2007). It provides a rationale for how CAI supports students with systematic supplemental reading instruction that fosters extensive rehearsals, allows students to work at their own pace, and maintains consistent feedback (Gagne & Briggs, 1979; Stetter & Hughes, 2010; Vadasy & Sanders, 2008; Williams & Brown, 1990).

Although CAI has been found to be effective in teaching a variety of reading skills including phonological awareness and word recognition (Lai & Chang, 2006; Walcott, Marett, & Hessel, 2014), research is limited and not much is known about how CAI compares with teacher-led instruction in producing increased reading outcomes. With the potential benefits of CAI (e.g., individually paced instruction and extensive rehearsals) and an increase in the use of CAI in an effort to support classrooms instruction, it is important to determine whether CAI is a valid alternative to teacher-led instruction. If students learn as well as or better when instructed using CAI, teachers may be justified in providing CAI as an alternative method for increasing reading skills.

Comparing Computer-Assisted with Teacher-Led Reading Instruction

The development of reading skills in the elementary grades is the focus of the study presented in this article, however, over the last fifteen years few studies have examined how CAI compares with teacher-led instruction in the elementary grades.

In a study conducted by Mioduser, Tur-Kaspa, and Leitner (2000), 46 kindergarteners at risk for reading disabilities received interventions to help improve their phonological awareness, letter naming, and word recognition skills. Researchers examined three groups. Group one received teacher- led instruction paired with CAI, group two received teacher-led instruction only, and group three served as the treatment control. Mioduser et al. (2000) found that the participants in the CAI/teacher-led group made significant gains in phonological awareness, word recognition, and letter naming skills when compared to the teacher-led and control groups.

Similarly, Torgesen, Wagner, Rashotte, Herron, and Lindamood (2010) compared the effects of a CAI only intervention, CAI paired with teacher-led intervention, and a control on first grade students' phonemic awareness, decoding, word recognition, and comprehension skills. Students received four 50-minute sessions per week focused on phonological awareness and phonics for the entire school year. Students in the CAI groups used a software program with animation and digitized speech. Students in the group that paired CAI with teacher-led instruction received pre-teaching from the teacher covering skills to be practiced on the computer. Unlike Mioduser et al. (2000), researchers found no significant differences between the two CAI intervention groups

on any components of reading but significant differences were found between the control condition and the CAI paired with teacher-led instruction condition.

Mitchell and Fox (2001) compared the effectiveness of CAI on the phonological awareness of 72 kindergarten and first grade students classified as at-risk. The researchers examined three groups. Group one received CAI phonological awareness instruction, group two received teacher-led phonological awareness instruction, and group three served as a control group. Participants received instruction in five 20-minute sessions over four weeks. Researchers found no significant differences between the teacher and the computer groups. Both groups, however, exhibited significant improvements over the control group.

Lewandowski, Begeny, and Rogers (2006) compared the effects of a computer-assisted program with traditional teacher-led tutoring on the word recognition of 63 third-grade struggling readers. The study also included a control group. Students received three ten-minute intervention sessions over three weeks. The computer program was specifically written for the study. Students received speech feedback on individual words but researchers did not include any graphics or animation. Like Mitchell and Fox (2001) researchers found no differences between the CAI and teacher-led groups. Students in both treatment groups experienced significant improvements over the control group in reading fluency.

Saine, Lerkkanen, Ahonen, Tolvanen, and Lyytinen (2010) compared the use of traditional remedial phonics instruction with CAI on the fluency skills of 166 first grade struggling readers. The intervention consisted of 45-minute sessions, four times per week, for 28 weeks. The same phonics program was used for both treatment groups, however, participants were either assigned to received the teacher-led version or the CAI version of the program. The CAI version of the program included graphics and speech feedback. Researchers also included a control group in their study. Researchers found that students in the CAI condition experienced the most significant increases in fluency achievement especially among students exhibiting the most significant deficits at the onset of the study.

The current study seeks to extend the work of Saine, Lerkkanen, Ahonen, Tolvanen, and Lyytinen (2010). Like Saine et al., (2010), the same commercial reading program is used across both the teacher-led and CAI intervention groups. While Saine et al., (2010) focused their research on the effects of word recognition and phonics instruction on reading fluency, this study examines the impact of a fluency based instructional intervention on reading fluency, vocabulary, and comprehension. In addition, Lewandowski, Begeny, and Rogers (2006) use their discussion to call for future research that engages in a longer and more sophisticated examination of how teacher-led instruction compares with CAI. The current study involves three treatment conditions, one teacher-led and two computer-assisted. The two computer-assisted conditions incorporate some sophisticated controls in an attempt to isolate and understand which components of CAI instruction are most beneficial for students with severe reading deficits.

The following research questions were used to frame this study:

1. Is a computer-assisted method of instruction as effective as a teacher-led method of instruction in improving the fluency skills of children who demonstrate delayed fluency development?

2. Is a computer-assisted method of instruction as effective as a teacher-led method of instruction in improving the vocabulary and comprehension skills of children who demonstrate delayed fluency development?

Data from two dependent measures— a standardized measure of oral reading fluency and a standardized measure of vocabulary and comprehension—were analyzed using an analysis of covariance to answer these research questions.

Methods

Research Design

A quasi-experimental pretest – posttest design was used in this study. Participants were randomly assigned by school to one of the three treatment groups. Because the study included third-grade participants who were being prepared to take statewide high-stakes tests, a treatment control group was not feasible. Each of the schools that were involved in this study planned on providing struggling students who did not participate in this study with their own forms of supplementary fluency instruction.

Instructional Settings

Two elementary schools located in the Southeast were chosen as sites for this study. Both schools were chosen because a prior relationship existed between each school and the primary researcher and because they had large populations of students in the third-grade who struggled in oral reading fluency. One school served primarily a rural population while the other school represented an urban population.

An important factor when selecting schools was the availability of adequate computer resources. In both schools, the computer-assisted instruction groups, time and text controlled, received their instruction in the school computer laboratory. It was therefore critical that these schools had a computer laboratory with a minimum capacity of 15 students. The teacher-led instruction small group took place in a quiet area (e.g., an unused classroom) provided by each school.

Participants

All third-grade students in the two elementary schools were assessed using the Dynamic Indicators of Basic Early Literacy Skills (DIBELS), an individually administered standardized measure of oral reading fluency. The test was administered by teachers and reading coaches in each of the schools. Students qualified for the study if they had an existing diagnosis of a learning disability or behavior disorder and scored between the 10th and 39th percentile or between 35-76 words correct per minute (wcpm) according to benchmark goals and indicators of risk provided by the test manual (Hasbrouck & Tindal, 1992). The 10th to 39th percentile range was chosen because Hasbrouck and Tindal (1992) suggest that students scoring within this range on measures of oral reading fluency beginning in second grade are good candidates for interventions in oral reading fluency development. Students scoring at this level are more likely to have the basic foundational skills (e.g., phonemic awareness, phonological awareness, word recognition) needed to be ready for fluency instruction (Rasinski, 2004). Students who score below the 10th percentile needed substantial in-

terventions beyond the scope of this study, and students who scored above the 39th percentile were considered normally achieving readers.

Students scoring within the 10th and 39th percentile were given letters of parental informed consent to take home that explained the purpose of the study. Participants who returned letters of consent were included in the study. Within each research site, students were randomly assigned to one of three experimental groups using a random number table. Each participant was assigned a number and grouped using an electronic random number generator. Because participants in the computer group worked individually, whether random assignment yielded heterogeneous or homogenous groupings was irrelevant. Participants in the teacher-led groups were placed in instructional groupings that were as close to homogeneous as possible after the random assignment process.

Once participants were finalized, frequencies were tabulated for demographic variables. Struggling students who did not participate in the study received computer- assisted *Read Naturally* fluency instruction through their individual schools.

Measures

The Dynamic Indicators of Basic Early Literacy Skills (DIBELS) was used as a screening measure for the study because it has been shown to be a reliable and valid measure for identifying children at risk for reading failure (Good & Kaminski, 2002). The test-retest reliability for elementary age students ranges from .92 to .97; and the alternate forms reliability ranges from .89 to .94. The criterion validity ranges from .52 to .91.

DIBELS was also used as an outcome measure for oral reading fluency. Pretest (fall assessment scores) and posttest (winter assessment scores) data were compared. Because DIBELS is not designed to serve as a comprehensive reading assessment tool (Good, Simmons, Kame'enui, 2001), the Gates-MacGinitie Reading Test Level Three (4th ed.) was also used as an outcome measure for overall reading achievement. The Gates-MacGinitie is a group-administered assessment that specifically assesses vocabulary and comprehension

Materials

The study materials included the *Quick Reads* program, an instructional program using controlled grade level appropriate vocabulary to build oral reading fluency (Hiebert, 2005). The books are thematically grouped based on non-fiction science, social studies, and mathematics topics. The software version allows students to request speech feedback on the definitions of pre-selected words and on the pronunciation of individual words throughout the passage. *Quick Reads* was chosen for several reasons. First, it comes in both a print and a software format. Also, both formats include the same passages with an introduction to each passage accompanied by a caption and comprehension questions following each passage. Finally, researchers have found that students with or at risk for disabilities benefit more from engaging in oral wide reading of diverse texts than from engaging in repeated readings of the same text (Kuhn, 2005; Schwanenflugel, et al., 2006). The *Quick Reads* program uses controlled grade level appropriate vocabulary and students are repeatedly exposed to similar vocabulary in the context of different passages.

Personnel Training

The primary researcher (first author) trained two graduate students in education to supervise the students in the computer-assisted groups and to teach students in the teacher-led instruction group. Each graduate student was randomly assigned to each of the participating schools. Because each school was assigned only one graduate student, each graduate student was responsible for supervising both the computer-assisted groups and teaching the print based group in their assigned school. Each of the graduate student instructors had previous or concurrent coursework in literacy instruction for the elementary grades. Training occurred during one four hour session and involved a general overview of fluency instruction followed by specific details about the components each of the three treatments.

First, the primary researcher reviewed the concept of fluency and its relation to reading with the graduate students. Next, the primary researcher reviewed the components of the teacher-led treatment. Scripts for 30 lessons were provided to each instructor. The primary researcher modeled procedures for one lesson. In pairs, the graduate students practiced until they became comfortable using the scripts. The primary researcher observed each graduate student and provided corrective feedback on all procedures as needed. Finally, the primary researcher taught the instructors how to operate the *Quick Reads* software program. The graduate students were allowed to view the tutorial and to practice navigating through different sections of the program.

Instructional Procedures

Because the software program was new to students, the primary researcher trained the student participants in the CAI groups to use the *Quick Reads* software program before the study began. Participants were allowed to view the tutorial that accompanied the software program. Then participants practiced several procedures necessary for daily use of the program including: accessing the menu of stories, accessing the individual stories, testing and using the microphone, requesting speech feedback on the vocabulary of target words by clicking on bolded words and hearing the computer say the word and its definition, and pronunciation of individual words. Students in the teacher-led group did not receive training because no new knowledge was needed to participate in this group.

Participants who received teacher-led instruction were grouped based on their DIBELS ORF scores. Participants with similar ORF scores were placed in the same group. Teachers in the teacher-led group followed a script created and provided by the primary researcher that took approximately 20 minutes per day to complete. Students completed one passage per day and received instruction for three days per week across a period of 10 weeks. The steps for the teacher-led script are provided in *Table 1*.

Several controls were implemented to limit the differences between groups to the variables of interest. Because participants in the teacher-led group engaged in predicting to activate prior knowledge, participants in the text-equivalent CAI group were required to request speech feedback on at least two target vocabulary words prior to reading a given passage. This requirement helped to serve as a pre-reading activity to help students begin to think about the text before beginning to read. Also,

participants in this group were allowed to complete only one passage in a given daily 20-minute instructional session.

Table 1. ***Quick Reads Steps: Teacher-led***

Step Number	Action
1	The teacher begins by browsing the title, picture and caption with students.
2	The teacher uses a graphic organizer to help students to make predictions about what might occur in the passage.
3	The teacher then reads the passage as students follow along silently.
4	Students then choral read the passage.
5	Students practice the passage by reading with a partner.
6	The teacher then times the student for one minute.
7	The teacher and student chart the number of words read correctly per minute.
8	As students wait to be time, they respond to the comprehension questions that accompany a particular passage. Review the comprehension questions with students.

Participants in the time-equivalent CAI group were also required to request speech feedback on at least two target vocabulary words. To investigate the full effects of using CAI during fluency instruction, participants in this group who completed a passage within the allotted 20-minute instructional period were allowed to move to another passage. However, to ensure that students had fulfilled all the completion requirements, participants in this group were required to check in with a graduate student before moving on to a new passage. The steps for both the text-equivalent and time-equivalent groups are provided in *Tables 2 and 3*.

Table 2. ***Quick Reads Steps: Computer: Text-equivalent***

Step Number	Action
1	The student logs into the program.
2	The student tests the microphone.
3	The student logs into the reading passage.
4	The student chooses at least two vocabulary words.
5	The student chooses to have the computer read or to read to the computer.
6	The student chooses to have the computer read or to read to the computer.
7	The student chooses to have the computer read or to read to the computer.
8	The student chooses to have the computer read or to read to the computer.
9	The student responds to comprehension questions.
10	The student begins a math program.

Table 3. ***Quick Reads Steps: Computer: Time-equivalent***

Step Number	Action
1	The student logs into the program.
2	The student tests the microphone.
3	The student logs into the reading passage.
4	The student chooses at least two vocabulary words.
5	The student chooses to have the computer read or to read to the computer.
6	The student chooses to have the computer read or to read to the computer.
7	The student chooses to have the computer read or to read to the computer.
8	The student chooses to have the computer read or to read to the computer.
9	The student responds to comprehension questions.
10	The student moves on to another passage (if time).

Treatment Integrity

Because this research study was conducted with students and instructors in different schools, it was important to ensure that instructional content was delivered consistently and with integrity across schools and groups. Treatment integrity was evaluated using a researcher-created observer rating scale. Rating scales were tailored to match the requirements for conducting each of the techer-led and computer groups. For the teacher-led group, the focus was on the instructor's ability to follow each scripted step of the program and maintain student engagement throughout each session. For the computer group, the focus was on the graduate student teachers' ability to prepare and manage the software and assist students in navigating the software. The primary researcher observed each instructor using the observer rating scale at least once per week or the equivalent of approximately 30% of the instructional sessions. Each observation was followed by a debriefing in which graduate students were informed about how they performed on each aspect of the treatment integrity rating scale. The average treatment fidelity score was 92%.

Results

In this study, we investigated the following research questions: (1) Is a computer-assisted method of instruction as effective as a teacher-led method of instruction in improving the fluency skills of children who demonstrate delayed fluency development? and (2) Is a computer- assisted method of instruction as effective as a teacher-led method of instruction in improving the vocabulary and comprehension skills of children who demonstrate delayed fluency development? To answer these questions, each student in the study was pre- and post-tested using alternate forms of two measures of reading (i.e., DIBELS ORF and the Gates-MacGinitie). The resulting data were analyzed. Descriptive statistics for each group is reported in Table 4. Scores for fluency, vocabulary, and comprehension were analyzed using an analysis of covariance with group (i.e. print/teacher-led, text-equivalent, and time-equivalent) as the independent factor and the mean post-test scores on DIBELS and the Gates-MacGinitie as the dependent factors. Comparisons of pretest and posttest means by group are reported in Tables 5 and 6.

Table 4. ***Descriptive Statistics by Group***

	Teacher-led (N=17) Mean			Text-equivalent (N=17) Mean			Time-equivalent (N=16) Mean		
	Pre	Post	Increase	Pre	Post	Increase	Pre	Post	Increase
ORF	52.94	69.59	16.65	61.19	82.59	21.40	61.63	83.56	21.93
Vocabulary	417.12	439.53	22.41	433.30	441.35	8.05	429.19	453.88	24.69
Comprehension	409.94	432.24	22.30	407.41	425.06	17.65	404.44	429.75	25.31

Table 5. ***Comparison of Pretest Means by Group***

Dependent Measure	Teacher Group	Textequivalent Group	TimeControl Group	F	df	p
Fluency	52.94	61.19	61.63	3.28	2	.389
Vocabulary	417.12	433.30	429.19	0.96	2	.742
Comprehension	409.94	407.41	404.44	0.30	2	.046

Table 6. Comparison of Posttest Means by Group

Dependent Measure	Teacher Group	Textequivalent Group	TimeControl Group	F	df	p
Fluency	69.59	82.59	83.56	1.08	2	.350
Vocabulary	439.53	441.35	453.88	3.76	2	.031
Comprehension	432.24	425.06	429.75	1.06	2	.357

Research Question 1: Is a computer-assisted method of instruction as effective as a teacher-led method of instruction in improving the fluency skills of children who demonstrate delayed fluency development?

Posttest fluency scores were analyzed across the three groups through an ANCOVA using the pretest scores as the covariate. No significant differences were found across the three groups, $F(2, 49 = 1.08, p = .350)$.

Research Question 2: Is a computer- assisted method of instruction as effective as a teacher-led method of instruction in improving the vocabulary and comprehension skills of children who demonstrate delayed fluency development?

Posttest Gates MacGinitie subtest scores in vocabulary and comprehension were analyzed across the three groups through an ANCOVA using pretest scores as the covariate. No significant differences were found across the three groups on the comprehension subtest, $F(2,49) = 1.06$, p=.357. However, significant differences were found on the vocabulary subtest, $F(2,49) = 3.76$, $p = .034$. A post hoc analysis was subsequently performed using Tukey's HSD. Post hoc analysis revealed that significant differences in vocabulary existed between the text-equivalent and the time-equivalent computer groups ($p = .034$) with the differences favoring the time-equivalent group.

Discussion

Previous research comparing CAI with teacher-led reading instruction can be categorized in two ways. In the first category, researchers included a treatment group receiving CAI combined with teacher-led instruction, a group receiving teacher-led instruction only, and a control group (Mioduser, Tur-Kaspa, & Leitner, 2000; Torgesen, Wagner, Rashotte, Herron, & Lindamood, 2010). In the second category, researchers included a treatment group receiving CAI only, a group receiving teacher-led instruction only, and a control group (Lewandowski, Begeny, & Rogers, 2006;

Mitchell & Fox, 2001; Saine, Lerkkanen, Ahonen, Tolvanen, & Lyytinen, 2010). Both categories of research yielded mixed results. Significant benefits could not be consistently attributed to any one treatment condition (e.g., CAI combined with teacher-led instruction, CAI only, or teacher-led instruction only). Significant differences over treatment control were the only consistent finding across studies.

This research study, despite some differences (e.g., lack of control group and an inclusion of two CAI treatment groups), falls into the latter aforementioned category and the results are consistent with previous research. Significant differences were not found between the two CAI and teacher-led groups for most outcome measures. Significant differences were found between the text-equivalent and timeequivalent groups in the area of vocabulary with the time-equivalent group surpassing the text-equivalent group. To better understand why a difference in vocabulary could have occurred between these two groups, it is necessary to examine the fundamental differences between the treatment conditions. In both the text and time-equivalent groups, students were required to access at least two vocabulary words before beginning a new passage. This was an attempt to provide the students in the CAI group with a pre-reading activity similar to the kind of activity provided to students in the teacher-led group. Students in the text-equivalent group, however, were only allowed to read one passage per session whereas students in the time-equivalent group were not restricted to reading just one passage in a given session. The study design allowed for the participants assigned to the time-equivalent condition to receive more exposure to vocabulary words than the participants in the text-equivalent condition. This supports the theoretical benefit that CAI fosters extensive rehearsals which in turn leads to more effective processing of information (Gagne & Briggs, 1979; Williams & Brown, 1990).

No differences in vocabulary were found between the time-equivalent and teacher-led groups. This may have occurred because the pre-reading activity in the teacher-led group involved discussion of target words. Vocabulary instruction is most effective when students are provided with the opportunity to interact with and discuss words (Baumann & Kame'enui, 2004; Beck et al., 2002; Mitchell & Brady, 2013). Although the time-equivalent group experienced increased exposure to words, this finding was tempered by the fact that the teacher-led group received more meaningful exposure to words. Because the students in the teacher-led group had the opportunity to engage in pre-reading discussions involving a graphic organizer and discussions during and after the readings, these students received more in-depth exposure to text.

Implications for Research

Individual analysis of student data suggests that CAI does not impact all students in the same way. Many researchers have assumed that struggling students would automatically respond in a positive way to computer-assisted instruction. But students who struggle respond to CAI in different ways (e.g., some students may be completely engaged while others may be disengaged) (Anderson, 2008; Bangert-Drowns & Pyke, 2001). On average, about half the students in the time-equivalent condition took advantage of the ability to read multiple passages. This may be because some students were not engaged during CAI instruction. Aspects of the com-

puter such as interactivity and animation can improve engagement but these same aspects can also be distracting. Little research has evaluated the characteristics of students who could most benefit from CAI given the appropriate levels of enhancements. More research is needed to determine whether certain student characteristics allow some students to be more engaged during CAI.

Also, questions arose during this study surrounding issues of cost effectiveness. When evaluating cost effectiveness many researchers focus on the issue of money but more research is needed to determine how the issue of time and teacher availability impacts the difference in cost between teacher-led and computer-assisted programs.

In addition, the current study compared a print-based teacher-led program to a computer-assisted version. However, some researchers suggests that it might be beneficial to combine teacher-led instruction with CAI (Mioduser, Tur-Kaspa, & Leitner, 2000). More research is needed to determine the most effective ways to do so.

Finally, some researchers have suggested that the efficacy of CAI is not solely inherent to CAI. CAI is a vehicle for the delivery of instructional strategies and if the strategy isn't sound then the potential benefits of that strategy will not be realized (De Jong, 2010; Meyer, 2010). More research is needed to determine that most effective CAI/instructional pairings.

Implications for Practice

The results of this study and similar studies conducted in recent years suggest that CAI can be used in classrooms to meet the needs of students with severe reading deficits. Specifically, CAI can be beneficial as a supplement to traditional reading instruction and be used to target skills that need more practice. Also, because the program used during this study, *Quick Reads*, includes content focused text (i.e., social studies, science, and mathematics). This may also be beneficial for classroom teachers in the current climate of common core standards and increased emphasis on informational text. The *Quick Reads* program could allow for exposure to meaningful informational text while also targeting reading skills during instructional interventions. Finally, although there were no significant differences between treatments on the majority of outcome measures, students did experience gains from pretest to posttest within each treatment group. This suggests that the targeted and explicit fluency instruction used during this study would be beneficial for teachers to implement in their instructional practice.

Limitations

Because of the nature of conducting applied research in schools, several limitations were experienced. To begin, the findings of this study are only generalizable to the third grade students who participated in the study. In addition, students in all three groups made improvements on all measures from pre to posttest. However, with the study's lack of control group, it is difficult to determine whether the increase can be attributed to the *Quick Reads* program, to time, or to a combination of both. Because participants were struggling readers at a critical stage in their reading development, establishing a control group would have been difficult. In addition, comparisons to non-study participants would have proven complex because the par-

ticipating schools provided intervention instruction to a majority of the struggling readers who were not involved in the study. The aforementioned factors made it difficult to draw conclusions about the efficacy of the interventions used in this study.

In addition, the effects of the software program used in this study may not be generalizable to other software programs because of such effects as instructional design and delivery. The teacher-led condition took place outside of the regular classroom environment and thus the results of the teacher-led group may not be generalizable to instruction that may take place within regular classroom environments. In addition, because of the short duration of this study, ten weeks, it is difficult to make assumptions about the longitudinal effects of the intervention. This intervention period was also negatively affected by such realities of everyday schooling as holidays, school plays, practice tests in preparation for statewide assessments, make up tests related to the regular curriculum, and early release days. As a result, the maximum number of instructional sessions was only 23. The original goal for the study was 25 to 30 sessions. It is possible that the reduction in the number of sessions may have negatively impacted one or all outcome measures.

Also, several technology problems may have hindered students' ability to use the software program as prescribed (i.e., three days per week, 20 minutes per day). These problems included the computer erroneously correcting student dialect as well as challenges to testing the software's microphone. The software does not allow students to begin working with fluency passages until they have tested the microphone. There were several instances when it took students several minutes to check the microphone. This task should only take a few seconds. These issues may have impacted the lack of differences between the teacher-led and computer-assisted groups.

In addition, approximately 80% or 50 out of 64, of the identified population participated in the study. Fifty participants is only a moderate number and a larger sample size may have yielded more conclusive results. Finally, additional outcome measures may have yielded more conclusive results. Measurements such as the *Woodcock Johnson* vocabulary and comprehension subtests or the *Qualitative Reading Inventory* which is a one-on-one comprehension measure, although more time consuming may have provided more precise measures of the dependent variables.

Conclusion

This study and similar studies indicates that although CAI possesses many characteristics that benefit effective information processing (outlined in cognitive learning theory), a balance exists in the benefits and drawbacks between CAI and traditional forms of instruction. It is beneficial that CAI can be tailored to students with learning rates that differ from average learning rates. Conventional instruction primarily focuses on the needs of students with average learning rates (Cotton, 2001). It is also beneficial that because CAI provides individualized instruction, students can work at their own pace, receive consistent specific feedback, and feel a sense of control over their own learning. CAI also lacks some human characteristics that can be detrimental to students' learning. Unlike humans, the computer is "infinitely patient, never gets tired, and never gets frustrated or angry" (Cotton, 2001, p.4). Although CAI seems to be made for students who struggle, there are several limitations, most of which are ironically also connected to the fact that CAI lacks human attributes.

To begin, in the current study, there was no way for the software version of the program to equate the kinds of pre-reading activities that the teacher-led groups experienced. Pre-reading activities assist in activating background knowledge. Activating background knowledge is crucial to enhancing comprehension of text (Adams, 1990; Fisher & Frey, 2010). Also, the quality of the interactions that occurred between the teacher and students during pre and post reading activities could not have been duplicated by the software version. In the case of this study, CAI would be most effective if used either in conjunction with or as a supplement to traditional teacher-led instruction.

Whether it is used as a supplement to teacher-led instruction or as a stand alone, advancements in computer technology are increasing as rapidly as the costs for that technology are decreasing. This makes the increased use of computer technology in schools promising. The challenge researchers and practitioners continue to face lies in finding the most effective and efficient ways to use computer technology to support students experiencing severe reading deficits.

References

Adams, M. J. (1990). *Beginning to read: Thinking and learning about print.* Cambridge, MA: MIT Press.

Anderson, C. (2008). Barriers and Enabling factors in online teaching. *International Journal of Learning*, 14, 241-246.

Bangert-Drowns, R. L., & Pyke, C. (2001). A taxonomy of student engagement with educational software: An exploration of literate thinking with electronic text. *Journal of Educational Computing Research, 24*, 213-234.

Baumann, J. F., & Kame'enui, E. J. (2004). *Vocabulary instruction: Research to practice.* New York, NY: The Guiford Press.

Cotton, K. (2001). Computer-assisted instruction (School Improvement Research Series Closeup No. 10). Portland, OR: Northwest Regional Educational Laboratory. Retrieved on February 20, 2006 from www.nwrel.org.

Craik, F.I., & Lockhart, R.S. (1972) Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior*, *11*, 671-684.

De Jong, T. (2010). Cognitive load theory, educational research, and instructional design: Some food for thought. *Instructional Science*, *38*, 105-134.

Digest of Education Statistics 2012 (NCES 2014-015). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.

Fisher, D., & Frey, N. (2010). Building and activating background knowledge. *Principal Leadership*, 11, 62-64.

Gagne, R.M., & Briggs, L.J. (1979). Principles of authoring computer-assisted instructional lessons. *Educational Technology*, *21*, 17-26.

Good, R. H., & Kaminski, R. A. (2002). Dynamic Indicators of Basic Early Literacy Skills (6th ed.). Eugene, OR: Institute for the Development of Educational Achievement. Retrieved July 9, 2006, from http://dibels.uoregon.edu

Good, R. H., Simmons, D.C., & Kame'enui, E. J. (2001). The importance and decision-making utility of a continuum of fluency-based indicators of foundational reading skills for third grade high stakes outcomes. Scientific Studies of Reading, 5, 257-288.

Hasbrouck, J. E., & Tindal, G. (1992). Curriculum based oral reading fluency norms for students in grades 2 through 5. *Teaching Exceptional Children, 24*, 41-44.

Hiebert, E. H (2005). *Quick reads: A research based fluency program.* Parsippany, NJ: Modern Curriculum Press.

Joshi, R M., Binks, E, Hougen, M., Dahlgren, M.E., Ocker-Dean, E., & Smith, D.L. (2009). Why elementary teachers might be inadequately prepared to teach reading. Journal of Learning Disailities, 42, 392-402.

King-Sears, M. E., & Bowman-Kruhm, M. (2010). Attending to specialized reading Instruction for adolescents with mild disabilities. *Teaching Exceptional Children*, 42, 30-40.

Kuhn, M. R. (2005). A comparative study of small-group fluency instruction. *Reading Psychology, 26*, 127-146.

Lai, S.I., & Chang, T.S. (2006). Computer usage and reading in elementary schools: A cross-cultural study, Journal of Educational Computing Research, 34, 47-66.

Lewandowski, L., Begeny, J., & Rogers, C. (2006). Word recognition training: Computer versus tutor. *Reading & Writing Quarterly*, *22*, 395-410.

Malmgren, K. W., & Trezek, B. J. (2009). Literacy instruction for secondary students with disabilities. *Focus on Exceptional Children*, *41*, 1-12.

Mayer, R.E. (2009). *Multimedia learning* (2nd ed). New York, NY: Cambridge University Press.

Mayer, R.E. (2010). Seeking a science of instruction. *Instructional Science*, 38, 143-145.

Meyen, E. (2015). Significant advancements in technology to improve instruction for all students including those with disabilities, *Remedial and Special Education*, 36, 67-71.

Mitchell, A., & Brady, S. (2013). The effect of vocabulary knowledge on novel word identification. *Annals of Dyslexia*, 63, 201-216.

Mitchell, M. J., & Fox, B. J. (2001). The effects of computer software for developing phonological awareness in low-progress readers. *Reading research and instruction, 40*, 315-332.

Mioduser, D., Tur-Kaspa, H., & Leitner, I. (2000). The learning value of computer-based instruction of early reading skills. *Journal of Computer-assisted Learning, 16*, 54-63.

Neddenriep, C.E., Fritz, A.m., & Carrier, M.E. (2011). Assessing for generalized improvements in reading comprehension by intervening to improve reading fluency. *Psychology in the Schools*, 48, 14-27.

Norton, P. (1983). Computer potentials and computer educators: A productive view of computer education. *Education Technology*, 23, 25-28.

Pagan, S., & Senechal, M. (2014). Involving parents in a summer book reading program to promote reading comprehension, fluency, and vocabulary in grade 3 and grade 5 children. *Canadian Journal of Education*, 37, 1-32.

Pikulsi, R., & Chard, D. (2005). Fluency: Bridge between decoding and reading comprehension. *The Reading Teacher*, 58, 510-519.

Rasinski, T. V. (2004). *Assessing reading fluency*. Monograph published by Pacific Resources for Education and Learning, Honolulu, HI.

Rasinski, T. V., Rikli, A., & Johnston, S. (2009). Reading fluency: More than automaticity? More than a concern for the primary grades? *Literacy Research and Instruction*, 48, 350-361.

Regan, K., Berkeley, S., Hughes, M., & Kirby, S. (2014). Effects of computer-assisted instruction for struggling elementary readers with disabilities. *The Journal of Special Education*, 48, 106-119.

Renkl, A., & Atkinson, R.K. (2007). Interactive learning environments: Contemporary issues and trends. An introduction to the special issue. *Educational Psychology Review*, 19, 235-238.

Schwanenflugel, P. J., Meisinger, J. M., Wisenbaker, Kuhn, M. R., Strauss, G. P., & Morris, R. D. (2006). Becoming a fluent and automatic reader in the early elementary school tears. *Reading Research Quarterly, 41*, 496-522.

Stahl, S, (2003). Vocabulary and readability: How knowing word meanings affects comprehension. *Topics in Language Disorders*, 23, 241-247.

Stetter, M.E., & Hughes, M.T. (2010). Computer-assisted instruction to enhance the reading comprehension of struggling readers: A review of the literature. *Journal of Special Education Technology*, 25, 1-16.

Torgesen, J.K., Wagner, R.K., Rashotte, C.A., Herron, J., & Lindamood, P. (2010). Computer-assisted instruction to prevent early reading difficulties in students at risk for dyslexia: Outcomes from two instructional approaches. *Annals of Dyslexia*, 60, 40-56.

Vadasy, P.F., & Sanders, E.A. (2008). Code-oriented instruction for kindergarten students at risk for reading difficulties: A replication and comparison of instructional grouping. *Reading and Writing*, 21, 929-963.

Williams, C.J., & Brown, S.W. (1990). A review of the research issues in the use of computer-related technologies for instruction: An agenda for research. *International Journal of Instructional Media*, 17, 213-225.