An Investigation of the Effects of a Computer-Assisted Reading Program on the Oral Reading Fluency and Comprehension of Elementary Students

Margaret Carol Bush

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An investigation of the effects of a computer-assisted reading program on the oral reading fluency and comprehension of elementary students

By
Margaret C. Bush

A Dissertation
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An investigation of the effects of a computer-assisted reading program on the oral reading fluency and comprehension of elementary students

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An important reading skill that is often overlooked by educators is reading fluency. There is a paucity of studies that have investigated computer programs that address this and other critical reading skills. Reading Assistant™ is a form of computer-assisted instruction that uses speech recognition technology and research supported strategies to target reading fluency, vocabulary, and comprehension. The purpose of the present study was to examine the effects of Reading Assistant™ on the oral reading fluency and comprehension skills of second through third grade students considered at-risk for reading failure.

A total of eight participants were involved in this study across a 6- to 8-week intervention period. In order to evaluate the impact of Reading Assistant™, a multiple baseline across participants design was used. Multiple sources of data were collected to determine the overall effectiveness of the Reading Assistant™ computer program. Data for reading fluency was collected using AIMSweb reading curriculum based measurement (CBM) probes while data for reading comprehension was collected using AIMSweb maze CBM probes. The effect of the Reading Assistant™ computer program
was also evaluated by determining the rate of improvement (ROI) as well as by
calculating the percentage of non-overlapping data points (PND).

The results of this study suggest that Reading Assistant™ may have been
somewhat effective for improving the oral reading fluency and reading comprehension
skills, but only for some of the participants. The effect size data do not provide a
convincing demonstration that Reading Assistant™ had a substantial impact on the
majority of struggling readers involved in this study. Further research is needed to
establish the effectiveness of Reading Assistant™ as an intervention for reading fluency.
DEDICATION

I am honored to dedicate this research to my children, Lauren and Grant, and my husband, Adam. Without their love and support, this endeavor would not have been possible.
ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to Dr. Carlen Henington. Without your guidance, encouragement, and support, I would never have been able to complete this project. I would also like to thank Dr. R. Anthony Doggett, who previously served as my dissertation chair and helped enormously in the initial stages of this process. Dr. Carmen Reisener’s expertise and support was also invaluable. I am also very appreciative of all the contributions of my remaining committee members: Dr. Kent Coffey, Dr. Tawny McCleon, and Dr. Cheryl Justice. In addition, I would like to thank the school district and my colleagues who supported this research.
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INTRODUCTION

Reading assessments indicate that almost 40% of U.S. school children are reading at or below a basic level of proficiency (National Center for Educational Statistics, 2003). Learning disabilities in reading also account for the largest single group of children receiving special education services (Gresham, 2002). These findings are particularly disheartening, as reading is considered to be the foundation on which many other academic skills are developed (Flanagan, West, & Walston, 2004). Researchers have suggested that although students who perform below grade level early in their academic career may experience improvements in reading skills over time, the gap in reading ability between poor readers and proficient readers often remains stable or increases over time without receipt of supplemental or individualized intervention services (Chard & Kameenui, 2000; Shaywitz, 2003). Intervening with struggling readers early is important as those students who cannot read by the end of the third grade have been found to be more likely to experience a number of negative outcomes, including eventually dropping out of school (Denti & Guerin, 1999). Individuals with low levels of literacy will also have decreased employment opportunities in a society that requires effective reading skills within the workplace (Torgeson, 2002).

One critical reading skill that has been frequently cited as a referral concern of educators is the fluency with which a student reads text (Allington, 1983; Fuchs, Fuchs,
Hosp, & Jenkins, 2001; National Reading Panel, 2000). Fluent readers are able to read with speed, accuracy, and proper expression and this enables them to focus their attention on the ideas in the text and therefore comprehend what they read (Wolf & Katzir-Cohen, 2001). One potential reason that reading fluency has not previously been a common instructional target may be due to the fact that many of the research-validated fluency interventions require a one-to-one tutor to student ratio. One method of delivering reading fluency interventions to students, which decreases the need for individual attention from staff is computer assisted instruction (CAI). Besides freeing staff time, CAI may also improve intervention treatment integrity, assist teachers with monitoring student progress, is highly engaging to students, and allows for frequent opportunities to respond while providing high rates of success and reinforcement (Macaruso, Hook & McCabe, 2006). There has been considerable research on interventions using human tutors, but there is a paucity of studies that have investigated computer programs designed to improve reading fluency. Due to the limited research on CAI and reading fluency, this study will investigate Reading Assistant™, a widely used commercial computer program targeting this critical skill.

This chapter will present a brief overview of the legislative response to reading failure including an important discussion regarding the Individuals with Disabilities Education and Improvement Act (IDEA, 2004). The typical approach to remediating academic deficits will be discussed along with a review of the Response to Intervention (RTI) model. The chapter will conclude with an overview of computers being used as instructional tools followed by the statement of the problem, purpose of the study, and proposed research questions.
Legislative Response to Reading Failure

The problems associated with reading failure prompted the passing of the Reading Excellence Act in 1998 (P.L. 105-277). This legislation provided 260 million dollars for professional development and instructional materials focused on scientifically based reading programs to schools throughout the United States. Later in 2002, the No Child Left Behind Act (NCLB; P.L. 107-110) was signed into law, which produced broad changes in federal education policy. The primary goals of NCLB include closing the achievement gap between disadvantaged and minority students and their peers and requiring the use of quality, research-based instructional strategies. An underlying assumption of NCLB is that all children should be capable of attaining a certain level of academic success (Batsche et al., 2005). The law was also created and implemented as a means of ensuring greater school accountability (United States Department of Education, 2002).

Under NCLB, schools are mandated to set high goals in reading and math and are responsible for monitoring the progress of students in these academic areas. One emphasis of NCLB is the requirement that federal funding should only be provided to support reading programs that are empirically investigated and found to be effective. In order to support this mandate, Reading First was initiated, which is a program designed to help direct the provision of early reading instruction, interventions and assessment. Reading First is an important initiative as it emphasizes accountability and the use of empirically-based instruction to teach reading skills. Federal funding, which is tied to Reading First, has been awarded to school districts across the country so that they may
utilize research supported instructional strategies to improve the performance of young readers.

**The Reauthorization of IDEA**

NCLB provisions stipulating the use of empirically-based instructional strategies apply to all students, including those identified as having disabilities. IDEA (P.L. No: 108-446) was amended on December 3, 2004 by legislatures as the Individuals With Disabilities Education Improvement Act, known as IDEIA. This act incorporated changes that closely aligned IDEA with NCLB. Another important feature of IDEIA (2004) that builds upon concepts established in NCLB is the incorporation of an alternate assessment procedure that can be utilized instead of the previously mandated IQ-achievement discrepancy approach when determining eligibility for special education services under the specific learning disability (SLD) category. This provision, which indicates that identification of a SLD no longer requires evidence of a discrepancy between intellectual aptitude and achievement, marked the first change in policy regarding the identification of learning disabilities for special education purposes since the 1970s.

**Traditional Approach to Providing Interventions**

The United States Department of Education defined the diagnostic criteria for a SLD in 1977 as (a) failure to benefit from adequate instruction, (b) a severe discrepancy between achievement and intellectual ability, and (c) the exclusion of sensory impairments, mental retardation, emotional disturbance, or environmental, cultural, or economic disadvantage (Speece, Case, & Malloy, 2003). From these criteria set forth by the federal government the IQ-achievement discrepancy model was formed. This model
is based on the assumption that an individual whose cognitive ability on standardized
tests is commensurate with current levels of measured achievement is performing up to
his or her learning potential and, consequently, is not capable of achieving greater
academic success. Therefore, the use of this model results in students who are at risk for
reading failure being denied additional academic support through special education
(Restori, Gresham, & Cook, 2008).

The IQ-achievement discrepancy model has been the most commonly used
approach to identifying learning disabilities, and has been implemented in the majority of
states, although there is no single operational definition of what constitutes a severe
discrepancy (Fuchs, Mock, Morgan, & Young, 2003). A number of methods used to
calculate the discrepancy have been developed, as well as variations in the required size
of the discrepancy in order to determine eligibility for special education services.

Despite the widespread continued use of the IQ-achievement discrepancy model,
the validity of this approach for identifying learning disabilities is not supported. Two
independent meta-analyses have indicated effect sizes on measures of achievement and
intelligence in the negligible range for comparison groups formed on the basis of
discrepancies between IQ and reading achievement and those poor readers without the
IQ-achievement discrepancy (Hoskyn & Swanson, 2000). Further, Ysseldyke,
Algozzine, Shinn, and McGuire (1982) compared the scores of intelligence tests of
students identified as having learning disabilities and students who are academically at-
risk without learning disabilities and demonstrated that there was no significant
difference in test scores between the two groups. These researchers also found that
schools misidentified students without learning disabilities (i.e., false-negative) and those
without learning disabilities as having learning disabilities (i.e., false-positive), and the misidentification rate was approximately 50%. Given these outcomes, the IQ-achievement discrepancy model does not appear to an effective means of distinguishing separate groups of students with learning needs.

When the IQ-achievement discrepancy model is used, individuals who are experiencing academic difficulties are typically not identified until they maintain a certain level of progress that is markedly atypical from peers and persists for a period of time (i.e., repeated failure and grade retention). This ‘wait to fail’ approach results in a delay in students receiving targeted instruction for academic deficits (Fuchs et al., 2003). Typically, once a student has been identified as someone who may potentially have learning difficulties and may be in need of special education services, the student is referred for a psychological or psycho-educational evaluation. The psychological assessment, commonly comprised of intellectual and achievement testing, is then administered. Afterward, an Individualized Education Program (IEP) committee convenes to ascertain if information supports special education eligibility which includes determining whether a significant discrepancy is present between cognitive ability and one of the eight areas in which a specific learning disability may exist. If testing does not reveal a large enough discrepancy between cognitive ability and achievement as defined by the state, then the child will be found ineligible for special education services. This latter finding can occur even if the student is progressing at a pace much slower than peers and is experiencing school failure. Many students who would benefit from more individualized, intense academic support therefore do not qualify for these services (Reschly & Ysseldyke, 1995). Unfortunately, this results in struggling students being left
in a general education system whose personnel may not have the resources or skills to meet the academic needs of referred students (Lentz & Shapiro, 1985).

In addition to the IQ-achievement model lacking empirical support, the traditional approach to identifying learning disabilities has been criticized for several other reasons. First, instead of offering intervention early to reduce the likelihood of failure, the traditional approach offers no assistance and requires students to experience failure academically in order to potentially create the IQ-achievement discrepancy that will qualify them for special education services (Fletcher et al., 2004). Further, the traditional discrepancy model makes the assumption that there is a difference in academic achievement between students with and without a discrepancy, which has not been found to necessarily be the case. Specifically, the concept that the severity of a learning disorder can be determined by the discrepancy between IQ and achievement has not been empirically supported (Vaughn & Fuchs, 2003). This model also does not link directly to effective, individualized interventions and to positive results for students (Gresham & Witt, 1997). The majority of states continue to utilize the IQ-achievement discrepancy model (Restori et al., 2008). This is particularly troubling given the fact that there is little scientific evidence to support the use of this approach to identifying learning disabilities.

In summary, the IQ-achievement discrepancy model was formed from criteria set forth by the federal government in 1977. When this model is utilized, students who experience learning difficulties are generally not identified until they experience significant academic failure. Further, the IQ-achievement discrepancy model lacks empirical support and delays implementation of individualized, targeted academic interventions. Although the IQ-achievement discrepancy model continues to be utilized,
changes in IDEIA (2004) eliminated the requirement that students must exhibit a severe discrepancy between intellectual ability and achievement in order to be determined eligible for special education services. This change has increased attention on an alternative model of instruction referred to as RTI.

RTI

As stated previously in this chapter, the U. S. Department of Education now allows the use of a process based on a child’s response to scientific, research-based interventions when attempting to identify a SLD. This empirically validated process, also known as RTI, facilitates a more appropriate and timely identification of children with learning disabilities so that they can benefit from research-based interventions. RTI provides a method to rule out inadequate instruction as a cause of insufficient academic achievement and promotes data-based decision making.

Essential Components of RTI

There are several core features of RTI methodology. To begin with, RTI was developed as a school-wide intervention approach and designed to be implemented within the general education setting. All students in a school utilizing RTI receive high quality, scientifically-based instruction. Underlying the RTI model is the belief that all children are capable of learning (National Association of State Directors of Special Education [NASDSE], 2006). The majority of students (i.e., 75-80% of the student population) should respond and be successful with the quality instruction that is provided in the general education curriculum at the school level (Walker & Shinn, 2002). When a child does not learn at an expected rate even when given scientifically-based instruction,
early intervention in the form of additional academic support using empirically-based interventions is provided. Some students may only need supplemental support at the secondary or Tier II level. Other students may require more individualized and intensive supports at the tertiary or Tier III level within the RTI model. According to Fuchs, Fuchs, and Speece (2002) “when a low-performing child fails to manifest growth in a situation where others are thriving, alternative instructional methods must be tested to address the apparent mismatch between the student’s learning requirements and those represented in the conventional instructional program” (p. 35). RTI represents an opportunity to provide early intervention for students at-risk for academic difficulties such as reading failure, while at the same time reducing inappropriate special education referrals. A prevention model for students is therefore put in place eliminating the wait to fail approach (NASDSE, 2006).

Besides providing scientifically-based instruction to all students and targeted interventions to those at risk of academic failure, there are also several other essential elements of RTI. These essential elements include monitoring and measuring student progress to instruction and interventions and using measures of student progress to direct instructional and educational decisions (Klotz & Canter, 2006). Curriculum based measurement (CBM) is the tool that is used in RTI to determine a student’s initial proficiency level and to monitor skill acquisition.

Deno and colleagues (1985) developed CBM in order to assess academic skills in a manner that was precise, direct and sensitive to growth. CBM has been defined as a standardized progress monitoring procedure that uses direct observations and recordings used to make instructional decisions regarding a student’s performance in the school’s
curriculum (Deno, 1987). CBM commonly involves administering repeated and frequent skill probes from the curriculum in order to evaluate the impact of instruction. National norms for academic skills such as oral reading fluency are available, and local norms for CBM can also be developed for each school or district. These norms can be utilized to operationalize student achievement expectations at each grade level (Shinn, Rosenfield, & Knuston, 1989). CBM is sensitive to small changes in skill acquisition, frequent administrations are possible, and the assessments are quick, inexpensive, and easy to administer (Deno, Marston, & Tindal, 1986). Thus, there is currently strong conceptual and empirical support for CBM being used in the RTI process. Common CBM reading measures used in RTI include one minute timed tests of oral reading fluency known as reading CBM (R-CBM) and three minute timed cloze tests designed to assess reading comprehension known as maze CBM.

Another essential element of RTI is the incorporation of a problem-solving model for making decisions regarding the development and evaluation of interventions. Within the RTI problem-solving model, student learning is analyzed by examining data to guide and evaluate decision making (Fuchs & Fuchs, 2004). The RTI problem-solving model has been based on the behavioral consultation model (Bergan & Kratochwill, 1990). This four-stage model consists of (a) problem identification, (b) problem analysis, (c) plan implementation, and (d) problem evaluation. The problem identification phase involves creating an operational definition of the target behavior. In the problem analysis stage, the problem is evaluated in order to determine environmental features that could be manipulated to address the problem and a plan is also developed to address the target behavior. The plan implementation stage consists of implementing the plan as well as
determining integrity with which the treatment or intervention is carried out. The final step of the four-stage model is problem evaluation. This stage consists of evaluating the efficacy and integrity of the plan, with the plan being modified as needed.

**Tiers of RTI**

As stated previously, RTI is also a multi-tiered process by which services and interventions are provided to struggling learners at increasing levels of intensity (NASDSE, 2006). The RTI model is typically implemented through three or four tiers of intervention. The use of a three-tier RTI model for reading has been proposed by researchers in the fields of educational and school psychology (Denton & Mathes, 2003; Vaughn & Fuchs, 2003).

Fuchs and Fuchs (1997) have provided a description of the three-tier model for the determination of a learning disability. In Tier I, students receive an empirically-based, core instructional program that is often aligned to the benchmarks for each grade as outlined by state departments of education. CBM probes are administered to all students, with this ‘benchmarking’ typically completed at the beginning, middle, and end of the school year (i.e., fall, winter, spring) as a form of universal screening. These probes are conducted in core academic areas such as mathematics and reading in order to determine each child’s level of proficiency. Evaluations of CBM probes are made by school personnel to pinpoint those students at-risk.

During Tier II, targeted or supplemental interventions involving empirically validated instructional practices are implemented, with CBM data collected to assess the effectiveness of the interventions. During this phase, assistance is generally given in a small group setting (Vaughn & Fuchs, 2003). It is estimated that approximately 15% of
the school population will benefit from this support (Walker & Shinn, 2002). Those children who do not respond to these interventions progress to Tier III.

In this final tier, an individualized and intensive intervention plan is implemented, with probes used for ongoing progress monitoring in order to assist with determining intervention effectiveness. The third tier consists of the most intensive instructional support and is individualized for each student. It is estimated that approximately 1-5% of a school’s student population will require Tier III interventions (Walter & Shinn, 2002). In many states, Tier III represents a special-education diagnostic period in which the student’s responsiveness to intensive intervention is measured. After Tier III, the assessment team convenes to make decisions regarding a child’s placement in special education. Students who have responded to interventions at an adequate rate are considered non-disabled. For those students who have not responded to the interventions at a level or rate of progress that was expected, the special education category of Specific Learning Disability may be considered. This three-phase, or three-tier model, has been implemented successfully in schools across the United States (Fuchs, Compton, Fuchs, Bryant, & Davis, 2008; VanDerHeyden, Witt, & Gilbertson, 2007).

**Benefits of RTI**

There are many benefits to adopting the RTI model for use when identifying students with learning disabilities. To begin with, by basing learning disability determination on the failure to respond to scientifically-based instructional strategies, the identification process eliminates poor instruction as an explanation for inadequate learning. Instead, inadequate learning can instead be attributed to the student’s disability (Fuchs, 2003). In other words, a failure to produce a discrepancy within a reasonable
period of time (i.e., an inadequate response to intervention) is considered evidence for the presence of a learning disability. Secondly, at-risk children are identified early with the intervention phase serving to remediate academic problems. As a result, academic support is provided sooner to students than within the traditional IQ-achievement discrepancy model. Finally, RTI is considered a possible means of reducing inappropriate referrals for special education and may serve as a means to reduce bias by teachers in the referral process by using universal screening methods (Vaughn & Fuchs, 2003).

**Limitations of the RTI Model**

Despite its many advantages, there are several limitations of the RTI model (Gresham, 2002). A fundamental tenet of the RTI model is the expectation that general education staff members are required to implement interventions with an adequate amount of treatment fidelity (i.e., at least 90% intervention integrity). These staff may not have the adequate training to identify students in need of interventions or to develop and appropriately implement and monitor interventions. However, interventions must be implemented with integrity within the RTI model in order to make accurate decisions about children’s response to instructional strategies. Other factors of concern include the lack of empirical support for implementation of the RTI process on a large scale, whether RTI is a permanent service delivery model or a temporary fad, and using RTI for disability determination in special education without also conducting a comprehensive psychological assessment (Reynolds & Shaywitz, 2009). Given these concerns, some authors have argued that it may difficult, if not impossible, for some schools to implement RTI effectively (Gerber, 2005). One potential solution to some of the aforementioned difficulties is the use of computers as a means to deliver academic
interventions. The use of computerized instruction will be discussed in more detail in the subsequent sections.

Computers as Instructional Tools

Torgeson (1986) reported that computers have the “capacity to deliver motivated, carefully monitored, individualized, and speed-oriented practice not available in traditional assessment” (pp. 158-159). In addition to these potential advantages, computer programs can be structured to function with minimal staff support and can operate in a consistent manner for set periods of time, aspects that may directly relate to improved treatment integrity.

Computers have been used as intervention agents for academic difficulties, especially in the area of reading, for a number of years. Torgeson (1986) proposed that computerized techniques were ideal for “speed-oriented practice in reading” (pp. 27-28). Consequently, CAI is a potentially viable option for providing targeted reading fluency instruction. Addressing reading fluency skills within the RTI process may be a particularly important goal as reading fluency has been found to be an essential stage in the development of proficient reading skills, but is an area that is often overlooked by educators (Allington, 1983; Fuchs et al., 2001; National Reading Panel, 2000).

There are a number of commercial computer programs that have been developed and are currently available that are advertised as being effective at improving reading fluency. One commercially available program that may be of interest to educators is Reading Assistant™. This program, designed for individuals in grades second to twelfth, consists of a number of features that have been empirically supported to improve fluency. Some of these empirically supported features include previewing, repeated reading of
text, and error correction. Reading Assistant™ may be particularly appealing to educators since it is computer based and requires minimal staff supervision. Further, individuals progress through the program at their own pace and data are maintained by the computer program regarding student performance. However, despite the potential for this program to improve reading fluency, there have been few studies that have investigated this possibility.

**Statement of the Problem**

Reading skills are vital to educational success. In spite of this fact, many school children in the United States are struggling to reach basic proficiency levels in reading. Researchers have shown, however, that when provided with appropriate instruction early, nearly all students can become competent readers (Mathes & Denton, 2002). The use of RTI procedures to address difficulties in reading has been advocated by multiple consensus reports (e.g., the 1998 National Reading Council’s Preventing Reading Difficulties in Young Children, the 1998 National Reading Panel Report) due to its focus on accountability, evidence-based instructional practices, and its ability to provide information that pinpoints at-risk students.

One area of reading that has been frequently overlooked by educators according to researchers is oral reading fluency (Allington, 1983; Fuchs et al., 2001; National Reading Panel, 2000). A substantial research-to-practice gap currently exists despite the development of instructional strategies to improve oral reading fluency (Denton, Vaughn, & Fletcher, 2003). This may be in part due to the personnel requirements involved in many of the reading fluency interventions. Although there is considerable research supporting the use of interventions to address reading fluency with students using human
tutors, there is a paucity of studies that have been completed investigating computer programs that target this critical reading stage. Overall, research investigating the effectiveness of computer based reading interventions is very limited. Additional research needs to be conducted with computer based interventions for reading fluency.

**Purpose of Present Study**

The purpose of the present study was to examine the effects of CAI on oral reading fluency and comprehension using Reading Assistant™. Reading Assistant™ is a web-based reading program for individuals who are in second through twelfth grade as well as for adults who are remedial readers. The program is designed to target fluency, vocabulary, and comprehension by increasing opportunities to read orally. It is intended to be used as an intervention or a supplement to a traditional reading program.

Specifically, this study will examine if Reading Assistant™ can be used to increase the oral reading fluency and comprehension skills of second through third grade students considered at-risk for reading failure. An additional focus is to determine if improvements in oral reading fluency skills will generalize to untaught, grade level passages. Therefore, the current study was designed to address the following research questions:

1. Will participating in the Reading Assistant™ computer based intervention sessions result in the improved oral reading fluency on instructional level R-CBM probes of students in the second through third grades who are performing at least one year below grade level in reading?
2. Will participating in the Reading Assistant™ computer based intervention sessions improve the literal comprehension skills on unpracticed maze CBM
passages at instructional level of students in the second through third grades who are performing at least one year below grade level in reading?

3. Will participating in the Reading Assistant™ computer based intervention sessions result in the improved oral reading fluency on grade level R-CBM probes of students in the second through third grades who are performing at least one year below grade level in reading?

4. Will participating in the Reading Assistant™ computer based intervention sessions improve the literal comprehension skills on unpracticed maze CBM passages at grade level of students in second through third grades who are performing at least one year below grade level in reading?

**Definition of Terms**

1. *Comprehension*: For the purpose of this study, comprehension will be measured using AIMSweb instructional and grade level maze CBM passages.

2. *Curriculum-based assessment (CBA)*: Curriculum-based assessment is a performance based assessment technique that utilizes a student’s curriculum and includes direct observations and recordings of performance.

3. *Curriculum based measurement (CBM)*: This progress monitoring system was developed by Deno and colleagues at the University of Minnesota (e.g. Deno, 1985). Typically, CBM involves frequent administrations of skills probes taken from the curriculum the student is being instructed and serves as a general outcome measurement.

4. *Computer-assisted instruction (CAI)*: Computer-Assisted Instruction (CAI) refers to instruction provided by a computer to include drill and practice,
simulation activities, or tutorial activities that are offered independently or as a supplement to teacher provided instruction.

5. *Correct words per minute (CWPM):* CWPM is determined by the number of words read correctly in one minute.

6. *Current grade level:* The current grade level indicates that actual grade level that the student is placed. For example, if a student is placed in the fifth grade at school, his current grade level is fifth grade despite any potential grade retentions that may have occurred for the student.

7. *Errors per minute:* Errors per minute is defined as the number of words read incorrectly in one minute (Deno & Mirkin, 1977).

8. *Fluency:* Fluency is defined as “the ability to read accurately, quickly, effortlessly, and with appropriate expression and meaning” (Griffith & Rasinski, 2004, p. 126).

9. *Frustrational level:* Frustrational level is the level of material considered too difficult for the student to learn. Reading at a rate of less than 40 CWPM is considered frustrational for Grades 1 and 2. Reading at a rate of less than 70 CWPM for students in third to sixth grade indicates the frustrational level. For seventh grade and beyond, no frustrational reading level has been determined (Fuchs & Deno, 1982).

10. *Generalization:* Generalization refers to behavior change that occurs in nontraining conditions, for example, on non-practiced or grade level probes in the current study.
11. **Instructional level:** The instructional level refers to the level a student will likely be challenged, but will probably succeed if instructed at this level. For first and second grade, reading at a rate of 40 to 60 CWPM indicates an instructional level. For grades third through sixth reading at a rate of 70 to 100 CWPM indicates an instructional level. For seventh grade and beyond, no instructional reading level has been determined (Fuchs & Deno, 1982).

12. **Listening previewing:** Listening Previewing is an intervention that entails exposing a student to a correct model of the appropriate reading of a passage. The student listens to the passage prior to attempting to read the passage. This intervention is designed to improve oral reading rates and comprehension.

13. **Mastery level:** Mastery level is the level that indicates that reading material does not provide sufficient challenge for an individual. For first and second grade, reading at a rate of more than 60 CWPM indicates a mastery level. For third through sixth grade, reading at a rate of more than 100 CWPM indicates a mastery level. For students in seventh grade and beyond, no mastery level reading rate has been determined (Fuchs & Deno, 1982).

14. **Oral reading fluency:** For the purpose of this study, oral reading fluency will be measured by AIMSweb R-CBM grade level and instructional level progress monitoring probes.

15. **Repeated reading:** Repeated reading is an intervention that entails having the student read the same passage several times. This intervention provides additional practice of reading skills and is designed to improve oral reading rates and comprehension.
16. *Speech recognition*: The ability of a computer to understand and carry out spoken commands or receive and interpret dictation.
CHAPTER II
LITERATURE REVIEW

This chapter begins with important information about current academic outcomes from the National Reading Panel. Next, reading fluency and CAI will be discussed. The section on reading fluency will include an overview of how this critical skill develops for school age students and will include a review of prominent models in the field regarding reading education and skill development. There will also be a discussion regarding the most effective empirically-based instructional practices to improve reading fluency. Next, the potential benefits of CAI will be presented along with a brief historical background pertaining to the use of computers to address reading skills. Finally, current research on the use of CAI for reading fluency will be reviewed.

The National Reading Panel Report

In 1997, the National Reading Panel was commissioned by Congress. The National Reading Panel, which consisted of 14 experts on reading development, was asked to review the existing literature regarding reading instruction in order to determine the most effective, research-based methods for teaching students to read. After completing a comprehensive analysis, a report was submitted to Congress entitled *Teaching Children to Read: An Evidence-Based Assessment of the Scientific Research*
The report that was issued by the National Reading Panel focused on the development of five skills that were identified as being critical for students to acquire in order for them to become effective readers. These skills included: (a) phonemic awareness, (b) the alphabetic principle, (c) reading fluency, (d) vocabulary, and (e) reading comprehension. Phonemic awareness refers to the ability to identify and manipulate phonemes, the smallest units of spoken language (National Reading Panel, 2000). Another critical skill for beginning readers involves understanding letter-sound correspondences, otherwise known as the alphabetic principle. Vocabulary knowledge refers to understanding the meaning of words that are presented in text. The ability to understand what is written, known as comprehension of reading material, is closely aligned to vocabulary knowledge. Reading comprehension has also been strongly linked to reading fluency, which is another critical skill for students (Fuchs et al., 2001; Torgeson & Hudson, 2006). Due to the nature of this study, reading fluency will be discussed in more detail in the next section.

**Reading Fluency**

As stated earlier in this document, if a student is reading fluently, they can focus their attention on comprehending what he or she is reading. Reading is smooth and accurate, decoding is relatively effortless, and the individual reads with correct prosody (Wolf & Katzir-Cohen, 2001). It is important to emphasize that fluent reading includes not only quick and accurate word recognition but also with correct prosody, which means
with appropriate expression so that text sounds like spoken language when read aloud. Accuracy, rate, and prosody are each important when defining oral reading fluency.

Huey (1968) described the development of fluent reading by comparing it to the development of other skills such as riding a bike, indicating that such skills can improve with practice. “Repetition progressively frees the mind from attention to details, and makes facile the total act, shortens the time, and reduces the extent to which consciousness must concern itself with the process” (Huey, 1968, p. 104). Later in 1974, LaBerge and Samuels proposed a model to attempt to describe how reading fluency affects comprehension of text. According to these authors, students who expend greater attention decoding words have lower capacity to process text on other levels (Cunningham, 1979; LaBerge & Samuels, 1974). In other words, when an adequate degree of fluency is developed, cognitive resources become available to comprehend text. The model that was developed by LaBerge and Samuels is known as the theory of automatic information processing. According to Samuels (2002, p. 167), “To experience good reading comprehension, the reader must be able to identify words quickly and easily”. This model indicates that reading must be automatic in order for comprehension of text to occur.

Not long after LaBerge and Samuel suggested their model of automatic information processing, Perfetti (1977, 1985) proposed the verbal efficiency model of reading. Like the theory of automatic information processing, the verbal efficiency model suggests that slow word processing interferes with comprehension of reading material. Perfetti suggested that slow word identification consumes working memory which inhibits the ability to process the content of text while reading. More recent
conceptualizations propose that reading is an interactive process (Stanovich, 1980), with prior contextual information contributing to word identification. Although these models may differ, both bottom-up serial models of reading and interactive models of reading are based on the assumption that automatic word recognition allows for higher level processing of information to take place. In other words, improvement in fluency allows an individual to move from word-by-word reading to understanding of text (i.e., comprehension of the written word).

Reading fluency has been found to correlate with comprehension and is a good predictor of overall reading achievement (Fuchs et al., 2001; Pinnell et al., 1995; Rasinski, 2000). As discussed previously, theoretical models have been proposed that attempt to explain this relationship (LaBerge & Samuels, 1974; Perfetti, 1977, 1985). Research has repeatedly supported these models, with multiple studies providing evidence of a moderate to strong relationship between oral reading fluency and reading comprehension (Hosp & Fuchs, 2005, Schwanenflugel et al., 2006).

Hosp and Fuchs (2005) conducted a study with 310 students in the first through fourth grades in order to investigate the relationship between oral reading fluency, decoding, word reading, and passage comprehension. The word reading and passage comprehension subtests from the Woodcock Reading Mastery Test - Revised (WRMT-R) were used as was R-CBM. Results indicated that reading fluency and reading comprehension were strongly correlated. For first grade, a .79 correlation was obtained, for second grade .83, for third grade .84, and for fourth grade .82.

Reading fluency has also been linked to the amount of material a student reads. Individuals who struggle to decipher text will likely read less than other students who are
fluent readers. This limits vocabulary exposure, which ultimately affects the ability to comprehend material. Stanovich (1986) reported that there was a reciprocal relationship between reading fluency and the amount of time that a student spent reading. He termed this phenomenon the ‘Mathew Effect’, whereby good readers read more and become better readers whereas poor readers read less and fall further behind. In other words, those individuals who are successful with reading typically spend more time engaged in this activity than those who have evidenced less success.

**How Reading Fluency Develops**

As students acquire the skill of reading they pass through various stages or phases of proficiency. Models that may be useful for understanding how reading fluency develops will be presented in the next section.

**The Instructional Hierarchy Model.** One model that can assist with understanding how reading fluency develops is known as the Instructional Hierarchy model. The developers of this model describe four separate stages that an individual progresses through as they acquire new skills. The stages are as follows: acquisition, fluency, generalization, and adaptation (Haring & Eaton, 1978).

The first stage of the Instructional Hierarchy model is the acquisition stage. This stage consists of the student being introduced to a new skill set. An example of a student in the acquisition stage of reading would be one that is developing phonemic awareness and understanding of the alphabetic principle. A student in the acquisition stage may be able to identify words but his or her reading is likely to be slow and effortful. Once the student is able to respond accurately then fluency becomes the objective. Fluency refers
to speed and accuracy of response. Within the fluency stage, a student progresses from word by word reading to being able to respond accurately and quickly without having to decode individual words. Reading fluency, like many skills, shows incremental improvements through practice (Samuels, 1979). Once a student has obtained a fluent skill level, then generalization becomes the focus of instruction. Generalization refers to the ability to use a new skill set in different contexts. In the generalization stage, a student should be able to read and understand a variety of reading materials. Adaptation is the final stage of the Instructional Hierarchy model. In this stage, acquired skills can be used in new ways or with new problems (i.e., mathematics word problems).

**Chall’s stages of reading.** The Instructional Hierarchy model describes a sequential series of four stages that an individual progresses through as they acquire new skills. Chall (1996) also presented a model specific to reading development that involves six qualitatively different stages. This model is important to review as it provides a theoretical framework for many of the interventions used to address reading fluency.

The initial stage in the reading process described by Chall is known as ‘prereading’ or ‘pseudo reading’. In this stage, a student learns about concepts of print and develops phonemic awareness. The next stage of reading according to Chall is one of ‘conventional literacy’ or ‘decoding’. This stage marks the initiation of formal reading instruction and focuses on a student acquiring decoding skills by learning sound-symbol correspondences. In addition, students receive basic sight word identification. The third stage, known as ‘confirmation and fluency’ or ‘ungluing from print’, entails students learning to develop appropriate prosody and automaticity with print. Chall suggested this stage is for “confirming what is already known to the reader” (Chall, 1996, p. 18). Like
the fluency stage of the Instructional Hierarchy model, this stage is critical in allowing readers to learn from what they have read. This is an important stage, because as students progress through school, the focus of instruction typically changes from ‘learning to read’ to ‘reading to learn’ (Harlaar, Dale, & Polmin, 2007). Chall termed the next stage ‘reading for learning the new’, as reading instruction now shifts to understanding content. The final two stages include ‘multiple viewpoints’, a stage in which students learn to develop the ability to grasp a variety of viewpoints and critically appraise text, and ‘construction and reconstruction’ which involves synthesizing various viewpoints and developing one’s own perspective.

**Ehri’s phases of reading fluency.** Chall’s model (1996) emphasized fluency as a critical stage in the development of reading. Fluency, like many skills, is not a skill that is acquired instantaneously but develops gradually through repeated practice. Students progress through separate fluency phases according to Ehri (1995). These phases are known as the prealphabetic, partial alphabetic, full alphabetic, and consolidated alphabetic phases and are described below. The prealphabetic phase corresponds to the acquisition stage of the Instructional Hierarchy model as well as Chall’s decoding stage. In this phase, individuals are able to recognize sight words based on visual attributes. After this phase, students progress to the partial alphabetic recognition phase. This phase entails students remembering sight words based on their ability to identify some of the letters of the word as well as the letter sounds. Next, individuals can proceed to the next phase of reading fluency, which involves the complete alphabetic coding of words. In this phase, readers develop the ability to recognize similar spelling patterns in different words (e.g. shark and park), and can apply their knowledge of how graphemes
correspond to phonemes. Words that are encountered repeatedly can eventually be identified automatically. The last phase of Ehri’s model, known as the consolidated alphabetic phase, involves readers being able to recognize visual letter patterns as whole units. Otherwise known as orthographic knowledge, this skill makes it easier to identify and learn new words. It is in this final phase of fluency that individuals establish a level of automatic word recognition that allows for fluent reading of text.

In summary, the Instructional Hierarchy model, Chall’s stages of reading, and Ehri’s phases of reading fluency all provide a framework for understanding how reading, and in particular reading fluency, develops. Chall’s stages of reading delineates how the reading process develops, while Ehri’s phases of reading fluency focuses on the progression of the specific skill of reading fluency. In contrast, the Instructional Hierarchy model is a general model of how skills develop that can be applied to reading. The next section of this chapter will focus on empirically based reading fluency interventions.

**Reading Fluency as an Instructional Target**

As stated previously, reading fluency has been strongly linked to the ability to comprehend text, which many argue is the ultimate goal of the reading process. Unfortunately, the importance of promoting reading fluency as an academic goal has been frequently overlooked by educators. Of all the reading skills, reading fluency is considered the most neglected (Allington, 1983). Results from a large scale reading assessment conducted by the National Assessment for Educational Progress (NAEP) in 1995 supported this notion, as it was determined that approximately 44% of fourth grade students in the United States scored low on measures of fluency when reading grade level
text (National Center for Educational Statistics, 2003). More recent assessments indicate that 36% of fourth graders read below the basic level, according to the National Assessment of Educational Progress (U.S. Department of Education, 2006).

These findings are troublesome, because as students matriculate through school, they are expected to read more complex material in shorter periods of time and perform at increasingly higher reading levels. By the time students reach the upper levels of elementary school, teachers are no longer focusing on learning to read, but in reading to learn (Espin & Tindal, 1998). However, without well-developed reading fluency, comprehension of complex textual material is often difficult. Consequently, given that reading fluency is critical to future success as a reader, it is important that educators have effective instructional strategies that target reading fluency. There are several factors to consider when determining whether to target reading fluency and what intervention to select. These factors will be discussed in the subsequent paragraphs.

**Foundational skills required by student.** An understanding of the stages of reading, as well as the process through which reading fluency develops, are important starting points in helping determine appropriate instructional approaches for this critical skill area. In fact, researchers have suggested that reading interventions will be more effective if they contain components within the stages of the Instructional Hierarchy model (Daly & Martens, 1994). Based on the Instructional Hierarchy model as well as Chall’s model, one would expect that interventions to address fluency should begin once a student has acquired some rudimentary decoding and sight word identification skills. This assumption has been supported through research (Hollingsworth, 1970). Kuhn and
Stahl (2000) have suggested “Fluency instruction seems to work best with children between a late preprimer level and late second-grade level” (p. 27).

**Focus of intervention.** Another important point to consider when selecting fluency interventions is whether to focus on letter, sounds, single words, or words in context. Studies using methods to increase fluency in identifying letters, sounds and words have been found to be inconclusive, causing many to suggest that reading of connected text is more beneficial to the overall reading progress than is isolated word training (Fuchs et al., 2001). The National Reading Panel also noted “Competent reading requires that skills extend beyond the single-word level to contextual reading, and this skill can be best acquired by practicing reading in which words are in a meaningful context” (National Reading Panel, 2000, p. 11).

**National Reading Panel report on reading fluency.** As stated previously, reading fluency interventions appear to be most effective for students who have acquired at least basic decoding and sight word identification skills and when students are required to read connected text. There are a number of specific instructional strategies that have been identified which have been found to be effective for educators to choose from to improve reading fluency. In order to provide recommendations regarding the most effective instructional practices, the National Reading Panel reviewed the research literature pertaining to the two major approaches used by educators to improve reading fluency: guided oral reading and sustained silent reading.

Guided oral reading involves having a student read aloud with guidance and feedback provided to the student. Programs that are included under the category of
guided oral reading include neurological impress, repeated reading, shared reading, and paired reading. When sustained silent reading is used, a period of time (e.g., 30 minutes) is typically set aside daily during which students are required to read material silently and independently. Programs within the sustained silent reading category include those that are designed to increase the amounts of independent reading engaged by a student.

After completing a thorough review of the literature and a meta-analysis on the selected studies, the National Reading Panel (2000) found minimal support for the continued use of sustained silent reading practices within the school setting. It is important to note that few studies that evaluated programs met the National Reading Panel selection criteria, and those that did meet their standards generally assessed overall reading instead of focusing specifically on reading fluency.

Although the National Reading Panel (2000) did not find support for the continued use of sustained silent reading, it did find support for the use of guided oral reading as an intervention for reading fluency. Guided oral reading procedures produced a moderate effect on reading achievement, with an overall mean weighted effect size of .41. Other results included average effect sizes of .55 (reading accuracy), .44 (reading fluency), and .35 (reading comprehension). In addition to analyzing the statistical results from group-based studies, 12 additional single subject research design studies were also analyzed. The National Reading Panel concluded that the studies revealed substantial improvements in reading accuracy, speed, or comprehension. Further, the National Reading Panel reported “An extensive review of the literature indicates that classroom practices that encourage repeated oral reading with feedback and guidance leads to meaningful improvements in reading expertise for students” (National Reading Panel,
In fact, the studies reviewed by the National Reading Panel that emphasized repetition of reading material and feedback found improvement regardless of a student’s age or reading level, although younger students typically made greater gains than older students. Due to small sample sizes, the National Reading Panel could not perform analyses to compare different treatments that fell under the guided oral reading category.

**Reading fluency interventions.** There have been a number of instructional strategies that have been developed to improve oral reading fluency based on the assumption that students will be able to read faster, more accurately, and with better prosody under supportive conditions. The data from the National Reading Panel analysis offer support for the use of guided oral reading as an effective method for improving reading fluency. One of the most heavily researched guided oral reading methods for improving reading fluency is repeated reading.

**Repeated reading.** Repeated Reading (RR) has been described as the most widely used method for improving reading fluency (Kuhn & Stahl, 2000). It is a drill-based procedure that utilizes practice as a method of instruction and is based on the assumption that repetition of material will increase automaticity, which translates into increases in reading fluency. There have been numerous empirical studies investigating and finding support for RR (e.g., Dowhower, 1987; Koskinen & Blum, 1986; Rashotte & Torgeson, 1985; Swain & Allinder, 1996), and it has been found to be an effective intervention for improving reading fluency and decreasing the number of word errors across several different populations of students (National Reading Panel, 2000; Rashotte & Torgeson, 1985). RR has been found to be effective for students with learning
disabilities (Dahl, 1979), students with intellectual disabilities (Samuels, 1979),
transitional and less skilled readers (Downhower, 1987), and nondisabled students
(O’Shea, Sindelar, & O’Shea, 1985).

RR was first described by Dahl (1974), but Samuels (1979) has been credited with
emphasizing the importance of repeatedly reading text. Samuels developed the method
of RR in 1979 in order to improve reading fluency by applying the automaticity model
(Mathes, Simmons, & Davis, 1992). Samuels (1979) described the basic process as
“rereading a short, meaningful passage several times until a satisfactory level of fluency
is reached” (p. 404). Further, he suggested the importance of emphasizing speed over
accuracy: “if 100% word recognition accuracy is required before a student can move to a
new passage, the student becomes fearful of making a mistake, and consequently the pace
of reading slows down” (Samuels, 1979, p. 377).

In 1979, Samuels conducted a study to investigate the RR strategy. In this study,
students read a short passage to a teacher’s assistant who recorded the speed and accuracy
of the reading. Students read the story four consecutive times. Once the fourth reading
was completed, the number of words read correctly during one minute was determined.
Study results demonstrated that participants improved their rate and accuracy of reading
after repeatedly reading the same material.

Rashotte and Torgesen (1985) also investigated the use of RR with students
identified with learning disabilities. Specifically, the authors looked at the amount of
word overlap and similarity in context between reading passages and investigated
whether this affected reading accuracy and rate as well as comprehension of text. The
authors were also interested in finding out if the use of non-repetitive reading was as
effective as RR for improving reading fluency. There were three different study conditions. In the first condition, participants were instructed to read one of seven stories that did not contain a high amount of overlapping words four times. In the second condition, participants were instructed to read one of seven stories that were highly related a total of four times. In the third condition, participants read four different stories one time.

Rashotte and Torgeson (1985) found that students who read stories repeatedly that had similar words and meaning demonstrated a higher rate of speed and accuracy than when stories were different. Further, there was a difference between the RR conditions, with the condition with the most overlapping words found to be the most effective. Individuals in the RR condition with fewer overlapping words had comparable fluency gains to those individuals in the nonrepetitive reading condition.

RR has been further developed and refined over the past three decades since the Samuels (1979) and Rashotte and Torgeson (1985) studies. Despite the different variations, RR interventions all have the same basic structure. To begin with, these approaches typically entail having a student read a short passage (e.g., approximately 100-150 words). All versions also include reading and re-reading passages of connected text until a specified level of proficiency is obtained, the passage has been read a certain number of times, or the student has spent a specific amount of time reading (Mathes et al., 1992).

The typical approach for determining the specified level of proficiency prior to beginning a RR intervention is to first determine a student’s instructional reading level. Reading goals are then set by referencing grade appropriate increases in words read.
correctly per minute, otherwise known as rates of improvement (ROI). Researchers have suggested that the most successful approaches to improving reading fluency involve having children read text that is at their instructional level or, if provided with sufficient support, at their frustrational level (Kuhn & Stahl, 2000). When the method involves having the student read a passage a predetermined number of times, the number of times a passage is to be read is generally set across all the passages in the intervention. Four re-readings of a passage has been recommended by Rashotte and Torgesen (1985). There is support for this recommendation, as O’Shea and colleagues (O’Shea et al., 1987) reported that 83% of the gains in reading fluency occur by the fourth reading of a passage.

In addition to the RR of a passage, the total number of words read accurately within the first 60 seconds is typically recorded. As students read a passage, an evaluator will note any errors such as reversals, repetitions, hesitations, substitutions, and omissions. The number of word errors is then subtracted from the total words read, with this measure known as the number of CWPM. Calculating CWPM using reading probes is an empirically supported method for tracking student progress (Deno, 1985).

In summary, LaBerge and Samuel’s Theory of Automaticity (1974) is the underlying theoretical basis for the RR technique. RR is a research validated method for improving reading fluency, and it is often used independently or as an adjunct with other techniques contained within packaged interventions. For example, previewing and performance feedback are techniques often associated with RR. Previewing as it relates to reading fluency will be discussed in more detail in the next section.
**Previewing.** Previewing is another strategy that has been utilized along with RR and error correction to improve reading fluency. It is an intervention that allows students to gain exposure to vocabulary, phrasing, and emphasis before reading the text themselves and has been found to be effective at increasing both word comprehension and word recognition skills.

Variations of previewing include allowing students to preview the material aloud, silently, or listening to another individual read the material aloud. Rose (1984) compared the effects of two different previewing procedures: silent previewing and previewing with listening. Six students who had been diagnosed with having a specific learning disability participated in the study and an alternating treatments single subject design was used. In the silent previewing condition, students read the passage silently and then read the passage aloud. In the listening previewing condition, students listened to a teacher model the correct reading of a passage and then the student read the passage aloud. Results revealed that silent previewing and listening previewing were more effective than no previewing for four of five students. Overall, the authors concluded that listening previewing was more effective than silent previewing.

Skinner and colleagues (1993) also investigated listening previewing techniques. A fast-rate intervention, a slow-rate intervention and silent previewing conditions were studied in order to determine their effects on the oral reading rates of junior high students who had been determined to have learning disabilities. In the silent previewing condition, students read passages silently while being timed by an experimenter. The student was then asked to read the same passage orally and was once again timed by the experimenter. In the slow-rate listening previewing condition, the experimenter read a
passage to the student at a rate ‘slightly faster’ than the student’s rate. The student then read the same passage while being timed. For the fast-rate listening previewing condition, the experimenter read the passage to the student at a rate “much faster” than the student’s rate. The student then read the same passage while being timed. A within-subjects repeated measure design was used to evaluate data. All three interventions were found to improve oral reading rates.

Fascio-Vereen (2004) investigated the use of RR and listening previewing of social studies text with 10 middle school students reading at least two years below grade level in an alternating treatments design across subjects was used to evaluate the effectiveness of the two reading interventions. In this study, a student would read a passage three times for the RR condition. Each time an error was made during the first two readings, immediate corrective feedback was given. The student would then read the passage a third time with no corrective feedback given while the interventionist timed the student for one minute. This procedure was repeated for two additional passages at the same level in the packet. If the student met mastery level (i.e., 100 or more WCPM), the individual would move to the next higher level during the next intervention session. In the Listening Previewing condition, the student listened to a passage being read to them before reading it to the experimenter orally. Immediate corrective feedback was given, and this procedure was repeated two more times with additional passages at the same level. If the student reached the mastery level on all three passages, higher-level material was used at the next session. Results indicated that both RR and Listening Previewing improved oral reading rates of social studies text; however, the RR intervention produced greater improvements in oral reading rate.
Taken together, research suggests that various types of previewing activities have the potential to improve reading fluency, especially when they are combined with RR. Of the different forms of previewing techniques, listening previewing is perhaps the most effective form of this instructional technique as it provides an accurate and fluent model of reading for the referred student.

**Performance feedback and contingent reinforcement.** Hasbrouck, Ihnot, and Rodgers (1999) reviewed fluency research and found three types of interventions that were deemed particularly effective. These interventions include RR, hearing a demonstrated reading of a text (i.e., previewing) and reading along with a model and providing direct student feedback. Researchers have proposed that these interventions for improving reading fluency can be grouped into two distinct categories: skill based and performance based (Eckert, Ardoin, Daly, & Martens, 2002). The skill-based interventions include RR and previewing while performance based strategies includes performance feedback and programmed contingencies of reinforcement.

**Performance feedback.** According to Perkins (1988) performance feedback helps students focus on accuracy of responding, allows them to distinguish between correct and incorrect answers and also prompts them to self-correct mistakes. Perkins found that corrective feedback produced greater increases in accuracy than simply providing information to students regarding their performance. Corrective feedback, otherwise known as error correction, is a widely used procedure (Heubusch & Lloyd, 1998). In its most basic form, error correction is a technique in which one individual corrects another individual’s errors when the person fails to self-correct
Direct feedback to correct errors has been found to be important for any academic area, but especially for reading instruction (Heubusch & Loyd, 1998; Welsch, 2006).

There are a number of error correction procedures that have been used successfully to address reading deficits. These procedures typically vary based on the form or type of error correction, the type of errors that receive feedback and the time that the error correction is provided. Jenkins and Larson (1979) investigated the effects of five different error correction techniques to include word supply (immediately providing the correct word), sentence repeat (providing the correct word and then having the student reread the entire sentence), end of page preview (supplying the correct word and then reviewing errors at the end of the page), word meaning (providing the correct word as well as the meaning if the student is unfamiliar with the word), and drill (providing the correct word and then drilling the missed words at the end of the reading) on the word recognition skills of five middle school boys who had been designated as having a specific learning disability. A single subject design was used to evaluate the effectiveness of the different error correction techniques. Results revealed that drill produced the most improvement on measures of word recognition.

Nelson, Albert, and Grody (2004) evaluated an error correction procedure to examine its effectiveness at increasing CWPM. Four second-grade students diagnosed with a learning disability participated in this study. Students were exposed to several treatment phases: baseline, a systematic error correction procedure, error correction paired with RR, and the use of previously practiced text with the combination of error correction and RR. Results revealed an overall increase in CWPM when comparing
baseline to all other conditions. This investigation provided further support for the use of systematic error correction procedures.

_Contingent reinforcement._ Although error correction is one method of providing feedback regarding a student’s performance, there are other means of providing information regarding progress. For individuals with motivational deficits, contingent reinforcement may be particularly important. Research has found that some reading problems may occur as a result of a performance deficit rather than from skill deficit (Lentz, 1988). Consequently, the provision of reinforcement contingent upon meeting a specified criterion may enhance the efficacy of skills based interventions.

Daly, Martens, Hamler, Dool, and Eckert (1999) examined the effects of various interventions. These interventions included contingent reinforcement on participants’ oral reading fluency for both instructional text and high content-overlapping text. After a baseline phase, interventions were implemented in the following sequence: contingent reinforcement, RR, passage preview plus RR, and passage preview plus RR on easier material. Brief experimental analysis methodology was used to evaluate the different conditions. After the introduction of a treatment resulted in noticeable reading fluency gains, the treatment was briefly withdrawn in order to confirm the effects. Results demonstrated that RR alone was most effective in increasing oral reading fluency on instructional passages for two participants. Passage preview with RR on instructional level and passage preview with RR on easier material was most effective for the other two participants. Contingent reinforcement as a single treatment was not found to increase reading fluency, suggesting that contingent reinforcement may need to be combined with another intervention in order to improve oral reading fluency.
Eckert and colleagues (2002) also conducted a study using brief experimental analysis to investigate the effectiveness of combining contingent reinforcement or performance feedback with listening passage preview and RR on the oral reading fluency of six elementary students. Listening passage preview and RR were found to increase the number of CWPM for all six students. Although four of the students responded positively to pairing listening passage preview and RR with either contingent reinforcement or performance feedback, two were found to have undifferentiated results. Further, individual participants responded differently to the consequences and no participants evidenced greater reading fluency gains when the two consequences were combined. The authors concluded that although combining interventions with contingent reinforcement or performance feedback may improve oral reading fluency rates, individual responsiveness must be taken into consideration and brief experimental analysis may be needed in order to determine the most effective intervention components.

Another study was conducted by Eckert and colleagues (2006) with 6 second-grade students who struggled with reading fluency. Two conditions were used: performance feedback on words read correctly and performance feedback on words read incorrectly. Students were given graphs that displayed the number of words read correctly or incorrectly based on the condition the student was participating in at the time. After conducting twice weekly sessions for 20 minutes over the course of 10 weeks, results showed that all students benefitted from performance feedback. Five of the six participants evidenced greater gains when they were given feedback on the number of incorrect words as opposed to correct words.
In summary, corrective feedback and contingent reinforcement are two methods of providing information regarding progress which have research support for improving reading skills. The studies examining the effects of combining these interventions with other reading fluency strategies such as RR have produced mixed results. Research has suggested that there is not a single approach to intervention selection for individuals requiring remediation of reading skills deficits and that individual variables, such as current skill level and motivational variables, are important to consider when selecting instructional strategies.

**Combined intervention packages.** Combining interventions such as RR, error correction, and previewing as well as contingent reinforcement and performance feedback has been shown to produce some of the greatest reading fluency gains (Eckert, Ardoin, Daisey & Scarola, 2000; Eckert et al., 2002). Many studies have demonstrated that combining reading interventions into a single intervention package can enhance results (Alber-Morgan, Ramp, Anderson, & Martin, 2007; Martens et al., 2007). Multi-component interventions to address reading fluency typically consist of several common components (Skinner, Turco, Beatty, & Rasavage, 1989). These components include: previewing, immediate corrective feedback, RR, instructional level materials, performance feedback and mastery based progression.

One intervention package for reading fluency that incorporates core features of RTI including the provision of research-based interventions and continuous progress monitoring is Reading to Read (RTR; Edwards, Tingstrom, & Cottingham, 1993). In addition to RR, RTR also includes the use of Curriculum-Based Assessment (CBA) to establish instructional levels prior to initiation of the intervention, immediate corrective
feedback of reading errors, performance feedback after completion of each passage through student self-charting, the requirement of mastery before progressing to more difficult levels, and positive verbal reinforcement. According to the intervention developers, the main objective of the RTR intervention is to improve the reading performance of students until their performance is essentially equivalent to that of their grade-level peers. RTR has consistently demonstrated its usefulness in improving oral reading fluency and literal comprehension skills as well as generalizing skills to new reading materials (e.g., Bolton, 1992; Boyer, 1991; Friedberg, 1994).

RTR (Edwards et al., 1993) has been the focus of numerous studies directed at determining its usefulness and the value of its separate components (Tingstrom, Edwards, & Olmi, 1995). Specifically, Boyer (1991) used a multiple baseline design to determine the effects of the RTR intervention with four low achieving second-grade students. Baseline levels of CWPM and errors were determined by having students read five stories from the level at which the middle reading group in their class was receiving instruction. Two of the students in the study received RTR following baseline and two students received one or two placebo conditions prior to receiving RTR. The placebo treatments involved repeated readings of passages with and without corrective feedback. Results showed significant improvements for all students in regards to overall reading fluency. No significant improvements were found when looking at performance when students read passages in the placebo conditions. RTR also produced greater gains in instructional level compared to the placebo conditions.

Besides improving oral reading fluency, the RTR intervention has also been found to be effective in producing gains in reading comprehension and the generalization of
reading gains to new material. For example, Boyer (1993) compared student performance using RTR and a standard RR procedure with corrective feedback. Participants included 4 first-grade and 4 second-grade students identified by their teacher as having reading difficulties. A modified multiple baseline design was used, with students randomly assigned to begin treatment using the RR procedure. Participants were then introduced to the RTR intervention after receiving a varied number of treatments under the RR procedure. Results revealed that students demonstrated progress under both experimental conditions, but had greater gains in reading fluency, passage mastery rates, and literal comprehension skills with the RTR intervention. Reading gains also generalized better to other passages under the RTR condition.

Besides RTR, investigators have evaluated other multi-component reading interventions. Eckert and colleagues (2002) found that combining interventions into a reading treatment program produced the greatest gains in reading fluency for three out of four participants in their study. Chafouleas, Martens, Dobson, Weisntein, and Gardner (2004) reported that the combined effects of an intervention package that included performance feedback, a contingent reward, and RR produced the greatest gains in fluency for one out of three participants. Martens and colleagues (2007) used a treatment package with a group of second and third grade students that included a multi-component fluency building activity consisting of a phrase drill correction procedure, listening passage preview, and RR of material. Results revealed that treatment group participants made more significant gains on untrained generalization passages as well as standardized reading assessments than did the control group of students. The results of these studies suggest that at least for some students, combining interventions into a single treatment
package may be more effective at improving oral reading fluency than single component interventions.

**Generalization of Reading Fluency Gains**

The reading stage following fluency in the Instructional Hierarchy is generalization (Haring & Eaton, 1978). Generalization occurs as a function of transferring fluency skills from passages that were used during intervention to untrained passages. An important consideration when selecting an intervention to address reading fluency is how well intervention gains will translate to unpracticed reading material. According to Daly, Lentz, and Boyer (1996) fluency training should occur within the context of using readings of connected text in order to promote greater generalization. Further, the reader should also be provided with frequent opportunities to promote generalization of fluency gains.

Generalization was previously not a common outcome measure in reading fluency research, but more current studies often include checks for generalization. Daly, Bonfiglio, Mattson, Persampieri, and Foreman-Yates (2005) conducted an investigation with three individuals identified as having a specific learning disability. High content overlap passages were used in this study. The difficulty level of the material was varied from easy to hard, tangible rewards were used for meeting a criterion of CWPM on high content overlap passages, and whether or not the participant received instruction was varied. Two participants demonstrated higher increases in CWPM when instruction was provided with easier passages while one student evidenced greater gains when instruction was provided with harder passages. Generalization of skills was found for all four participants but only after instruction on the high content overlap passages. The results of
this study suggested that common words may need to be incorporated across passages in order to achieve better generalization results with oral reading fluency skills.

Generalization was also an outcome measure studied with 42 second grade students by Ardoin and colleagues (2008). RR, listening passage preview, and error correction were treatment components that were studied. Generalization was assessed immediately after each intervention session, with researchers using passages with both high and medium word overlap. Oral reading fluency increased significantly for students in the RR condition. When looking at generalization, more gains were evidenced with passages using medium word overlap than with the high overlap passages. The authors suggested this finding may be due to the medium overlap passages allowing students to learn more new words than did the high overlap passages.

Martens and colleagues (2007) studied second and third grade students using a multi-component reading intervention. Individuals in the treatment group were given a pre-training assessment passage and asked to state their fluency goal for reading the passage. If the goal was reached, they could earn a ticket towards a prize. Students read the passage, and if they reached the goal, they were able to earn a ticket. For those individuals who failed to reach the goal, the passage was then used for training. Several components were used during training activities in order to build fluency. The components included error correction, listening passage preview, and RR. Participants also had to meet a predetermined criterion for the retention check before they could proceed to the next level. Generalization checks were also completed with reading probes administered prior to reading and after reading the untrained passages. Treatment group participants were found to make more significant gains on standardized reading
assessments as well as the untrained generalization passages than did the control group of students.

**Summary.** In summary, fluency is one of the essential components of successful reading. Although reading fluency has frequently been an overlooked component of reading by educators, research indicates that direct efforts to improve this critical reading skill is advantageous to students. Interventions to target fluency can begin early in a student’s academic career, once individuals have acquired basic decoding and sight word identification skills. RR has strong empirical support, and when combined with other strategies such as previewing and corrective feedback, it can become an even more powerful intervention agent. Generalization of skills to untrained text is another important consideration when targeting reading fluency as researchers have suggested that generalization may not automatically occur as a result of intervention.

Although the fluency interventions discussed in this chapter have been found to be effective, they are typically delivered individually and therefore can take up considerable staff time. Further, many of the researched procedures and intervention packages delineate specific steps to be implemented in a particular order. It is possible that these procedures may not produce the same robust outcomes if not implemented with a high degree of fidelity within the classroom setting. One possible solution to staffing and treatment integrity issues is the use of technology as a supplementary instructional tool. CAI will be discussed in greater detail in the next section of this chapter as a potential alternative for addressing the reading skills deficits of referred students.
Computer Assisted Instruction

Computers and other forms of technology have been used to support reading instruction for several decades (Chomsky, 1976; Mastropieri, Leinart, & Scruggs, 1999). There are several key features of CAI that makes it attractive as an instructional tool. To begin with, CAI enables the ability to provide individualized, differentiated instruction to students. CAI can also decrease the need for extensive teacher monitoring and can save instructional and preparation time for teachers (Lee & Vail, 2005). Further, CAI can be engaging to students, allows for frequent opportunities to respond, can involve immediate student feedback (Lonigan et al., 2003), and can provide high rates of success and reinforcement (Macaruso et al., 2006). Students may also be able to work in an instructional environment that is not intimidating or embarrassing (Diem & Katimes, 2002).

National Reading Panel report on technology and reading

The National Reading Panel (2000) reviewed a total of 21 studies that directly investigated the effects of using computer technology for literature instruction. None of these programs looked directly at the effect of CAI on reading fluency, but instead addressed such topics as vocabulary instruction, word recognition, comprehension, spelling, and learning to read. The National Reading Panel was unable to complete a meta-analysis due to the small number of studies identified that met their selection criteria. The panel concluded that, although it was difficult to make recommendations based on the available data, it was evident that computer technology could be used for reading instruction. The National Reading Panel noted that this area needed “a great deal of additional exploration” (National Reading Panel, 2000, p. 6-2).
CAI for Reading Fluency

Computers have been used as intervention agents for reading difficulties since as early as the 1960s (Fletcher & Atkinson, 1972). As the use of technology in educating students continued to grow, researchers and developers began to customize software programs to address specific areas of reading such as phonemic awareness, decoding skills, reading fluency, and reading comprehension. CAI that is designed to address reading fluency will be discussed in the following section.

Project LISTEN. One important program in the development of CAI designed to target reading fluency is Project LISTEN (Literacy Innovation that Speech Technology ENables). This program was initially implemented at Carnegie Mellon University in the 1990s. Project LISTEN is unique in that it utilizes speech recognition technology, specifically the Carnegie Mellon Sphinx-II continuous speech recognition system, and was designed in an effort to model expert teachers’ professional skills (Mostow & Aist, 2001).

The software developed under Project LISTEN has been modified and adapted over the past 15 years in order to improve its usability and effectiveness. Originally known as the ‘Reading Coach’, the software was redesigned to operate on personal computers. With the Reading Tutor, the current version of the software, students are presented with text and are required to read aloud using a headset microphone. The Reading Tutor analyzes the student’s oral reading, tracks their place within a story, and provides feedback in response to difficulties encountered when reading (Mostow & Aist, 2001). Although there are numerous studies that form the research basis for the Reading Tutor, only a few will be reviewed in the next section.
In 1998, 72 second-, fourth-, and fifth-graders participated in an investigation that compared the Reading Tutor to regular classroom reading instruction as well as commercial reading software during a four-month period. All participants were pre-tested using the Word Attack, Word Identification, and Passage Comprehension subtests from the Woodcock Reading Mastery Tests (Woodcock, 1998) and then were randomly assigned to treatments. After four months, participants who used the Reading Tutor were found to significantly outgain matched classmates who did not use the Reading Tutor on the Passage Comprehension subtest of the Woodcock Reading Mastery Test.

Another study was conducted using the Reading Tutor software program with a total of 178 students in grades 1 through 4 at two different schools (Mostow et al., 2002). Students were randomly divided into two groups, with one group using Reading Tutor while the other group participated in sustained silent reading. Subtests from the Woodcock Reading Mastery Tests as well as the Comprehensive Test of Phonological Processing (CTOPP; Wagner, Torgesen, & Rashotte, 1999) were administered to participants before and after the interventions were implemented. Results indicated that the Reading Tutor group performed better on almost every assessment when compared to the sustained silent reading group. Of note, differences between students who used the Reading Tutor and those that engaged in sustained silent reading varied according to grade levels, with more substantial effects found with first and second grade students. The study’s authors suggested that the Reading Tutor program may be most effective when used at the early grades and for those students who scored lowest on pre-test measures of reading.
Project LISTEN’s Reading Tutor was again investigated in 2003 (Mostow et al., 2003) during a year long study of 131 second- and third-graders. Fifty-eight students used Reading Tutor for three 20-minute periods daily while other students served as in-class controls and received regular reading instruction. An additional 34 students received individual tutoring with certified teachers. The human tutors used the same set of stories used by the Reading Tutor. Woodcock Reading Mastery subtests and curriculum based measures of oral reading fluency were used to determine pre- and post- levels of performance. Results indicated that the human tutored group showed significantly more growth on only one subtest (Word Attack, a subtest that measures the ability to decode nonsense words) of the Woodcock Reading Mastery Test when compared to the group that received the Reading Tutor intervention. Individuals in the computer and human tutoring conditions outperformed the control group on the Word Comprehension and Passage Comprehension subtests. No significant differences were found between the groups receiving human and computer tutoring and the control groups on the Word Identification subtest of the Woodcock Reading Master test or on measures of oral reading fluency. The findings of this study indicated that individuals in the human tutored group demonstrated greater gains in decoding than did the group that received the Reading Tutor intervention. Further, although individuals in the human and computer tutored groups outperformed the control group on measures of reading comprehension, no significant differences were indicated on measures of word identification or reading fluency.

The previously reviewed studies were conducted by researchers who had developed the Reading Tutor software. Poulson, Hastings, and Allbritton (2007)
conducted an independent evaluation of the Project LISTEN’s Reading Tutor. The one-month study compared the Reading Tutor software program to sustained silent reading. A total of 34 Hispanic students, who were English Language Learners, participated in the study. A crossover model, which entails treatments being reversed between groups was implemented. Students were randomly assigned to two groups. During the first month of the study, one group engaged in the Reading Tutor intervention while the other group of students was assigned to sustained silent reading, which served as the control condition. A reversal of group treatments occurred during the second month of the study.

Curriculum-based measures of oral reading fluency and comprehension adapted from the curriculum as well as measures of sight word identification were taken pre- and post-intervention for both groups of students as well as once during the crossover phase. The reading passages used were one year below participant’s grade level. Individuals who received the Reading Tutor program outperformed the control group with effect sizes considered ‘large’ for gains in CWPM and ‘medium' for gains on sight word identification. Measures of comprehension did not differ significantly between treatments.

Results from studies utilizing Project LISTEN’s Reading Tutor are encouraging, although results have been mixed an reading fluency has not been a consistent outcome measure. The research reviewed is significant for several reasons. To begin with, few other studies have directly examined the impacts of using CAI for reading instruction and those that have typically have not looked at the effects over prolonged periods of time. These studies have also compared the use of CAI to human tutors and SSR, common methods used within the classroom setting to target reading skills. Further, Project LISTEN incorporates
guided oral reading, a research supported practice for improving reading fluency, and does so with the use of speech recognition technology that allows the computer to respond with assistance that was modeled after expert reading teachers. It is important to note that despite its potential use as a supplementary instructional tool, Reading Tutor is still in product development and is not sold commercially. Two commercially available software programs that are similar to Reading Tutor in that they use speech recognition technology to enable guided oral reading will be discussed later in this chapter.

**Additional research on CAI and reading fluency.** Besides research on Project LISTEN’s Reading Tutor, there are limited studies of CAI that have included oral reading fluency as a target for instruction. In one study, Lewandowski, Begeny, and Rogers (2006) explored whether human tutoring or computer assisted word recognition was more effective at improving word identification and oral reading fluency in a sample of students. The entire third grade in an elementary school, consisting of a total of 66 students, participated in this study. Students were randomly assigned to one of three conditions (e.g., computer based, human tutor, control). Training sessions consisted of two practice exposures to a word list comprised of 100 of the most challenging words from the reading passages, followed by a timed oral reading of the list. Within the computer-based condition, students were asked to focus on a textbox on the computer screen, see and hear the word, and then say each word silently. In the condition involving a human tutor, students worked with an individual who read each word on the training word list aloud. Students saw and heard each word, and then said the word silently. In the control condition, an experimenter scrolled down the word list as the students practiced reading each word. Each training session consisted of two trials of practice with the word
list, followed by an oral reading of the word list that was scored for time and accuracy. Training occurred over a 3-week period with three training sessions lasting approximately 10 minutes per student.

Results of the study indicated that practice alone did not significantly improve word reading. The use of a human tutor and the use of the computer were found to improve student’s reading accuracy on the trained word list but results between the two treatments were not significantly different from one another. No improvements were found on the generalization list. When evaluated using the same 10 passages read prior to the treatment phase, the tutor and computer groups were found to significantly outperform the control group on CWPM, but did not differ from one another. In general, the results were similar for students in the human tutor and computer groups. According to the authors of this study, the corrective feedback provided during the human tutor and computer conditions likely accounts for the reading fluency gains. In the control condition, students were not given corrective feedback.

In summary, the Lewandowski et al., (2006) study provided additional evidence of the importance of providing error correction in order to improve reading fluency. However, reading gains did not generalize to untrained word lists and oral reading fluency was not measured post intervention using reading probes unfamiliar to participants. Consequently, generalization of reading skills to untrained reading passages was not measured. Further, although computer tutoring was found to be similar in effectiveness to human tutoring, it required just as much attention from an adult intervention agent. This method of CAI to target reading fluency may beneficial in terms of cost, but lacks practical significance within the school setting. Research on
commercially available computer programs that target reading fluency that are designed to be independently manipulated by students will be the focus of the next section.

**Commercially Available Computer Programs**

Schools that are embracing the RTI methodology may find packaged, scripted interventions attractive as they attempt to implement research-based instructional strategies. Commercially available computer software programs may be especially enticing due to the added benefits of being able to provide an intervention with little staff supervision needed and the built in ability to track student progress. A brief search on the internet reveals a number of computer-based, commercially available programs currently marketed to schools as research based interventions for reading fluency for students involved in a tier of RTI. Unfortunately, a number of these programs do not incorporate empirically proven strategies and lack research support. Read Naturally and Reading Assistant™ are two programs that do incorporate research-based strategies and have been empirically investigated. These programs will be discussed in the next section.

**Read Naturally.** Another program that is available that incorporates research based strategies for improving reading fluency is Reading Assistant™, which is the focus of the present study. A similar computer program is called Read Naturally (Hasbrouck et al., 1999). Reading Assistant™ and Read Naturally share some of the same features as Project LISTEN’s Reading Tutor in that both utilize speech recognition technology and are customizable based on the student’s reading level.

Read Naturally was originally developed by Candyce Ihnot, a Title 1 teacher in Minnesota, and is available in two versions. One version uses CDs along with hard-copy
reading materials while the other version is entirely computer based. The Read Naturally software program allows students to systematically progress through reading material at their independent pace and is designed to build vocabulary, comprehension, and oral reading fluency. This program also incorporates guided oral reading with immediate error correction as well as repeated readings of text.

The few studies published in peer-reviewed journals that have investigated the effectiveness of Read Naturally have utilized the print based edition. Several doctoral dissertations were located which report findings on investigations of the software version of the program. These studies will be briefly reviewed below.

Gibson (2009) studied the effects of the Read Naturally computer software program on the oral reading fluency and comprehension of eight first grade students who were considered ‘at-risk’ or ‘some-risk’ based on DIBELS oral reading fluency benchmark assessments. Students were engaged with the computer program for approximately 30 minutes three to four times per week for 14 to 16 weeks. Outcome measures for this study were oral reading fluency, as measured by CWPM, word retell (the student tells about he or she just read), and percentage of comprehension questions answered correctly on treatment and generalization probes. Results indicated that oral reading fluency as well as comprehension on treatment probes improved over baseline levels for students in the treatment condition. Another treatment phase was implemented with an increase in oral reading fluency requirements. During the second phase, five out of eight participants were able to decrease their DIBELS risk status.

Arvans (2011) also conducted a study of the computer-based version of Read Naturally as part of her doctoral dissertation. A total of 82 second through fourth grade
students who attended a public elementary school participated. Students were matched on DIBELS scores, grade, race, and gender and then randomly assigned to either a Read Naturally condition or to the control group. Students who were in the Read Naturally condition were engaged with the computer program for 30-45 minutes each day, 5 days per week for a total of 8 weeks. Students were assessed with DIBELS progress monitoring oral reading fluency probes weekly during the course of the study. Additional assessments to include the Word Attack, Letter Word Identification, and Passage Comprehension subtests from the Woodcock Johnson Tests of Achievement, Third Edition (Woodcock, McGrew, & Mather, 2001) were also administered pre-treatment and post-treatment. Results revealed significant improvements on all reading measures regardless of the condition to which the students were assigned, although small positive effect sizes were found for the Read Naturally program. The author concluded that Read Naturally may not be more efficacious than typical education practices for reading, but may be beneficial in terms of being individualized and targeting larger groups of students.

Keyes (2010) also evaluated the effects of the Read Naturally software program on the oral reading fluency and comprehension of at-risk second grade students. Six second-grade students who were at risk for reading failure participated in the study. Students in the intervention received the Read Naturally program four times a week for 20 to 45 minutes for a total of 7 to 12 weeks. A multiple baseline design with an embedded changing criterion design was used in this study. Due to the changing criterion aspect of the design, the experimenter was able to determine effects of increasing the goal criterion of CWPM on a student’s oral reading fluency. The first and second groups of
students had six criterion changes over the course of the study while students in the third group had five criterion changes. Dependent variables included CWPM and errors per minute on Read Naturally passages and two measures of generalization (e.g., AIMSweb and classroom curriculum passages), the number of words retold within one minute and the number of comprehension questions that were answered correctly. Pre-treatment and post-treatment data were also collected using the WJ-III Tests of Achievement Reading Fluency, Letter-Word Identification, Word Attack, and Passage Comprehension subtests.

Results from the study suggested that Read Naturally was effective at increasing oral reading fluency for each participant when given Read Naturally passages and AIMSweb passages. Five of six participants also increased their oral reading fluency when given the classroom curriculum passages. Half of the participants demonstrated improvement over baseline on the percentage of comprehension questions that were answered correctly. All participants increased the number of words that they were able to re-tell within one minute on all three types of passages. The author concluded that the results of this study support the use of CAI for reading with this referred population.

**Reading Assistant™.** The Reading Assistant™ software program utilizes Carnegie Mellon University’s Sphinx speech recognition technology, which was developed for use under Project LISTEN as described previously in this chapter. The development of Reading Assistant™ began in 2000 with the establishment of Soliloquy Learning, Inc. In 2008, Soliloquy was acquired by Scientific Learning Corporation and Reading Assistant™ became part of a suite of educational software products. Reading Assistant™ has been revised several times since its inception, and is currently a web-based application known as Reading Assistant™, Expanded Edition. Since it initially
became available, Scientific Learning estimates that more than 50,000 students have used Reading Assistant™ (Beattie, 2010). Although no articles regarding Reading Assistant™ were found in peer reviewed journals, two studies were found that have investigated the impact of the software program on reading skills. These studies will be reviewed in the next section. It is important to note that the Scientific Learning Corporation has also published research on their company website (http://www.scilearn.com) which has evaluated the effects of Reading Assistant™. This research has only been used in conjunction with Fast ForWord, which is another one of their computer-based products.

In 2006, Reading Assistant™ was evaluated in a quasi-experimental study by Adams, the chief scientist and cofounder of Soliloquy, the company which developed Reading Assistant™. A total of 410 second- to fifth-grade students from two schools participated in this study that lasted approximately 17 weeks. The control condition consisted of 182 students, while the treatment condition consisted of 228 students. Notably, students were not randomly assigned, with groups based on classroom placement. The second- and third-grade classrooms at one school participated in the Reading Assistant™ program while the fourth- and fifth-grade at another school participated in the program. Corresponding grades at the different schools served as controls. Although students reported to the computer lab at least twice a week for 30-minute sessions using Reading Assistant™, it was found that the actual time on task reading averaged about 8 minutes per session.

R-CBM passages were used as measures of oral reading fluency pre- and post-treatment. Based on a statistical analysis of results, reading fluency gains were found to be significantly greater (p < .001) for students who used the Reading Assistant™ software
than for control students. Effect sizes were larger for second- (.53) and third-grade (.49) than fourth-grade (.19), and fifth-grade (.26) students. The oral reading fluency growth in CWPM of students using Reading Assistant™ was also compared to normative reading fluency growth expectations. Fall-to-spring gains were adjusted by the total number of weeks students were in the treatment condition. Students who had participated in the Reading Assistant™ program were found to have significantly greater fluency gains than those who had not participated in the program. These results suggest that Reading Assistant™ was an effective intervention for improving the oral reading fluency of general education students, with the greatest gains evident for second and third graders.

In another study exploring interventions related to Read Naturally, Devine (2009) used a mixed methodology design in order to investigate the efficacy of two fluency intervention programs on the reading skills and attitudes toward reading of 90 students, comprising the entire second grade in one school, over an eight week period. Students were assessed prior to intervention implementation as well as following the interventions on their reading fluency, prosody when reading, reading comprehension, and attitudes toward reading. The Reading Fluency Progress Monitor, developed by Read Naturally (www.readnaturally.com), served as the measurement for obtaining data regarding oral reading fluency and reading comprehension skills. Fry’s high frequency words and phrases (Fry, 2004), The Multi-developmental Fluency Scale (Zutell & Rasinski, 1991), the Elementary Reading Attitude Survey (McKenna & Kear, 1990), and student interviews were also used for data collection. Finally, prosody was measured using a 6-point fluency rubric adapted by Rasinski (1985).
The Reading Assistant™ computer program and drills of high frequency words and phrases embedded in guided repeated oral reading were the fluency treatments that were utilized. A total of 45 students participated in the drills of high frequency words and phrases while a total of 45 students participated in the Reading Assistant™ intervention. These interventions took place within an RTI framework, for 20 minutes daily in addition to normal classroom reading instruction. Based on an informal analysis of results, the researcher concluded that neither drills of high frequency words and phrases or the Reading Assistant™ software program appeared to have a significant impact on growth in oral reading fluency or reading comprehension. The author did indicate that the interventions appeared to make a noticeable difference in student attitudes toward reading. Further, the author drew conclusions based on descriptive statistics of the data and did not complete additional statistical analyses. Without progress monitoring data or statistical analysis, it is difficult to accurately determine the impact of the Reading Assistant™ program on participant’s oral reading fluency or comprehension skills. Thus, additional research on this potentially effective intervention is necessary.

**CAI for Reading Summary**

CAI is attractive as an instructional tool due to its ability to provide individualized, engaging instruction for students with minimal staff monitoring needed. The aforementioned studies offered mixed findings in regards to the effectiveness of CAI for addressing reading fluency skills. Project LISTEN studies have generally indicated positive, but altogether mixed results regarding its effectiveness with different reading skills. Further, reading fluency has not been a common outcome measure for Project LISTEN research.
In regards to the few studies that have investigated the effects of the Read Naturally computer program, results have generally indicated positive effects for both reading fluency and reading comprehension. Reading Assistant™, the focus of this study, has been used by large numbers of students despite lacking solid research support to date. Adams (2006) found medium effect sizes for the Reading Assistant™ program on the fluency growth of second and third grade students and a small effect size for the fluency growth of fourth and fifth grade students. The findings of this study, however, should be interpreted cautiously. To begin with, the study was carried out by the lead research scientist and cofounder of Soliloquy, Dr. Adams. The Reading Assistant™ computer program was designed based on her research. Further, given that it was a quasi-experimental design and students were not randomly assigned to treatments, it is possible that some of the difference in reading fluency growth between control and treatment conditions may be due to other factors such as teacher characteristics and other potential participant or environmental variables.

Devine’s (2009) study did not find positive effects for the Reading Assistant™ program in terms of oral reading fluency growth or growth in comprehension skills. The results of this study should also be interpreted cautiously primarily due to data analysis procedures. Despite this investigation occurring in an RTI framework that necessitates regular progress monitoring, CBMs were only taken pre- and post-treatment. Further, the author drew conclusions based on descriptive statistics of the data and did not complete additional statistical analyses. Without progress monitoring data or statistical analysis, it is difficult to accurately determine the impact of the Reading Assistant™ program on participant’s oral reading fluency or comprehension skills.
Project LISTEN’s Reading Tutor, Scientific Learning’s Reading Assistant™, as well as the software version of Read Naturally take advantage of speech recognition technology in order to provide students with guided oral reading practice. Reading Assistant™ and Read Naturally are computer programs that have the added benefits of requiring students to complete a series of sequenced steps which should improve treatment integrity, and also continually track and monitor student progress for additional analysis.

Although this technology holds substantial promise, there are unfortunately few studies that have directly investigated CAI and its effect on reading fluency. Research conducted to date is also inconclusive, with some studies finding support for programs and others finding no effect on reading fluency. More research is needed on computer programs targeting reading fluency in order to examine their effectiveness compared to other forms of intervention. Therefore, the purpose of this present study is to examine the effects of CAI on reading fluency skills using the most current version of the Reading Assistant™ computer software program. Specifically, this study will examine if Reading Assistant™ can be used to increase the instructional level oral reading fluency and comprehension skills of second through fifth grade students considered at-risk for reading failure. An additional focus is to determine if improvements in oral reading fluency and comprehension skills will generalize to untaught, grade level passages. The following section discusses the methodology used to address the purpose of the current study and specific research questions presented in the first chapter.
CHAPTER III

METHODS

This chapter describes the methodological procedures that were used in the current study. Specifically, the following components are included within this chapter: participants, setting, materials, dependent variables, independent variables, experimental design, procedural and treatment integrity, inter-observer agreement, and data analysis procedures.

Participants

The participants were selected from an elementary school serving students in a rural school district in the southeastern United States. Approximately 697 students in kindergarten through fifth grade attended this school, with 34% of those students eligible to receive free or reduced-price lunch. For the 2011 to 2012 school year, approximately 74% of the student body was Caucasian, 17% African American, 5% Hispanic, and 3% Asian. At least 80% of the student body was performing at or above grade level in reading and in math based on state testing results.

Individuals in the second through third grades were selected for participation after being determined to be at-risk for reading failure based on teacher recommendation as well as from results of their STAR Reading assessment (Renaissance Learning, 2014). Subsequent determination for inclusion in this study was based on several selection
criteria. First, the difference between the student’s grade placement and reading level based on the STAR Reading assessment was used as one basis for this selection.

Secondly, students were also ranked in percentile groups based on their median CWPM on AIMSweb grade level R-CBM passages according to AIMSweb national norms (www.AIMSweb.com). Participants who scored in the 1st to 10th percentile range were determined to be at ‘high risk’ while participants scoring in the 11th to 24th percentile range were considered to be at ‘some risk’. Participants who scored in the 25th to 75th percentiles were considered to be in the average range and to be at ‘low risk’. Students were required to score in the high risk or some risk range for inclusion in the study. In addition, only students who met the following criteria were eligible for inclusion in the study: (a) they did not have an articulation or voice disorder that would interfere with speech intelligibility, (b) were not deaf or hard of hearing, (c) were not blind and did not have a vision impairment which would prevent them from clearly seeing the computer screen, and (d) did not have an orthopedic impairment that would prevent them from using a computer mouse or an alternate input device. Further, individuals who received special education services were not invited to participate in the current study.

After the superintendent of the school district approved the study, the researcher submitted a proposal to the University’s Institutional Review Board (IRB). After IRB approval was obtained (See Appendix A), parents were contacted by letter to determine if they were willing to allow their child to participate in the study. Parents who expressed an interest were given information regarding the nature and purpose of the investigation, information about confidentiality, and information concerning procedural safeguards as outlined by Mississippi State University IRB procedural requirements. After parental
consent was obtained, student participants were given a brief explanation of the study. Each student was also instructed that he/she had the option to refuse to participate. If a student chose to participate, they were presented with an assent form that was read to them by the evaluator. The students were given the option to be involved in the study or to choose to not participate in the study. A student signature agreeing to participate in the study was required before the student could be involved in the present research. The students were also told that they had the option of withdrawing from the study at any time.

Based on the aforementioned inclusion criteria, eight students were selected for the current research study. Students ranged in age from 8 to 9 years old. Seven students were in the second grade and one student was in the third grade. In terms of race, there were five Caucasian students and three African American students. Of these students, there were three females and five males.

Selected students were administered a set of three CBM probes at grade level in order to determine their risk status based on AIMSweb normative data as well as their instructional level. The results for each individual student are described in greater detail below. Notably, pseudonyms were used to maintain the confidentiality of the students. Information regarding participants is also summarized in Table 1.

**Ariana**

Ariana was a 9-year-old African American female in the third grade. She was in the regular education setting and had no prior history of receiving special education services. Ariana’s STAR Reading grade equivalent (GE) score prior to baseline was 2.1. According to the pre-treatment assessment, Ariana was found to be reading at the second-
grade instructional level. Ariana read a median of 49 CWPM on grade level R-CBM probes, which placed her performance at the less than 10th percentile and in the high-risk range according to AIMSweb normative data.

Ashley

Ashley was an 8-year-old Caucasian female in the second grade. She was in the regular education setting and had no prior history of receiving special education services. Ashley had been diagnosed with Attention-Deficit Hyperactivity Disorder (ADHD) and took medication to address symptoms of this condition at the time that the study was conducted. Ashley’s STAR Reading GE score prior to baseline was 1.4. According to pre-treatment assessment, Ashley was found to be reading at the first-grade instructional level. Ashley read a median of 30 CWPM on grade level R-CBM probes, which placed her performance at the less than 10th percentile and in the high-risk range according to AIMSweb normative data.

Devon

Devon was a 9-year-old Caucasian male in the second grade. He was in the regular education setting, and had no prior history of receiving special education services. He had been retained in the first grade. Devon’s STAR Reading GE score was 1.1 prior to baseline. According to pre-treatment assessment, Devon was found to be reading at the kindergarten instructional level. Devon read a median of 28 CWPM on grade level R-CBM probes, which placed his performance at the less than 10th percentile and in the high-risk range according to AIMSweb normative data.
Eli

Eli was an 8-year-old African American male in the second grade. Eli was in the regular education setting, and had no prior history of receiving special education services. His STAR Reading GE score was 1.6 prior to baseline. Eli read a median of 54 CWPM on grade level R-CBM probes, which placed his performance at the less than 25th percentile and in the some-risk range according to AIMSweb normative data. Eli was found to be reading at the first-grade instructional level.

Mickey

Mickey was an 8-year-old Caucasian male in the second grade. Mickey was in the regular education setting and had no prior history of receiving special education services. Mickey’s STAR Reading GE score was 1.5 prior to baseline. According to the pre-treatment assessment, Mickey was found to be reading at the second-grade instructional level. Mickey read a median of 60 CWPM on grade level R-CBM probes, which placed his performance at the less than 25th percentile and in the some-risk range according to AIMSweb normative data.

Toby

Toby was an 8-year-old Caucasian male in the second grade. Toby was in the regular education setting, and had no prior history of receiving special education services. Toby had been diagnosed as having ADHD and was taking medication to address symptoms of this condition during the time that this study was completed. Toby’s STAR Reading GE score was 0.9 prior to baseline. Toby read a median of 63 CWPM on grade level R-CBM probes, which placed his performance at the less than 25th percentile and in
the some-risk range according to AIMSweb normative data. Toby was found to be reading at the second-grade instructional level.

**Valerie**

Valerie was an 8-year-old Caucasian female in the second grade. Valerie was in the regular education setting and had no prior history of receiving special education services. Valerie’s STAR Reading GE score was 1.1 prior to baseline. Valerie read a median of 39 CWPM on grade level R-CBM probes, which placed her performance at the 10\textsuperscript{th} percentile and in the high-risk range according to AIMSweb normative data. According to pre-treatment assessment using CBM, Valerie was found to be reading at the first-grade instructional level.

**Zachary**

Zachary was a 9-year-old African American male in the second grade. Zachary was in the regular education setting, and had no prior history of receiving special education services. He had been retained in kindergarten. Zachary had been diagnosed as having ADHD and was taking medication to address symptoms of this condition during the time that this study was completed. Zachary’s STAR Reading GE score was 1.5 prior to baseline. Zachary read a median of 38 CWPM on grade level R-CBM probes, which placed his performance at the less than 10\textsuperscript{th} percentile and in the high-risk range according to AIMSweb normative data. Zachary was found to be reading at the first-grade instructional level.
## Table 1

*Participants*

<table>
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<tr>
<th>Grade</th>
<th>Race</th>
<th>STAR</th>
<th>AIMSweb</th>
<th>Instructional Reading Level</th>
<th>Diagnoses</th>
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<td>High</td>
<td>1</td>
<td>ADHD</td>
</tr>
</tbody>
</table>

### Settings

Data from CBM reading probes and maze passages were collected in a separate setting (e.g., empty classroom) in order to minimize distractions. The CBM sessions were conducted by the examiner and standardized procedures, detailed in the procedures section below, were followed. All of CBM sessions were audiotaped using a digital recorder.
recorder for the purpose of obtaining data for interobserver agreement and treatment integrity. All sessions utilizing the Reading Assistant™ computer program took place in a computer lab at the elementary school that the participants attended. The computer lab was staffed by at least one staff member trained in operating Reading Assistant™ during all intervention sessions.

**Materials**

The materials that were used in this study include the assessment materials (i.e., AIMSweb R-CBM probes and maze passages), the Reading Assistant™ computer program, desktop computers, a stopwatch, and a digital tape recorder. Reading Assistant™ and AIMSweb will be described in more detail in the following section.

**Reading Assistant™**

Scientific Learning Reading Assistant™ is an internet-based computer program that was developed to be used as an intervention or as a supplement to traditional reading instruction. Although psychometric data is currently not available on the program, Reading Assistant™ does use research supported strategies to target reading fluency, vocabulary, and comprehension by increasing guided oral reading practice for individuals who are in Grades 2 through 12, as well as for adults who are remedial readers (Scientific Learning Corporation, 2010). This program allows a student to read alone with the use of speech recognition software, while the student receives immediate corrective feedback when he or she encounters a difficult word. Reading Assistant™ also records what the individual reads and tracks student progress over a period of time.
According to the manual *How to Use the Scientific Learning Products* (Scientific Learning Corporation, 2010) the Reading Assistant™ Library provides texts within four content grade bands with selections that are written to appeal to students within those grades. Each grade band has content that is written at a range of reading levels and consists of a mix of fiction and nonfiction texts. Content grade bands are as follows: (a) kindergarten to third grade, (b) fourth to fifth grade, (c) sixth to eighth grade, and (d) ninth to twelfth grade. The content of units are sequenced from easier to more difficult, and therefore the difficulty level of the material increases as the student progresses through a grade band.

The initial reading level of a student can be assigned by either using the Reading Progress Indicator (RPI), which is a computerized reading assessment developed by Scientific Learning, or by using grade equivalent scores, guided reading levels, or Lexile scores. For this study, the reading levels of all participants were based on their STAR Reading GE. Once a student is assigned a reading level, the software selects the starting topic for the student within the grade band. Content progression is automatically locked by default, which means that each participant must complete all of the activities for each reading selection in order. The amount of time that a participant spends on the Reading Assistant™ program can also be pre-programed. For this study, each participant was scheduled to work on Reading Assistant™ for at least 20 minutes per day for five school days per week. If the participant missed school, then they were not scheduled for a make-up session. Scientific Learning suggests that students in kindergarten through third grade should engage in Reading Assistant™ for at least 20 minutes per day three days per week.
When a participant logs onto Reading Assistant™, the Library screen appears. When the student is on the Library screen, they are able to choose a selection that they can work on, review their progress in the program, and also access help if needed. Reading Assistant™ software requires participants to complete three activities with each reading selection. These activities are as follows: (a) preview and read silently, (b) record his or her reading, and (c) take a comprehension quiz. These computer-based activities are described in more detail in subsequent paragraphs.

In the preview and read silently phase, the student is expected to look over the text as well as pictures and then listen to a model of fluent reading of the text. The student can also choose to click on any word to be pronounced and can review vocabulary definitions using the Glossary. When the Glossary is enabled, each glossary word in the section is underlined. The participant can then click on underlined words to open a glossary screen which provides an audio pronounced version of the word and text definition of the selected word as well as the word used in a sentence. Before a student can move onto the next activity, the student must answer all of the guided reading questions for the reading selection.

Following Preview and Read Silently, the next activity is Record My Reading. In this activity, a student records their reading using speech recognition technology. A microphone check automatically begins at the start of each Record My Reading session. If this is the first time a student has used Reading Assistant™, a voice customization process begins. When the voice customization process occurs, the best acoustic model is chosen for the individual.
At the beginning of the Record My Reading activity, a student can listen to the selection again or a part of the selection read aloud and can also click on any word to hear it pronounced. When ready, the student clicks on the Record My Reading button and the software monitors the student as he or she reads aloud into a microphone headset. As the student reads, the software highlights a small section of the text to be read while the rest of the page is grayed out. If a student has difficulty with a word, the word is highlighted in yellow. If the software does not hear the word read correctly, then the word is provided. The default setting for second grade text levels and below is 3 seconds for the highlight and 3 seconds between the highlight and the word being provided. The default setting for third grade text levels and higher is 2 seconds for the highlight and 2 seconds between the highlight and the word being provided.

Reading Assistant™ software monitors how well a student has read words in a passage by highlighting the words in different colors while the student is orally reading text. Words that are clearly recognized are highlighted in green. Words that are recognized, but not read fluently based on interpretation by Reading Assistant™, are highlighted in blue. Words that are not read or not recognized are highlighted in red. Those words that have not been recorded are highlighted in black.

During the time that a participant’s reading is being recorded, the number of words that he or she read correctly within 1 minute is measured. When Reading Assistant™ calculates the CWPM, red-coded words are not included in the words correct total, but all other words that are read are included. In addition, the time corresponding to repeated words is removed from the total time taken to read the passage when calculating CWPM. Reading Assistant™ also recognizes short, common words known as ‘glue’
words (e.g., “the”). These words can be de-emphasized and may be misrecognized by Reading Assistant™ and therefore correct recognition of them is not required in order to allow a user to proceed in text. There are separate lists of glue words for each grade. The CWPM calculations made by Reading Assistant™ have been found to be lower than manual calculations of CWPM by approximately 6% (Scientific Learning Corporation, 2010).

After the first reading, the student is required to read the selection again. After the student reads the selection at least two times and reaches the words per minute goal in at least one of those readings, he or she has completed the activity. If the student does not reach the CWPM goal, then he or she is required to read the selection a third time. Once the student has read the selection a third time, then the Record My Reading activity is complete even if the fluency goal was not met. The participant can read the selection more than three times for additional practice. For this study, each student reads the selection a maximum of three times. CWPM goals are automatically set by the computer program for each story and cannot be individualized for participants.

The next activity that a student must complete is Take the Quiz. In this activity, the student is required to answer three to four comprehension questions. The student can click on a speaker button to hear questions and answer choices read aloud. The student also has the option of scrolling through the selection in order to find answers to questions. Questions are presented in either multiple choice or true/false formats. If the student does not answer the question correctly on the first attempt, then the software grays out the incorrect answer chosen by the participant and provides a prompt to try again. All quiz questions must be answered to complete the Take the Quiz activity.
Reading Assistant™ incorporates a point system in order to provide reinforcement for completion of tasks. Points can be earned by students for completing the required activities for each selection, with more points awarded for better performance. For example, students receive one point for each comprehension question that was answered correctly on the first try but do not receive any points for answering questions correctly on a second attempt.

Reading Assistant™ also provides immediate performance feedback to students. After each complete reading of the selection, a Fluency Progress report automatically appears on the screen. This report provides a bar graph, which indicates how well the participant performed (i.e., how many CWPM compared to the goal CWPM) as well as a list of words to practice. In addition, after the student completes the Take the Quiz activity, a Selection Report appears. This report provides information on the completion of activities for the selection, a point graph illustrating points earned in each activity as well as total points, the first quiz score, words that the participant should practice, and the average of the participant’s fluency scores for the selection.

AIMSweb

AIMSweb progress monitoring probes were used to measure each student’s oral reading fluency and reading comprehension skills. AIMSweb (www.AIMSweb.com) is a commercially available web-based program that is aligned closely with the principles of RTI. AIMSweb employs CBM principles and procedures in an effort to assess and monitor student performance. Measures are currently available to assess skills in several areas within the domains of reading, mathematics, and writing. Behavioral monitoring can also be supported through the use of AIMSweb.
When AIMSweb is used, a school typically conducts benchmarking in the fall, winter, and spring for all students. Students who are identified as having skill deficits during benchmarking are then monitored on a more frequent basis. Benchmarking and progress monitoring involve standardized administration of brief paper-and-pencil CBM probes to students. For progress monitoring, there are a total of 30 graded and equivalent oral reading fluency probes and 30 maze comprehension passages for second through the eighth grade (AIMSweb, 2012).

To assess oral reading fluency, students are asked to read aloud for one minute from word passages ranging from 250 to 350 words in length. These passages are narrative fiction stories written to ensure they are similar in difficulty level within each grade (See Appendix B). After a student has read for one minute, the number of CWPM and EWPM are calculated as indicated in Appendix C.

Data suggest that AIMSweb reading probes are reliable and valid. Howe and Shinn (2002) reported excellent reliability for AIMSweb reading assessment probes. Alternate-form reliability correlations for first through eighth grade passages ranged from .80 to .90. Adequate validity has also been indicated. Shinn and Shinn (2002) summarized data from 21 studies of oral reading fluency. Validity correlations from .26 to .91 were reported, with approximately half of the correlations equal to or greater than .75. Criterion validity measures for the CBM studies included commercially available basal readers and standardized academic achievement tests such as the Iowa Test of Basic Skills.

AIMSweb maze passages have also proven to be reliable and valid measure of reading comprehension skills. Administered using standardized procedures, maze probes
are timed, multiple-choice cloze tasks. Students are given a total of three minutes to read
silently a passage between 150 and 400 words in length. For each passage, the first
sentence is complete. For every seventh word thereafter, three words are given in
parentheses and students are asked to circle the one word that best fits the sentence. Of
the three words, one is the correct response, with the other two serving as distracters (See
Appendix D and E). Scores on maze probes are calculated in terms of number of correct
answers as well as errors as indicated in Appendix F. The criterion and concurrent
validity for maze CBM probes with standardized reading comprehension tests has been
found to be acceptable (Fuchs & Fuchs, 1992; Wayman, Wallace, Wiley, Tichá & Espin,
2007).

**Dependent Variables**

This study had two primary dependent variables. The first set of dependent
variables focused on each student’s oral reading fluency as measured by performance on
unpracticed AIMSweb R-CBM probes during baseline and intervention conditions
administered at both the student’s instructional level and grade level. Specifically, the
number of CWPM on unpracticed AIMSweb on R-CBM probes at instructional level and
at grade level were one set of data that was collected to evaluate student progress.

The second set of dependent variables focused on reading comprehension. Data
were collected regarding the literal comprehension skills of participants when they were
given unpracticed AIMSweb maze CBM passages. The data collected was the number of
items answered correctly that participants made within three minutes on instructional
level and grade level maze passages.
In addition to the information obtained on R-CBM and maze probes, data from Reading Assistant™ was also obtained for each participant. Specifically, information regarding number of reading selections completed as well as total usage time was collected.

**Independent Variable**

In this study, students participated in a computerized, web-based reading program called Reading Assistant™. Each session was set for a minimum of 20 minutes to be completed during a 30-minute block of time five days per week for a total of 6 to 8 weeks. If there was a school holiday or half day for students, participants did not receive the intervention that day. Student attendance was tracked in order to ensure that the participants attended at least 90% of the intervention sessions across the intervention phase of the study.

**Experimental Design**

A combined series, multiple baseline across participants design was used in the current study in order to evaluate changes in student performance across baseline and intervention phases. Although each student’s performance on instructional level and grade level R-CBM probes and maze probes was evaluated individually, the multiple baseline was staggered across three sets of students placed into two groups. For clarification, the students were not placed in groups for intervention sessions. This approach was utilized in order to refrain from exposing some students to an extremely long baseline phase, which would delay their exposure to intervention. Follow-up data was collected 2 weeks after the end of the Reading Assistant™ intervention.
The first group of participants consisted of Devon, Mickey, Ashley, and Valerie. Devon received the Reading Assistant™ intervention for 8 weeks, Mickey and Ashley received Reading Assistant™ for 7 weeks, and Valerie received the intervention for 6 weeks. The second group of participants consisted of Toby, Zachary, Ariana, and Eli. Toby received the Reading Assistant™ intervention for 8 weeks, Zachary received the Reading Assistant™ Intervention for 7 weeks, and Ariana and Eli received the Reading Assistant™ intervention for 6 weeks.

**Procedures**

**Baseline**

All students began with establishing a baseline level of performance. During baseline conditions, participants received reading instruction from their regular education teacher in the same manner as they did prior to the initial assessment conditions. The reading instruction in the classroom consisted of a combination of instructional methods to include independent reading, whole class instruction, whole class discussion of reading selections, as well as guided reading. During the baseline phase, each participant was presented with an AIMSweb R-CBM probe at the student’s identified instructional level and grade level to read for one minute to measure his or her CWPM across the pre-treatment (i.e., baseline) phase. In addition, each student was presented with an AIMSweb instructional and grade level maze CBM passage to measure his or her comprehension rates across the baseline phase. This procedure was repeated until a minimum of three data points (e.g., CWPM on instructional and grade level R-CBM probes, comprehension on maze CBM passages) was obtained for the first set of students. No more than one datum point for each dependent variable was collected per day in order
to reduce repeated practice effects. Administration of the R-CBM and maze CBM passages was counterbalanced to control for order effects.

**Intervention**

The independent variable was first applied to the two participants with the most stable baseline, with visual inspection of the data used to decide which students began the intervention. After approximately one week, the intervention was then implemented with three more participants. The intervention was then implemented with the final three participants after approximately 2 more weeks (this delay was due to the occurrence of Spring Break). The current recommended time period for measuring response to instruction is 8 weeks (Fuchs & Fuchs, 2005). However, due to state mandated testing which interfered with student schedules and computer lab access, only two participants received 8 weeks of intervention.

**Student Training.** Immediately following the baseline phase, the first two participants were trained in how to use the Reading Assistant™ by the lead experimenter. The remaining participants were also trained just prior to beginning intervention. The experimenter trained each participant using a set protocol, which is provided in Appendix G. During the training, the participants were instructed through each of the components for one reading selection.

In order for the training to be considered complete, the participants needed to exhibit a thorough understanding of how to use the program. A training checklist was used to ensure that participants were able to engage with the software. A secondary observer independently scored the training sequence for a minimum of 30% of the
participants in the study. After baseline was completed and participants completed the
training session, the Reading Assistant™ intervention was implemented. Procedural and
treatment integrity was monitored via student reports available from the Reading
Assistant™ software program.

Each student was assigned to a minimum of a 20-minute protocol on Reading
Assistant™, which meant that after 20 minutes, his or her session was finished. However, each student was present in the computer lab for 30 minutes, which allowed for
each to have sufficient time to log in and out of Reading Assistant™ and adjust
microphone headsets as needed. Therefore, actual intervention sessions lasted for
approximately 30 minutes.

Data regarding oral reading fluency was obtained by giving each participant a
grade level and an instructional level AIMSweb R-CBM probe weekly while the student
received the intervention. Following standardized administration of the grade level and
instructional level R-CBM probes, students were administered an AIMSweb maze CBM
passage. Specifically, each student received an AIMSweb instructional level and grade
level R-CBM probe at the end of each week prior to the receipt of intervention in a
counterbalanced order. Each student then received an AIMSweb maze CBM passage at
instructional and grade level prior to the receipt of intervention in a counterbalanced
order. Finally, AIMSweb instructional and grade level R-CBM probes and maze CBM
passages were administered to all students approximately 2 weeks after the intervention
ended in order to gather information regarding post-intervention maintenance of any oral
reading fluency or comprehension gains as well as generalization levels.
Summary of Procedures

After participants were selected, baseline data were collected using grade level and instructional level R-CBM and maze CBM probes. After three data points, the first two participants were trained in how to use Reading Assistant™. The first two participants then began the intervention phase, which consisted of daily sessions of Reading Assistant™ for 8 weeks. After 1 week, the next three participants were trained in how to use Reading Assistant™. These participants then began the intervention phase, which lasted 7 weeks. After an additional week of intervention, the next three participants were trained in how to use Reading Assistant™ and then began the intervention phase, which lasted a total of 6 weeks. Throughout the intervention phase, all participants received grade level and instructional level R-CBM and maze CBM probes on a weekly basis. Two weeks following the end of the intervention phase, follow-up data was collected using grade level and instructional level R-CBM and maze CBM probes.

Procedural Fidelity and Interscorer Reliability

Procedural integrity was assessed during 33% of the CBM reading probe baseline and intervention sessions using a checklist. The total number of steps implemented correctly was averaged across all participants. Actual procedural integrity was 100% during baseline and intervention phases. Treatment integrity was also evaluated during 33% of the sessions evenly distributed across all phases of the study based on completion of a checklist during each session. Reading Assistant™ functioned properly during 100% of the intervention sessions. Each session in which AIMSweb R-CBM probes were administered, to include those during baseline as well as intervention, were audio recorded. A second trained examiner then assessed the R-CBM and maze CBM data for
33% of the sessions evenly distributed across the baseline, intervention, and follow-up phases so that interscorer reliability could be assessed. Interscorer agreement was calculated using the following formula: Agreements / (Agreements + Disagreements) x 100 = % interscorer agreement. Actual interscorer agreement for data collected was 94%.

**Data Analysis**

CWPM on instructional and grade level R-CBM probes and words correct on the maze CBM passages were visually analyzed with regard to changes in level, variability, and trend. For this study, the identified mean of each phase was considered the level of the series of data points for that phase. Trend was defined as the direction of change from the very beginning of the series of data points to the end of that series of data points. As this study is designed to improve student-reading skills, an increasing trend in CWPM on AIMSweb R-CBM probes and number of correct answers on maze CBM passages was expected. Variability was defined as the spread of data points around the level and the trend. The more variable that a data set is in a particular phase, the more difficult it is to identify the student’s true level of performance. If there is a large amount of variability within a phase, this could indicate that extraneous variables (e.g., illness, other interventions) impacted results.

In addition to conducting a visual analysis of the progress monitoring data across baseline and intervention phases, statistical analysis was also used to evaluate student progress in the current study. Specifically, the mean performance across baseline and intervention phases as well as the range of scores for each phase was calculated and reported. In addition, each student’s ROI was calculated and reported. ROI for each student was calculated following procedures discussed by Fuchs and colleagues (Fuchs,
Fuchs, Hamlett, Walz, & Germann, 1993) by subtracting the baseline mean on instructional level and grade level R-CBM and maze CBM probes from the intervention mean and dividing by the number of weeks of intervention.

Expected ROI for students based on grade level has been established and is currently available from several sources. Fuchs et al. (1993) is one of the most widely used sources used for referencing ROI. ROI for R-CBM and maze CBM passages as well as math computation, math concepts, and spelling among typical performing students in two school districts across two consecutive years was determined. The ‘realistic’ and ‘ambitious’ growth standards, respectively, for oral reading fluency as follows: (a) 2 and 3 words per week for Grade 1; (b) 1.5 and 2.0 words per week for Grade 2; (c) 1.0 and 1.5 words per week for Grade 3; (d) .85 and 1.1 words per week for Grade 4; (e) .5 and .8 words per week at Grade 5, and (d) .3 and .65 words per week at Grade 6. In regards to student progress with maze passages, data indicated that grade placement was of no consequence when determining ROI. Realistic weekly improvement for first through sixth grade was found to be approximately .39 words per week while ambitious weekly improvement was calculated to be .84.

As limited data are available regarding the effectiveness of Reading Assistant™, additional data analytic techniques were utilized to evaluate the effectiveness of the intervention in addressing the oral reading fluency and comprehension rates of the participants. Visual analysis of data alone can lead to a Type I error, which would lead researchers to conclude that an intervention is effective when it is not (Beeson & Robey, 2006). In relation, Matyas and Greenwood (1990) found that Type I error rates for visual analysis ranged from 16% to 84% across studies. As such, calculation of effect sizes has
been suggested to evaluate intervention effectiveness (Beeson & Robey, 2006). Within single subject research design, effect sizes may be calculated using the percentage of non-overlapping data points (PND; Olive & Smith, 2005). PND is most commonly used in single subject design research and is calculated by dividing the number of non-overlapping data points with baseline by the total number of intervention data points. Because this study is designed to improve student academic skills, the highest baseline data point will be used to establish the overlap of baseline data points with progress monitoring data points. Benchmarks for PND scores have also been established by Scruggs and Mastropieri (1998). Specifically, PND scores below 50% suggest an ineffective intervention effect, PND scores between 50% and 70% suggest a questionable intervention effect, PND scores between 70% and 90% suggest an effective intervention effect, and PND scores above 90% suggest a very effective intervention effect.
CHAPTER IV

RESULTS

The purpose of this study was to empirically evaluate the effects of the Reading Assistant™ computer program on the oral reading fluency and reading comprehension skills of struggling readers. Data that were collected on each student in this study included CWPM on instructional and grade level R-CBM probes as well as total words correct for maze CBM passages at instructional and grade level. Data were collected during a baseline and an intervention phase using a multiple baseline across participants design.

For this study, the eight participants were placed into two groups. Thus, data for each student will be discussed in the context of their group. Oral reading fluency instructional data will be reviewed first. The mean CWPM for baseline and intervention phases will be presented. Each participant’s ROI will also be reported. Further, utilizing the procedures as well as the interpretation guidelines described by Scruggs and Mastropieri (1987), the PND was calculated for each participant and will be reported as a measure of effect size. Next, visual interpretation of the data for observable changes in trend, level, and variability between the baseline and treatment conditions will be discussed.

Following interpretation of the instructional level oral reading fluency data, the results for grade level oral reading fluency data will be presented. Next, instructional
level and grade level reading comprehension data will be reviewed following the same format described above. It should be noted that due to Mickey and Toby’s instructional level being the same as their grade level, their data will be presented only when discussing instructional level results. The results section will then conclude with a brief review of the data as it relates to the four research questions this study sought to examine.

**Group One Participants**

The first group of participants consisted of Devon, Ashley, Mickey, and Valerie. Intervention for Devon entailed receiving Reading Assistant™ daily for a total of 8 weeks. He completed 39 reading selections and had 11 hours and 54 minutes of total usage time. Ashley received Reading Assistant™ for 7 weeks. She completed 30 reading selections and had 9 hours and 40 minutes of total usage time. Mickey also received Reading Assistant™ for 7 weeks, completed 37 reading selections, and had 8 hours and 53 minutes of total usage time. Valerie completed a total of 33 reading selections during her 6 weeks of intervention and had 7 hours and 6 minutes of total usage time.

**Instructional Level Oral Reading Fluency Results for Group One**

Figure 1 depicts the CWPM for instructional level R-CBM probes for Group One participants across the baseline, intervention, and follow-up phases. For all students, mean CWPM modestly increased during the intervention phase relative to baseline levels of performance on instructional level text and was maintained at the 2-week follow-up.

**Devon.** For the instructional level R-CBM probes across all baseline sessions, Devon earned a mean of 47.5 CWPM. During intervention, Devon earned a mean of 56.3 CWPM. When comparing the means between conditions, there was an increase of 8.8
CWPM during the Reading Assistant™ intervention phase. On instructional level R-CBM probes, Devon obtained a ROI of 1.1 words per week while the PND was found to be 63%. Devon was also administered an instructional level R-CBM probe 2 weeks following the last day of intervention. He obtained a score of 56 CWPM on this probe.

Visual inspection of Devon’s instructional level R-CBM data revealed an increasing trend for CWPM across the baseline phase. After Reading Assistant™ was implemented, there was a decrease in level and an increase in variability. No changes in data were observed for the other Group One participants with the implementation of the Reading Assistant™ intervention for Devon. There was a decrease in level for CWPM when follow-up data were taken 2 weeks after the Reading Assistant™ intervention ended.

Ashley. For the instructional level R-CBM probes across all baseline sessions, Ashley earned a mean of 46.6 CWPM. During intervention, Ashley earned a mean of 50.4 CWPM. When comparing the means between conditions, there was an increase of 3.8 CWPM during the Reading Assistant™ intervention phase. For instructional level R-CBM probes, Ashley obtained a ROI of 0.6 words per week and a PND of 0%. Ashley was also administered an instructional level R-CBM probe 2 weeks following the last day of intervention. She read 56 CWPM, a score that was higher than any other datum point for instructional level probes in the baseline or intervention phases.

Visual inspection of Ashley’s instructional level R-CBM data revealed variability for CWPM across the baseline phase. Upon implementation of Reading Assistant™, an immediate decrease in level was observed for CWPM. There was decreased variability for CWPM as the intervention progressed, with a decreasing trend observed towards the
end of the phase. No changes in data were observed for Mickey and Valerie with the implementation of the Reading Assistant™ intervention for Ashley. There was an increase in level for CWPM when follow-up data were taken 2 weeks after the Reading Assistant™ intervention ended.

**Mickey.** For R-CBM probes across all baseline sessions, Mickey earned a mean of 51 CWPM. During intervention, Mickey earned a mean of 62.3 CWPM. When comparing the means of the baseline condition to the means of the intervention condition, there was an increase in 11.3 CWPM during the Reading Assistant™ intervention phase. Mickey also obtained a ROI of 1.9 words per week while the PND was found to be 71%. Mickey was administered an R-CBM probe 2 weeks following the last day of intervention. He read 84 CWPM, a score that was higher than any other datum point during the baseline or the intervention phase.

Visual inspection of Mickey’s R-CBM data revealed relatively stable data with an increasing trend across the baseline phase for CWPM. After implementation of Reading Assistant™, there was a continuation of the increasing trend for CWPM and an increase in level across the intervention phase. No changes in data were observed for Valerie with the implementation of the Reading Assistant™ intervention for Mickey. There was an increase in level for CWPM when follow-up data were taken 2 weeks after the Reading Assistant™ intervention ended.

**Valerie.** For the instructional level R-CBM probes across all baseline sessions, Valerie earned a mean of 46.3 CWPM. During intervention, Valerie earned a mean of 57.8 CWPM. When comparing the means of the baseline condition to the means of the
intervention condition, there was an increase in 11.5 CWPM during the intervention phase. Valerie also obtained a ROI of 1.9 words per week while the PND was 60%. When given an instructional level R-CBM probe 2 weeks following the last day of intervention, Valerie obtained a score of 47 CWPM.

Visual analysis of Valerie’s instructional level R-CBM data indicated a slight decreasing trend for CWPM across the baseline phase. Upon implementation of Reading Assistant™, there was an immediate increasing trend for CWPM and an overall increase in level during the intervention phase. There was a decrease in level for CWPM when follow-up data were taken 2 weeks after the Reading Assistant™ intervention ended.

**Grade Level Reading Fluency Results for Group One**

Figure 1 also depicts the CWPM on grade level R-CBM probes for Devon, Ashley, and Valerie across the baseline, intervention, and follow-up phases. Mickey’s instructional reading level and grade level were the same and therefore his data will be excluded from this section. For all students, mean CWPM increased during the intervention phase relative to baseline levels of performance on grade level text, with this increase maintained at the 2-week follow-up.

**Devon.** On grade level R-CBM probes during baseline, Devon earned a mean of 29.5 CWPM. During the Reading Assistant™ intervention, Devon earned a mean of 37 CWPM. When comparing means between conditions, there was an increase of 7.5 CWPM during the Reading Assistant™ intervention. For grade level R-CBM probes, Devon also obtained a ROI of 0.9 words per week while the PND was 88%. Devon was administered a grade level R-CBM probe 2 weeks following the last day of intervention.
Devon’s score of 44 CWPM on this probe was higher than all but one other datum point for grade level probes in the baseline and intervention phases.

Visual inspection of Devon’s grade level R-CBM data revealed a relatively stable level of performance for CWPM across the baseline phase. After Reading Assistant™ was implemented, CWPM were initially stable, but increased variability was observed as the intervention phase progressed. An overall increase in level was observed during the intervention phase. No changes in data were evident for the other Group One participants with the implementation of the Reading Assistant™ intervention for Devon. There was an increase in level for CWPM when follow-up data were taken 2 weeks after the intervention ended.

**Ashley.** On grade level R-CBM probes during baseline, Ashley earned a mean of 30.6 CWPM. On grade level R-CBM probes during the Reading Assistant™ intervention phase, Ashley earned a mean of 45.1 CWPM. When comparing the means between conditions, there was an increase in 14.5 CWPM after Reading Assistant™ was implemented. On grade level R-CBM probes, Ashley obtained a ROI of 2.1 words per week while the PND was found to be 71%. Ashley was administered a grade level R-CBM probe 2 weeks following the last day of intervention. She received a score of 56 CWPM on the grade level probe.

Visual inspection of Ashley’s grade level R-CBM data revealed that there was an increasing trend for CWPM towards the end of the baseline phase. With regard to the Reading Assistant™ intervention phase, a general upward trend was observed for CWPM until the last two data points, when a decrease in level was observed. No changes in data were observed for Valerie with the implementation of the Reading Assistant™
intervention for Ashley. There was an increase in level for CWPM when follow-up data were taken 2 weeks after the Reading Assistant™ intervention ended.

Valerie. On grade level R-CBM probes during baseline, Valerie earned a mean of 39.5 CWPM. During the Reading Assistant™ intervention, Valerie earned a mean of 51.9 CWPM. When comparing the CWPM means for grade level R-CBM probes between the baseline and intervention conditions, there was an increase in 12.4 CWPM during the Reading Assistant™ intervention phase. Valerie also obtained a ROI of 2.1 words per week on grade level R-CBM probes while the PND was 33%. Valerie was administered a grade level R-CBM probe 2 weeks following the last day of intervention. Valerie received a score of 47 CWPM for the grade level probe.

Visual inspection of Valerie’s grade level R-CBM data revealed a decreasing trend across the baseline phase for CWPM. With implementation of Reading Assistant™, an increase in trend was observed for CWPM and this was maintained across the intervention phase. There was an overall increase in level during the intervention phase but a decrease in level for CWPM when data were taken 2 weeks following intervention.
Figure 1.  Group One Reading Fluency

This graph depicts a multiple-baseline across four participants: Devon, Ashley, Mickey, and Valerie. CWPM is displayed across all phases (baseline, intervention, and follow up). CG = CWPM at grade level is depicted by square icons and CI = CWPM at instructional level depicted by diamond icons.
Instructional Level Reading Comprehension Results for Group One

Figure 2 depicts the words correct on instructional level maze CBM probes for Devon, Mickey, Ashley, and Valerie across the baseline, intervention, and follow-up phases. For all participants, mean words correct modestly increased during the intervention phase relative to baseline levels of performance. This increase was maintained at the 2-week follow-up for all participants except for Valerie.

Devon. On instructional level maze CBM probes during baseline, Devon earned a mean of 10.5 words correct. During the Reading Assistant™ intervention phase, Devon earned a mean of 14.1 words correct. When comparing results between conditions, there was an increase in 3.6 words correct during the Reading Assistant™ intervention phase. Devon also obtained a ROI of 0.5 words per week while the PND was 50%. Devon was administered an instructional level maze CBM probe 2 weeks following the last day of intervention. He received a score of 18 words correct for the instructional level probe.

Visual inspection of Devon’s instructional level maze CBM data revealed that there was slight variability for words correct across the baseline phase. Upon implementation of Reading Assistant™, there was an immediate increase in level for words correct and then a decreasing trend with minimal variability until the end of the intervention phase. Towards the end of the intervention phase, there was a sharp increase in level for words correct. No changes in data were observed for the other Group One participants with the implementation of the Reading Assistant™ intervention for Devon. There was a decrease in level for words correct when data were taken 2 weeks after the intervention ended.
Ashley. On instructional level maze CBM probes during baseline, Ashley earned a mean score of 5.3 words correct. During the Reading Assistant™ intervention phase, Ashley earned a mean score of 13.7 words correct. When comparing results between the baseline and intervention conditions, there was an increase in 8.4 words correct during the Reading Assistant™ intervention phase. Ashley also obtained a ROI of 2.3 words per week while the PND was 86%. Ashley was administered an instructional level maze probe 2 weeks following the last day of intervention. She received a score of 18 words correct for the instructional level probe.

Visual inspection of Ashley’s instructional level maze CBM data revealed an increasing trend for words correct during the baseline phase. After the Reading Assistant™ intervention was implemented, there was an increase in trend and variability. No changes in data were observed for Valerie and Mickey with the implementation of the Reading Assistant™ intervention for Ashley. There was an increase in level for words correct when data were taken 2 weeks following the end of the intervention.

Mickey. On maze CBM probes during baseline, Mickey earned a mean of 9.5 words correct. During the Reading Assistant™ intervention, Mickey earned a mean of 10.3 words correct. When comparing results between conditions, there was an increase in 0.8 correct words during the Reading Assistant™ intervention phase. Mickey also obtained a ROI of 0.1 words per week and a PND of 57%. Mickey was administered a maze CBM probe 2 weeks following the last day of intervention. He obtained a score of 27 words correct. This score was higher than any other datum point in the baseline or the intervention phase.
Visual inspection of Mickey’s maze CBM data revealed that words correct remained relatively stable across the baseline phase. With regard to the Reading Assistant™ intervention, there was a relatively flat trend for words correct, while variability remained low overall. An overall increase in level was observed during the intervention phase. No changes in data were observed for Valerie with the implementation of the Reading Assistant™ intervention for Mickey. There was an increase in level for words correct when data were taken 2 weeks following the end of the intervention.

Valerie. On instructional level maze CBM probes during baseline, Valerie earned a mean of 7.2 words correct. During the Reading Assistant™ intervention phase, Valerie earned a mean of 12.4 words correct. When comparing results between the baseline and intervention conditions, there was an increase of 5.2 words correct during the Reading Assistant™ intervention phase. Valerie also obtained a ROI of 0.9 words per week while the PND was 80%. Valerie was administered an instructional level maze CBM probe 2 weeks following the last day of intervention. Valerie received a score of 7 words correct for the instructional level probe.

Visual inspection of the maze CBM data indicates that words correct remained relatively stable across the baseline phase with a flat trend and minimal variability. Upon implementation of Reading Assistant™, there was an immediate increase in level for words correct. An overall increase in level was observed during the Reading Assistant™ intervention phase. There was a decrease in level for words correct when data were taken 2 weeks following the end of the intervention.
Grade Level Reading Comprehension Results for Group One

Figure 2 also depicts the words correct on grade level maze CBM probes for Devon, Ashley, and Valerie across the baseline, intervention, and follow-up phases. As indicated earlier, Mickey’s instructional and grade level scores were the same and therefore his data will be excluded from this section. Only Ashley and Devon demonstrated an increase in words correct during the intervention phase relative to baseline levels of performance. Furthermore, only Devon’s increase in words correct was maintained at the 2-week follow-up.

Devon. On grade level maze CBM during baseline, Devon earned a mean of 10.3 words correct. For the intervention phase, Devon earned a mean of 15.5 words correct. When comparing the means between conditions, there was an increase in 5.2 words correct during the Reading Assistant™ intervention phase. Devon also obtained a ROI of 0.7 words per week while the PND was found to be 25%. Devon was administered a grade level maze CBM probe 2 weeks following the last day of intervention. He received a score of 17 words correct for the grade level probe.

Visual inspection of Devon’s grade level maze CBM data indicates an increase in level for words correct during the baseline phase. After the Reading Assistant™ intervention was implemented, there was an immediate drop in level and a high degree of variability and an overall increase in level was observed. No changes in data were observed for the other Group One participants with the implementation of the Reading Assistant™ intervention for Devon. There was a decrease in level for words correct when data were taken 2 weeks following the end of the intervention.
Ashley. On grade level maze CBM during baseline, Ashley earned a mean of 6.7 words correct. For the intervention phase, Ashley earned a mean of 18.6 words correct. When comparing the correct word means for grade level R-CBM probes between the baseline and intervention conditions, there was an increase in 11.9 words correct during the Reading Assistant™ intervention phase. Ashley also obtained a ROI of 1.7 words per week and a PND of 71%. Ashley was also administered a grade level maze probe 2 weeks following the last day of intervention. She received a score of 14 words correct for the grade level probe.

Visual inspection of Ashley’s grade level maze CBM data revealed an increasing trend for words correct across the baseline phase. Upon implementation of Reading Assistant™, there was an immediate increase in level and variability. No changes in data were observed for Mickey or Valerie with the implementation of the Reading Assistant™ intervention for Ashley. There was a decrease in level for words correct when data were taken 2 weeks following the end of the intervention.

Valerie. On grade level maze CBM during baseline, Valerie earned a mean of 10.8 words correct. For the intervention phase, Valerie earned a mean of 8 words correct. When comparing the means for grade level maze CBM probes between the baseline and intervention conditions, there was a decrease in 2.8 words correct during the Reading Assistant™ intervention phase. Valerie also obtained a ROI of -0.5 words per week while the PND was 0%. Valerie was administered a grade level maze CBM probe 2 weeks following the last day of intervention. Valerie received a score of 13 words correct for the grade level probe.
Visual inspection of Valerie’s grade level maze CBM data revealed that words correct remained relatively stable across the baseline phase. With implementation of Reading Assistant™, there was an immediate decrease in level and no change in trend and variability were observed. There was an increase in level for words correct when data were taken 2 weeks following the end of the intervention.
Figure 2. Group One Reading Comprehension

This graph depicts a multiple-baseline across four participants: Devon, Ashley, Mickey, and Valerie. Words Correct is displayed across all phases (baseline, intervention, and follow up). CG = Words Correct at grade level is depicted by square icons and CI = Words Correct at instructional level depicted by diamond icons.
Group Two Participants

The second group of participants consisted of Toby, Zachary, Ariana and Eli.

Toby received Reading Assistant™ daily for 8 weeks, completed 39 reading selections, and had 11 hours and 44 minutes of total usage time. Zachary received Reading Assistant™ daily for 7 weeks. He completed 36 reading selections and had 9 hours and 54 minutes of total usage time. Ariana completed 30 reading selections and had 5 hours and 43 minutes of total usage time with Reading Assistant™ during her 6 weeks of intervention. Eli received Reading Assistant™ daily for 6 weeks, completed 15 reading selections, and had 6 hours and 46 minutes of total usage time. Figure 3 depicts the CWPM for instructional level R-CBM probes across the baseline, intervention, and follow-up phases. No Group Two participants demonstrated an increase in CWPM in the intervention phase over baseline levels.

Instructional Level Reading Fluency Results for Group Two

Toby. For R-CBM probes across all baseline sessions, Toby earned a mean of 64.3 CWPM. During intervention, Toby earned a mean of 61.3 CWPM. When comparing the means of the baseline condition to the means of the intervention condition, there was a decrease of 3 CWPM during the Reading Assistant™ intervention phase. Toby also obtained a ROI of -0.4 words per week while the PND was 29%. Toby was administered an R-CBM probe 2 weeks following the last day of intervention. He received a score of 75 CWPM on the probe. This score was higher than any other datum point in the baseline or intervention phase.

Visual inspection of the R-CBM data revealed that CWPM remained relatively stable with a slight increasing trend towards the end of the baseline phase. When the
Reading Assistant™ intervention was implemented, there was an immediate decrease in level and trend for CWPM. An increase in level was then observed on the fourth data point followed by increased variability across the baseline phase. No changes in data were observed for the other Group Two participants with the implementation of the Reading Assistant™ intervention for Toby. The level for words correct remained relatively stable when data were taken 2 weeks following the end of the intervention.

**Zachary.** For the instructional level R-CBM probes across all baseline sessions, Zachary earned a mean of 54.4 CWPM. During intervention, Zachary earned a mean of 51.7 CWPM. When comparing the means of the baseline condition to the means of the intervention condition, there was a decrease of 2.7 CWPM during the Reading Assistant™ intervention phase. Zachary also obtained a ROI of -0.4 words per week while the PND was found to be 0%. Zachary was administered an instructional level R-CBM probe 2 weeks following the last day of intervention. He received a score of 55 CWPM for the instructional level probe.

Visual inspection of Zachary’s instructional level R-CBM data revealed a slight increasing trend for CWPM across the baseline phase. When Reading Assistant™ was implemented, there was an increase in variability for CWPM across the intervention phase and an overall decrease in level. No changes in data were observed for Ariana or Eli with the implementation of the Reading Assistant™ intervention for Zachary. There was an increase in level for words correct when data were taken 2 weeks following the end of the intervention.
**Ariana.** For the instructional level R-CBM probes across all baseline sessions, Ariana earned a mean of 68.3 CWPM. During intervention, Ariana earned a mean of 60 CWPM. When comparing the means of the baseline condition to the means of the intervention condition, there was a decrease in 8.3 CWPM during the Reading Assistant™ intervention phase. Ariana also obtained a ROI of -1.4 words per week and a PND of 0%. Ariana was administered an instructional level R-CBM probe 2 weeks following the last day of intervention. She received a score of 46 CWPM for the instructional level probe.

Visual inspection of Ariana’s instructional level R-CBM data revealed a decreasing trend for CWPM across the baseline phase. After implementation of Reading Assistant™, there was an increase in variability, an overall decreasing trend, and a decrease in level. No changes in data were observed Eli with the implementation of the Reading Assistant™ intervention for Ariana. There was a decrease in level for words correct when data were taken 2 weeks following the end of the intervention.

**Eli.** For the instructional level R-CBM probes across all baseline sessions, Eli earned a mean of 60.2 CWPM. During intervention, Eli earned a mean of 59 CWPM. When comparing the means of the baseline condition to the means of the intervention condition, there was a decrease in 1.2 CWPM during the Reading Assistant™ intervention phase. Eli also obtained a ROI of -0.2 words per week while the PND was 0%. Eli was administered an instructional level R-CBM probe 2 weeks following the last day of intervention. He received a score of 77 CWPM for the instructional level probe. This score was higher than any other datum point for instructional level probes in the baseline or intervention phases.
Visual analysis of Eli’s instructional level R-CBM data revealed variability for CWPM across the baseline phase. After the Reading Assistant™ intervention was implemented, there was a decrease in variability for CWPM, while the level and trend remained relatively the same. There was an increase in level for words correct when data were taken 2 weeks following the end of the intervention.

**Grade Level Reading Fluency Results for Group Two**

Figure 3 also depicts the CWPM for grade level R-CBM probes for Zachary, Ariana, and Eli across the baseline, intervention, and follow-up phases. As indicated earlier, Toby’s instructional and grade scores level were the same and therefore his data will be excluded from this section. For all participants, mean CWPM increased during the intervention phase relative to baseline levels of performance, with this increase maintained at the 2 week follow-up. All three students demonstrated an improvement in CWPM during the course of the study.

**Zachary.** During baseline, Zachary earned a mean of 49.8 CWPM. On grade level R-CBM probes during the Reading Assistant™ intervention, Zachary earned a mean of 52.3 CWPM. When comparing the means between conditions, there was an increase in 2.5 CWPM during the Reading Assistant™ intervention phase. Zachary also obtained a ROI of 0.4 words per week while the PND was 14%. Zachary was administered a grade level R-CBM probe 2 weeks following the last day of intervention. He received a score of 48 CWPM for the grade level probe.

Visual analysis of the grade level R-CBM data indicated a slight increasing trend for CWPM across the baseline phase. After Reading Assistant™ was implemented, there
was a small increase in level but then a decreasing trend for CWPM. No changes in data were observed for Eli or Ariana with the implementation of the Reading Assistant™ intervention for Zachary. There was a small increase in level for words correct when data were taken 2 weeks following the end of the intervention.

Ariana. On grade level R-CBM probes during baseline, Ariana earned a mean of 55.1 CWPM. During the Reading Assistant™ intervention, Ariana earned a mean of 56 CWPM. When comparing the means for grade level R-CBM probes between the baseline and intervention conditions, there was an increase in 0.9 CWPM during the Reading Assistant™ intervention phase. Ariana also obtained a ROI of 0.2 words per week while the PND was 17%. Ariana was administered a grade level R-CBM probe 2 weeks following the last day of intervention. She received a score of 55 CWPM for the grade level probe.

Visual inspection of Ariana’s grade level R-CBM data revealed an increasing trend toward the end of the baseline phase for CWPM. When Reading Assistant™ was implemented, there was an immediate decrease in level and an increase in variability for CWPM in comparison to the baseline phase. The overall level during the Reading Assistant™ intervention phase increased relative to baseline conditions. No changes in data were observed Eli with the implementation of the Reading Assistant™ intervention for Ariana. There was a decrease in level for words correct when data were taken 2 weeks following the end of the intervention.

Eli. On grade level R-CBM probes during baseline, Eli earned a mean of 52.5 CWPM. During the Reading Assistant™ intervention phase, Eli earned a mean of 56
CWPM. When comparing the means between the baseline and intervention conditions, there was an increase of 3.5 CWPM during the Reading Assistant™ intervention phase. Eli also obtained a ROI of 0.6 words per week while the PND was 17%. Eli was administered a grade level R-CBM probe 2 weeks following the last day of intervention. He received a score of 64 CWPM for the grade level probe.

Visual inspection of Eli’s grade level R-CBM data revealed slight variability in CWPM across the baseline phase followed by a decrease in level just prior to intervention. With implementation of Reading Assistant™, there was an immediate increase in level for CWPM, but then a drop in level by the second datum point. An increasing trend in CWPM was observed for the rest of the intervention phase. There was a small increase in level for words correct when data were taken 2 weeks following the end of the Reading Assistant™ intervention.
Figure 3. Group Two Reading Fluency

This graph depicts a multiple-baseline across four participants: Toby, Zachary, Ariana, and Eli. CWPM is displayed across all phases (baseline, intervention, and follow-up). CG = CWPM at grade level is depicted by square icons and CI = CWPM at instructional level depicted by diamond icons.
Instructional Level Reading Comprehension Results for Group Two

Figure 4 depicts the words correct on grade level maze CBM probes for Toby, Zachary, Ariana, and Eli across the baseline, intervention, and follow-up phases. For all participants, there was a modest increase in mean words correct during the intervention phase relative to baseline levels of performance. This increase in CWPM was maintained at the 2-week follow-up for Toby and Zachary.

**Toby.** On maze CBM during baseline, Toby earned a mean score of 7 words correct. During the Reading Assistant™ intervention, Toby earned a mean of 7.8 words correct. When comparing means between conditions, there was an increase of 0.8 correct words during the Reading Assistant™ intervention. Toby also obtained a ROI of 0.1 words per week and a PND of 13%. Toby was administered a maze CBM probe 2 weeks following the last day of intervention. He received a score of 11 words correct on the maze CBM probe. This score was higher than all but one other datum point in the baseline and intervention phases.

Visual inspection of Toby’s maze CBM data revealed that words correct stabilized across the baseline phase. With regard to the Reading Assistant™ intervention phase, there was an immediate increase in level and then a slight increasing trend. The overall level increased during the Reading Assistant™ intervention relative to the baseline phase. No changes in data were observed for the other Group Two participants with the implementation of the Reading Assistant™ intervention for Toby. There was a slight increase in level for words correct when data were taken 2 weeks following the end of the intervention.
**Zachary.** During baseline, Zachary earned a mean of 6.2 words correct. During the Reading Assistant™ intervention phase, Zachary earned a mean of 8.3 words correct. When comparing results between the baseline and intervention conditions, there was an increase in 2.1 words correct during the Reading Assistant™ intervention phase. Zachary also obtained a ROI of 0.3 words per week and a PND of 30%. Zachary was administered an instructional level maze CBM probe 2 weeks following the last day of intervention. He received a score of 8 words correct for the instructional level probe.

Visual inspection of Zachary’s instructional level maze CBM data revealed a small increase in variability for words correct across the baseline phase. Upon implementation of Reading Assistant™, there was an immediate increase in level for words correct, with a high degree of variability observed across the intervention phase. No changes in data were observed for Ariana or Eli with the implementation of the Reading Assistant™ intervention for Zachary. There was an increase in level for words correct when data were taken 2 weeks following the end of the intervention.

**Ariana.** During the baseline phase, Ariana earned a mean of 11.8 words correct. During the Reading Assistant™ intervention, Ariana earned a mean of 18.8 words correct. When comparing results between the baseline and intervention conditions, there was an increase in 8 words correct during the Reading Assistant™ intervention phase. Ariana also obtained a ROI of 1 word per week while the PND was 60%. Ariana was administered an instructional level maze CBM probe 2 weeks following the last day of intervention. She received a score of 18 words correct for the instructional level probe.

Visual analysis of Ariana’s instructional level maze CBM data revealed that during baseline, there was minimal variability for words correct and a slight increasing
trend. After implementation of Reading Assistant™, there was an immediate increase in variability for words correct and an increasing trend towards the end of the intervention phase. The overall level for words correct increased during the Reading Assistant™ intervention in comparison to the baseline phase. No changes in data were observed for Eli with the implementation of the Reading Assistant™ intervention for Ariana. There was a decrease in level for words correct when data were taken 2 weeks following the end of the intervention.

**Eli.** During the baseline phase, Eli earned a mean of 14.2 words correct. During the Reading Assistant™ intervention phase, Eli earned a mean of 14.3 words correct. When comparing results between conditions, there was an increase of 0.1 words correct during the Reading Assistant™ intervention phase. Eli also obtained a ROI of 0 words per week while the PND was 0%. Eli was administered an instructional level maze CBM probe 2 weeks following the last day of intervention. Eli received a score of 11 words correct for the instructional level probe.

Visual inspection of Eli’s instructional level maze CBM data indicates that there was a gradual increasing trend for words correct and increased variability across the baseline phase. Upon implementation of Reading Assistant™, there was an immediate decrease in level for words correct, but then an increasing trend across the intervention phase. There was a decrease in level for words correct when data were taken 2 weeks following the end of the Reading Assistant™ intervention.
Grade Level Reading Comprehension Results for Group Two

Figure 4 also depicts the words correct on grade level maze CBM probes for Zachary, Ariana, and Eli across the baseline, intervention, and follow-up phases. As indicated earlier, Toby’s instructional reading level and grade level were the same and therefore his data will be excluded from this section. Only Eli demonstrated an increase in words correct during the intervention phase relative to baseline levels of performance. This increase in CWPM was also maintained at the 2-week follow-up.

**Zachary.** During baseline, Zachary earned a mean of 7.4 words correct. For the intervention phase, Zachary earned a mean of 5.7 words correct. When comparing means between the baseline and intervention conditions, there was a decrease of 1.7 words correct during the Reading Assistant™ intervention phase. Zachary also obtained a ROI of -0.2 words per week and obtained a PND of 0%. Zachary was administered a grade level maze CBM probe 2 weeks following the last day of intervention. He received a score of 12 words correct for the grade level probe. This score was higher than any other datum point for grade level probes in the baseline or intervention phases.

Visual inspection of Zachary’s grade level maze CBM data revealed a slight decreasing trend across the baseline phase for words correct. After Reading Assistant™ was implemented, there was a small increase in level but then a decreasing trend across the intervention phase. An increase in level was then observed for the last two data points. No changes in data were observed for Ariana or Eli with the implementation of the Reading Assistant™ intervention for Zachary. There was an increase in level for words correct when data were taken 2 weeks following the end of the Reading Assistant™ intervention.
**Ariana.** During baseline, Ariana earned a mean of 14.3 words correct. For the intervention phase, Ariana earned a mean of 13.6 words correct. When comparing the words correct means for grade level R-CBM probes between the baseline and intervention conditions, there was a decrease in 0.7 words correct during the Reading Assistant™ intervention phase. Ariana also obtained a ROI of -0.1 words per week on while the PND was 20%. Ariana was administered a grade level maze CBM probe 2 weeks following the last day of intervention. She received a score of 10 words correct for the grade level probe.

Visual inspection of Ariana’s grade level maze CBM data revealed an increasing trend across the baseline phase for words correct. After implementation of Reading Assistant™, there was a decrease in level and an increase in variability across the intervention phase. No changes in data were observed Eli with the implementation of the Reading Assistant™ intervention for Ariana. There was a decrease in level for words correct when data were taken 2 weeks following the end of the intervention.

**Eli.** During baseline, Eli earned a mean of 11.2 words correct. For the intervention phase, Eli earned a mean of 12.3 words correct. When comparing the words correct means for grade level R-CBM probes between the baseline and intervention conditions, there was an increase in 1.1 words correct during the Reading Assistant™ intervention phase. Eli also obtained a ROI of 0.2 words per week while the PND was 17%. Eli was administered a grade level maze CBM probe 2 weeks following the last day of intervention. He received a score of 8 words correct for the grade level probe.

Visual inspection of Eli’s grade level maze CBM data indicates that words correct remained relatively stable across the baseline phase until the last datum point when there
was an increase in level. After implementation of Reading Assistant™, there was an immediate decrease in level for words correct but then an increasing trend throughout the intervention phase. There was an increase in level for words correct when data were taken 2 weeks following the end of the intervention.
Figure 4. Group Two Reading Comprehension

This graph depicts a multiple-baseline across four participants: Toby, Zachary, Ariana, and Eli. Words Correct is displayed across all phases (baseline, intervention, and follow up). CG = Words Correct at grade level is depicted by square icons and CI = Words Correct at instructional level depicted by diamond icons.
Research Hypotheses

The four research questions that were proposed will be addressed below. Each question will be presented individually, with results from the study examined in order to address the question. As discussed earlier in this manuscript, when interpreting the data for ROI guidelines from Fuchs et al. (1993) will be utilized. Fuchs et al. (1993) reported ‘realistic’ and ‘ambitious’ growth standards, respectively, for oral reading fluency as follows: 1.5 and 2.0 words per week for second grade and 1.0 and 1.5 words per week for third grade. In regards to student progress with maze passages, realistic weekly improvement for first through sixth grade was found to be approximately .39 words per week while ambitious weekly improvement was calculated to be .84. Benchmarks utilized for the PND scores were established by Scruggs and Mastropieri (1998). Specifically, PND scores below 50% suggest an ineffective intervention effect, PND scores between 50% and 70% suggest a questionable intervention effect, PND scores between 70% and 90% suggest an effective intervention effect, and PND scores above 90% suggest a very effective intervention effect.

Research Question 1

*Will participating in the Reading Assistant™ computer based intervention sessions result in the improved oral reading fluency on instructional level probes of students in the second through third grades who are performing at least one year below grade level in reading?*

Of the eight participants that were involved in the study, there was an increase, although small in most cases, in mean CWPM during intervention over baseline levels for Ashley, Devon, Mickey, and Valerie after Reading Assistant™ was implemented. The
CWPM data for instructional level probes is presented in Table 2. Of the eight participants, Mickey and Valerie were the only two participants that had a ROI that met or exceeded the realistic weekly growth for their grade level. Only Mickey had a PND indicating that Reading Assistant™ was an effective intervention for improving oral reading fluency of instructional level text. The ROI and PND data for all participants is presented in Table 3.

Table 2

*Mean CWPM and Range for Instructional Level Reading CBM Probes*

<table>
<thead>
<tr>
<th>Student</th>
<th>Baseline</th>
<th>Reading Assistant™</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CWPM</td>
<td>Range</td>
</tr>
<tr>
<td>Ariana</td>
<td>68.3</td>
<td>55-83</td>
</tr>
<tr>
<td>Ashley</td>
<td>46.6</td>
<td>36-46</td>
</tr>
<tr>
<td>Devon</td>
<td>47.5</td>
<td>42-58</td>
</tr>
<tr>
<td>Eli</td>
<td>60.2</td>
<td>52-74</td>
</tr>
<tr>
<td>Mickey</td>
<td>51.4</td>
<td>39-57</td>
</tr>
<tr>
<td>Toby</td>
<td>64.3</td>
<td>61-68</td>
</tr>
<tr>
<td>Valerie</td>
<td>46.3</td>
<td>37-53</td>
</tr>
<tr>
<td>Zachary</td>
<td>54.4</td>
<td>49-65</td>
</tr>
</tbody>
</table>
Table 3

*Instructional Level Reading CBM Probes ROI and PND*

<table>
<thead>
<tr>
<th>Student</th>
<th>ROI</th>
<th>PND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ariana</td>
<td>-1.4</td>
<td>0</td>
</tr>
<tr>
<td>Ashley</td>
<td>0.6</td>
<td>0</td>
</tr>
<tr>
<td>Devon</td>
<td>1.1</td>
<td>63</td>
</tr>
<tr>
<td>Eli</td>
<td>-0.2</td>
<td>0</td>
</tr>
<tr>
<td>Mickey</td>
<td>1.9*</td>
<td>71*</td>
</tr>
<tr>
<td>Toby</td>
<td>-0.4</td>
<td>29</td>
</tr>
<tr>
<td>Valerie</td>
<td>1.9</td>
<td>60</td>
</tr>
<tr>
<td>Zachary</td>
<td>-0.4</td>
<td>0</td>
</tr>
</tbody>
</table>

*Note. *Data meet or exceeded improvement/growth criteria*

**Research Question 2**

*Will participating in the Reading Assistant™ computer based intervention sessions improve the literal comprehension skills on unpracticed maze probes at instructional level of students in the second through third grades who are performing at least one year below grade level in reading?*

For all students who were involved in the study, there was a mean increase, although small in most cases, in words correct during intervention over baseline levels on unpracticed maze probes during the intervention phase. CWPM data is presented in Table 4. Of the eight participants, Ariana, Ashley, Devon, and Valerie had a ROI that met or
exceeded the realistic growth rate for their grade level. Ashley and Valerie were the only two participants that had a PND indicating that Reading Assistant™ was an effective intervention for improving literal comprehension skills. The ROI and PND data for all participants is presented in Table 5.

Table 4

*Mean CWPM and Range for Instructional Level Maze CBM Probes*

<table>
<thead>
<tr>
<th>Student</th>
<th>Baseline</th>
<th>Reading Assistant™</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Words Correct</td>
<td>Range</td>
</tr>
<tr>
<td>Ariana</td>
<td>11.8</td>
<td>10-14</td>
</tr>
<tr>
<td>Ashley</td>
<td>5.3</td>
<td>3-7</td>
</tr>
<tr>
<td>Devon</td>
<td>10.5</td>
<td>7-12</td>
</tr>
<tr>
<td>Eli</td>
<td>14.2</td>
<td>8-21</td>
</tr>
<tr>
<td>Mickey</td>
<td>9.5</td>
<td>9-10</td>
</tr>
<tr>
<td>Toby</td>
<td>7.0</td>
<td>5-11</td>
</tr>
<tr>
<td>Valerie</td>
<td>7.2</td>
<td>5-11</td>
</tr>
<tr>
<td>Zachary</td>
<td>6.2</td>
<td>4-11</td>
</tr>
</tbody>
</table>
Table 5

*Instructional Level Maze CBM Probes ROI and PND*

<table>
<thead>
<tr>
<th>Student</th>
<th>ROI</th>
<th>PND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ariana</td>
<td>1.0*</td>
<td>60</td>
</tr>
<tr>
<td>Ashley</td>
<td>2.3*</td>
<td>86*</td>
</tr>
<tr>
<td>Devon</td>
<td>0.5*</td>
<td>50</td>
</tr>
<tr>
<td>Eli</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>Mickey</td>
<td>0.1</td>
<td>57</td>
</tr>
<tr>
<td>Toby</td>
<td>0.1</td>
<td>13</td>
</tr>
<tr>
<td>Valerie</td>
<td>0.9*</td>
<td>80*</td>
</tr>
<tr>
<td>Zachary</td>
<td>0.3</td>
<td>29</td>
</tr>
</tbody>
</table>

*Note.* *Data meet or exceeded improvement/growth criteria*

**Research Question 3**

*Will participating in the Reading Assistant™ computer based intervention sessions result in the improved oral reading fluency on grade level probes of students in the second through third grades who are performing at least one year below grade level in reading?*

Toby and Mickey will be excluded from this analysis since their instructional reading level and their grade level were the same. For all students that were involved in this analysis, there was an increase, although small in most cases, in CWPM on grade level R-CBM probes during intervention over baseline levels during the Reading Assistant™ intervention phase. CWPM for grade level R-CBM probes is presented in
Table 6. Of the six participants, Ashley and Valerie had a ROI that met or exceeded the realistic growth rate for their grade level. Only Ashley and Devon had a PND indicating that Reading Assistant™ was an effective intervention for improving oral reading fluency of grade level text. The ROI and PND data for participants for grade level R-CBM probes is presented in Table 7.

Table 6

*Mean CWPM and Range for Grade Level Reading CBM Probes*

<table>
<thead>
<tr>
<th>Student</th>
<th>Baseline Mean CWPM</th>
<th>Baseline Range</th>
<th>Reading Assistant™ Mean CWPM</th>
<th>Reading Assistant™ Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ariana</td>
<td>55.2</td>
<td>41-77</td>
<td>55.9</td>
<td>41-77</td>
</tr>
<tr>
<td>Ashley</td>
<td>30.6</td>
<td>22-41</td>
<td>45.1</td>
<td>34-54</td>
</tr>
<tr>
<td>Devon</td>
<td>29.5</td>
<td>28-30</td>
<td>37.0</td>
<td>20-53</td>
</tr>
<tr>
<td>Eli</td>
<td>52.5</td>
<td>37-64</td>
<td>56.7</td>
<td>39-71</td>
</tr>
<tr>
<td>Valerie</td>
<td>39.5</td>
<td>27-52</td>
<td>51.8</td>
<td>38-74</td>
</tr>
<tr>
<td>Zachary</td>
<td>49.8</td>
<td>39-62</td>
<td>52.3</td>
<td>39-63</td>
</tr>
</tbody>
</table>
Table 7

*Grade Level Reading CBM Probes ROI and PND*

<table>
<thead>
<tr>
<th>Student</th>
<th>ROI</th>
<th>PND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ariana</td>
<td>0.2</td>
<td>17</td>
</tr>
<tr>
<td>Ashley</td>
<td>2.1*</td>
<td>71*</td>
</tr>
<tr>
<td>Devon</td>
<td>0.9</td>
<td>88*</td>
</tr>
<tr>
<td>Eli</td>
<td>0.6</td>
<td>17</td>
</tr>
<tr>
<td>Valerie</td>
<td>2.1*</td>
<td>33</td>
</tr>
<tr>
<td>Zachary</td>
<td>0.4</td>
<td>14</td>
</tr>
</tbody>
</table>

*Note.* Data meet or exceeded improvement/growth criteria

**Research Question 4**

*Will participating in the Reading Assistant™ computer based intervention sessions improve the literal comprehension skills on unpracticed maze probes at grade level of students in second through third grades who are performing at least one year below grade level in reading?*

Mickey and Toby are excluded from this analysis, as their instructional reading level and grade level were the same. Out of the six participants that were involved in this analysis, Ashley, Devon, and Eli evidenced increase in a mean words correct during intervention over baseline levels on unpracticed maze probes during the Reading Assistant™ intervention phase. Ariana, Valerie, and Zachary experienced a decrease in mean words correct from their baseline. The data for words correct is presented in Table
8. Only Ashley and Devon had a ROI that met or exceeded the realistic growth rate for their grade level. One participant, Ashley, had a PND indicating that Reading Assistant™ was an effective intervention for improving literal comprehension skills of grade level text. The ROI and PND data for participants is provided in Table 9.

Table 8

*Mean CWPM and Range for Grade Level Reading Maze CBM*

<table>
<thead>
<tr>
<th>Student</th>
<th>Baseline</th>
<th>Reading Assistant™</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Words Correct</td>
<td>Range</td>
</tr>
<tr>
<td>Ariana</td>
<td>14.3</td>
<td>11-19</td>
</tr>
<tr>
<td>Ashley</td>
<td>6.7</td>
<td>2-13</td>
</tr>
<tr>
<td>Devon</td>
<td>10.3</td>
<td>4-18</td>
</tr>
<tr>
<td>Eli</td>
<td>11.2</td>
<td>7-21</td>
</tr>
<tr>
<td>Valerie</td>
<td>10.8</td>
<td>8-13</td>
</tr>
<tr>
<td>Zachary</td>
<td>7.4</td>
<td>5-10</td>
</tr>
</tbody>
</table>
Table 9

*Grade Level Maze CBM Probes ROI and PND*

<table>
<thead>
<tr>
<th>Student</th>
<th>ROI</th>
<th>PND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ariana</td>
<td>-0.1</td>
<td>20</td>
</tr>
<tr>
<td>Ashley</td>
<td>1.7*</td>
<td>71*</td>
</tr>
<tr>
<td>Devon</td>
<td>0.7*</td>
<td>25</td>
</tr>
<tr>
<td>Eli</td>
<td>0.2</td>
<td>17</td>
</tr>
<tr>
<td>Valerie</td>
<td>-0.5</td>
<td>0</td>
</tr>
<tr>
<td>Zachary</td>
<td>-0.2</td>
<td>0</td>
</tr>
</tbody>
</table>

*Note.* *Data meet or exceeded improvement/growth criteria*
CHAPTER V
DISCUSSION

Reading is the basis upon which many other academic skills are built (Flanagan et al., 2004). The National Reading Panel (2000) has identified the five essential skills students must master in order to become skilled readers. Reading fluency, or the ability to read text accurately and quickly, is one of the five essential skills. Struggling readers often require direct instruction in reading fluency, with this instruction including opportunities for intense, fluency-focused practice. Unfortunately, reading fluency is often a neglected component in reading instruction (Allington, 1983).

A number of empirically supported instructional strategies to address reading fluency have been identified by researchers. These strategies include RR (Dowhower, 1987; Koskinen & Blum, 1986; Rashotte & Torgeson, 1985; Samuels, 1979; Swain & Allinder, 1996), listening to a fluent model of reading (Rose, 1984; Skinner et al., 1993) and performance feedback (Heubusch & Loyd, 1998; Welsch, 2006). Reading Assistant™ incorporates these research-based strategies. It is a form of CAI that has been designed to be used as an intervention or as a supplement to traditional reading instruction. Due to the limited research on using CAI to address reading fluency, this study investigated the effects of Reading Assistant™ with struggling readers in the second and third grades.
Eight participants in the second and third grades determined to be at-risk of reading failure participated in the study. A multiple baseline across participants design was then used for the purpose of demonstrating if a functional relationship existed between the treatment (Reading Assistant™) and the dependent variable. Multiple sources of data were utilized to determine the overall effectiveness of Reading Assistant™. Data for reading fluency were collected using instructional and grade level R-CBM probes. CWPM served the primary unit of analysis for reading fluency. Data for reading comprehension were collected using instructional and grade level maze CBM probes. Words correct served as the primary units of analysis for reading comprehension. In addition to visual analysis of the data, the effect of the Reading Assistant™ computer program was also evaluated by determining the ROI as well as by calculating the PND for each participant.

The remainder of this chapter will address (a) each of the four research questions as they pertain to the results, (b) discussion of the results, (c) implications of the study and (d) limitations of the study as well as future research suggestions. The chapter will conclude with a summary of the investigation.

**Research Questions**

Four research questions will be addressed below. Each question will be explored relative to the group and then individual participants within the group. Guidelines from Fuchs et al. (1993) were used regarding expected ROI while the benchmarks utilized for PND were established by Scruggs and Mastropieri (1998).
Research Question 1

The first research question that was proposed looked at whether Reading Assistant™ would improve participants’ oral reading fluency on instructional level R-CBM probes relative to baseline conditions. This question required a direct comparison of CWPM means in the baseline and intervention conditions. The results of this study indicated that for four of the eight participants involved in the study, there was a mean increase in CWPM over baseline levels during the Reading Assistant™ intervention phase. The largest increase in CWPM was evidenced by Mickey (13.6), followed by Valerie (11.5), Devon (8.8), and Ashley (3.8). Visual inspection of the data revealed that there was a modest increasing trend for CWPM during the baseline phase for Ashley, Devon, and Mickey. Consequently, it is possible that the increase in CWPM during the intervention phase may have been due to another variable and may not be a result of Reading Assistant™. Follow-up instructional level R-CBM probes given 2 weeks after the Reading Assistant™ intervention indicated that for four of the eight participants in the study, there was an increase in CWPM relative to the last data point.

Of the four participants who had increases in oral reading fluency, only Mickey and Valerie exceeded the realistic weekly growth rate of 1.5 CWPM. Devon came close to the realistic weekly growth rate with a ROI of 1.1 while Ashley had a ROI of 0.6. The effect size for the four participants also varied. Effect size results suggest that Reading Assistant™ appeared to be an effective intervention for Mickey. Reading Assistant™ had questionable intervention effectiveness for Devon and Valerie. Further, although Ashley made improvements in her oral reading fluency over the course of this study on instructional level probes, based on her PND of 0%, Reading Assistant™ may have had
no impact on this improvement. PND results for other participants indicate that Reading Assistant™ was likely an ineffective intervention for improving their oral reading fluency when reading instructional level text.

**Research Question 2**

The second research question looked at whether Reading Assistant™ was effective at improving participants’ literal reading comprehension skills relative to their baseline functioning level on instructional level maze CBM probes. This question required a direct comparison of word correct means between the baseline and intervention conditions. The results of this study indicate that all eight of the participants evidenced a slight increase in word correct means from baseline to the intervention phase. Some students had larger increases than others. Ashley had the largest increase (8.4), followed by Ariana (7.0), Valerie (5.2), Devon, (3.6) and Zachary (2.1). Other students made smaller improvements. These students include Mickey (0.8), Toby (0.8), and Eli (0.1). The increase in words correct should be interpreted cautiously for Devon, Eli, and Ashley due to a high number of word errors during the intervention phase, which may suggest a possible tendency to randomly circle answer choices. Visual results of the data also revealed that Devon, Eli, and Ashley had an increasing trend for words correct in the baseline phase and, therefore, it cannot be conclusively determined that the increase in words correct was entirely due to the implementation of Reading Assistant™. Follow-up instructional level maze CBM probes given 2 weeks after the Reading Assistant™ intervention indicated that for all participants in the study, there was a small increase in words correct relative to the last data point.
Of the eight participants in the study, a total of four had a ROI that met or exceeded the realistic weekly rate of growth of .39 words correct per week. These students were Ariana, Ashley, Devon, and Valerie. The effect size for participants varied. Effect size results indicate that Reading Assistant™ appears to have been an effective intervention for Ashley and Valerie. Reading Assistant™ had questionable intervention effectiveness for Ariana, Mickey, and Devon. PND results for other participants indicate that Reading Assistant™ was likely an ineffective intervention for improving their comprehension of instructional level text.

**Research Question 3**

The third research question looked at whether Reading Assistant™ would improve participant’s oral reading fluency relative to baseline functioning level on grade level R-CBM probes. Toby and Mickey’s results will be excluded from this discussion because their grade level and instructional level were found to be the same. The results of this study indicated that for all students included in this analysis, there was an increase in mean CWPM on grade level probes over baseline levels in the Reading Assistant™ intervention phase. The largest increase in mean CWPM was evidenced by Ashley (14.5) followed by Valerie (12.3), Devon (7.5), Eli (4.2), Zachary (2.5) and Ariana (0.7). Visual inspection of the data revealed that Ashley and Ariana had increasing trends for CWPM on grade level probes during the baseline phase. Consequently, it cannot be conclusively determined that the implementation of Reading Assistant™ was entirely responsible for the increase in CWPM for the six participants. Follow-up grade level R-CBM probes given 2 weeks after the Reading Assistant™ intervention indicated that for all six participants there was a small increase in CWPM relative to the last data point.
Ashley and Valerie had the greatest rates of improvement, exceeding the realistic weekly growth rate of 1.5 CWPM per week. The effect size for participants varied. Effect size results indicate that Reading Assistant™ appears to have been an effective intervention to address reading fluency for Ashley and Devon. The PND results for other students indicate that Reading Assistant™ was likely an ineffective intervention for improving their oral reading fluency when reading grade level text.

**Research Question 4**

The final research question explored whether Reading Assistant™ would improve participant’s literal comprehension skills relative to their baseline functioning level on maze CBM probes at grade level. Three of the six participants included in this analysis evidenced increases in mean words correct over baseline levels. The participant with the largest increase in words correct was Ashley (11.9), followed by Devon (5.2), and Eli (1.1). This finding should be interpreted cautiously, however, due to the high number of word errors evidenced by Ashley, Devon, and Eli during the intervention phase which suggests that they may have had a tendency to randomly circle answer choices. Ashley and Eli also had increasing trends in regards to CWPM during the baseline phase and therefore it cannot be conclusively determined that Reading Assistant™ was responsible for the increase in words correct or whether this increase could be attributed to another extraneous variable. Follow-up maze CBM probes given 2 weeks after the Reading Assistant™ intervention indicated that for three of the six participants, there was a small increase in words correct, relative to the last data point.

Further, of the six students, Ashley and Devon had the greatest rates of improvement and exceeded the realistic weekly growth rate of .39 words correct. In
regards to effect size, Ashley was the only participant with a PND indicating that Reading Assistant™ may have been effective at improving her reading comprehension of grade level material. The remaining participants had effect sizes indicating that Reading Assistant™ was likely an ineffective intervention for improving their comprehension of grade level text.

Discussion of Results

When analyzing multiple sources of data, the results of this study suggest that Reading Assistant™ may have been a modestly effective intervention for a few of the participants. However, if looking solely at effect size data, results may be interpreted to mean that Reading Assistant™ did not have a significant impact on the reading fluency or the reading comprehension skills of the majority of students. Of the students who did demonstrate progress with Reading Assistant™, results indicate that they generally did not make the gains necessary for them to catch up with same grade peers. Only one student, Mickey, decreased his AIMSweb risk status and was considered in the ‘low risk’ range at the conclusion of the study. This finding is troublesome given that the majority of participants had started the study in the ‘high risk’ range. There are several potential reasons for the lack of effectiveness of the Reading Assistant™ computer program. These reasons will be discussed further in the section below.

One factor to consider is that three of the eight participants involved in the study had been diagnosed with ADHD. These students were Ashley, Toby, and Zachary. All three students were taking medication to address symptoms of ADHD at the time of the study. Although Reading Assistant™ may have had some positive effect for Ashley, Toby and Zachary did not appear to demonstrate a positive response to the intervention in
terms of either reading fluency or comprehension skills. These two students were ultimately found eligible to receive special education services under the Other Health Impaired (OHI) category. It is possible that Toby and Zachary’s difficulties with sustaining focused attention may have negatively impacted their response to the intervention. Research has found that 20-30% of children who have been diagnosed with ADHD are classified as having a learning disability (DuPaul & Stoner, 2003) while as many as 80% of individuals with ADHD exhibit academic performance problems (Cantwell & Baker, 1991). Although CAI has been proposed as an effective strategy for students with ADHD due to its engaging interactive nature (Ota & DuPaul, 2002) and research has demonstrated positive results for students with ADHD who have used CAI to address reading deficiencies (Clarfield & Stoner, 2005), further research needs to be conducted to determine if Reading Assistant™ is an appropriate intervention for this population of students.

Another potential explanation for the lack of effectiveness for participants could be attributed to the possibility that the at-risk readers in this study required a more intense, targeted level of intervention in order to demonstrate progress. Of the two prior studies of Reading Assistant™ that were reported earlier in this manuscript, both involved a general population of students and did not specifically target children with reading deficiencies as did the present study (Adams, 2006; Devine, 2009). Adams (2006) found positive results in the area of reading fluency, with a large effect size obtained for mainstream students in the second and third grades. These results differed from Devine’s (2009) investigation of Reading Assistant™ with mainstream second grade students, in which positive results were not obtained.
Al Otaiba and Fuchs (2002) reviewed 23 studies of literacy interventions with participants ranging from preschool to third grade and found that between 8 to 80 percent of all participants did not respond to interventions. These students have been called ‘non-responders’ (Torgesen, 2000). Students may be determined to be non-responders if they do not make adequate progress after being exposed to empirically based instruction. Determining whether a student is a non-responder is important, because within the RTI model, eligibility for special education services is based upon a student’s response to progressively intense levels of intervention. Torgesen (2000) has suggested that more intensive intervention may be necessary for students that do not respond to generally effective interventions.

Al Otaiba and Fuchs (2006) have identified several learner characteristics associated with a lack of responsiveness to intervention. These characteristics include deficits with verbal memory, rapid naming and vocabulary as well as with demonstration of problem behavior. These factors, in addition to the amount of intervention that children received, correctly identified 82.4% of those students who were non-responders. In addition to the individual learner characteristics as determined by Al Otaiba and Fuchs (2006), a further element that may have impacted results is amount of intervention that participants in the present study received. The current recommended time period for measuring response to instruction is at least 8 weeks (Fuchs & Fuchs, 2005). Only Toby and Devon had 8 weeks of intervention. In the present study, intervention sessions were scheduled for 30 minutes per day, but students were only required to complete a 20-minute session with Reading Assistant™. For students in kindergarten through the third grade, 20 minutes is the recommended amount of session time (Scientific Learning
Corporation, 2010). In the Adams (2006) study, individuals participated in the Reading Assistant™ intervention at least two times per week for 30 minutes over a 17 week period while in the Devine (2009) study, individuals participated daily for 20 minutes over an 8 week period. Positive results were only found in the Adams (2006) study, suggesting the possibility that a lengthened period of intervention is needed for students to evidence significant gains in reading fluency and comprehension when using Reading Assistant™. Evidence has suggested that increasing the intensity of effective instruction through more time spent in intervention or by smaller groups may have positive effects on student outcomes (Torgesen et al., 2001).

One factor that may have affected the amount of time some participants were able to use Reading Assistant™ is the difficulty that some students experienced with setting up the microphone headsets properly. Each time that a student logs onto Reading Assistant™, he or she has to complete a microphone check that automatically begins at the start of each Record My Reading session. For the software to work properly, the headset must be correctly positioned before student begins reading. Based on direct observation of Reading Assistant™ sessions by the author of this study as well as teacher anecdotal reports, students appeared to have some difficulty with positioning the headset in a manner so that the microphone was not either too close or too far away from their mouth. Further, too much background noise in the computer lab (e.g. other students talking) also interfered with voice intelligibility. This occurred when the noise in the room was louder than the participant’s voice. When a low signal-to-noise ratio is detected, Reading Assistant™ guides the student through basic troubleshooting and then initiates the microphone check again (Scientific Learning Corporation, 2010). Not only
did this have the potential to decrease the amount of time students spent engaged in the intervention, but it appeared to be a feature that was especially frustrating for some individuals. No formal data was taken on lost intervention time due to issues with noise or microphone placement.

It is important to note that Adams (2006) reported that actual reading time for participants using the Reading Assistant™ program in her study only averaged approximately 8 minutes. The remainder of the time was spent on teacher led tasks and text discussion, reviewing selections as well as comprehension activities. Although data on actual amount of time reading was not obtained in the present study, information was obtained on the number of reading selections that each participant completed. All participants, except for Eli, completed at least 30 reading selections. Eli was a student with persistent issues with coming to school late and this interfered with his ability to complete every scheduled intervention session. He completed only 15 reading selections during Reading Assistant™ intervention phase. The students who completed the most selections included Devon (39 reading selections), Mickey (37 reading selections), Toby (39 reading selections) and Zachary (36 reading selections).

Another factor to consider when interpreting the results of this study is whether this intervention was appropriate for all participants. Academic difficulties can be experienced for a variety of reasons and students can respond uniquely to different interventions (Wilber & Cushman, 2006). Understanding a student’s stage in the Instructional Hierarchy model and reason for academic difficulty are important starting places in selecting appropriate interventions. According to the Instructional Hierarchy model that was discussed earlier in this manuscript, a student must first acquire the
foundational skills of reading and become accurate with these skills before he or she will be able to read fluently (Haring & Eaton, 1978). Some of the participants in the present study may have not yet acquired some of the basic prerequisite skills needed to maximally benefit from a fluency building intervention due to being in the acquisition stage of reading. Reading Assistant™ does not target the foundational skills of reading such as phonemic awareness and decoding skills but instead targets reading fluency and comprehension. Accordingly, the intervention would most likely benefit students reading material slowly but with a minimal number of errors.

**Implications**

The concept of individualizing interventions by selecting them based on a student’s skill level and areas of need instead of using a one size fits all approach aligns with the RTI framework. Using such an intervention model allows school personnel to make intervention decisions based on student pre-intervention levels of performance. This RTI approach allows for special education eligibility under the assumption that those students who do not respond to targeted, empirically based interventions require more specialized, intense instruction in order to meet their needs (Barnett, Daly, Jones, & Lentz, 2004).

Reading Assistant™ is attractive given the constraints in the public education system in terms of limited time for intervention, available resources, as well as knowledge of and access to effective interventions. Reading Assistant™ also incorporates a number of research supported instructional strategies for addressing reading fluency to include RR, previewing, and error correction. Many studies have demonstrated that combining reading interventions into a single intervention package can enhance results.
(Alber-Morgan, Ramp, Anderson, & Martin, 2007; Martens et al., 2007). Despite the attractive aspects of this computer program, Reading Assistant™ is from a for profit company and requires a substantial investment from schools in terms of required equipment (e.g. computers, microphone headsets) as well as ongoing fees for product use. This program may, therefore, not be a cost effective solution to address reading fluency and comprehension.

Based on results from the present study, Reading Assistant™ also does not appear to be a program that is effective at improving reading fluency or comprehension skills of all struggling readers and it is not clear at this point in time what student characteristics determine whether or not the program will be effective. Consequently, it should likely only be considered for students on an individual basis and not used as blanket approach for addressing reading deficits. Within the RTI framework, Reading Assistant™ may be useful as a supplement to Tier I core instruction. Reading Assistant™ may not be appropriate as a Tier II intervention except for certain individuals, such as those who have mastered the foundational skills of reading and simply need more practice. These factors need to be strongly considered before a school decides to adopt Reading Assistant™ as an intervention or supplemental reading program.

This study expands upon the previous research of Adams (2005) that examined the effectiveness of Reading Assistant™ with 410 students in a mainstream setting and found support for the use of this program to address reading fluency. The results of the current study did not find the significant gains in reading fluency that were obtained by Adams. This study also expands upon the research of Devine (2009) who used a mixed methodology design in order to investigate Reading Assistant™ and another fluency
intervention program with 90 students in a mainstream setting. Through an informal analysis of results, Devine found that Reading Assistant™ was not effective at improving the reading fluency of participants. Unlike the previous studies that investigated the use of Reading Assistant™ with a general population of students, this study investigated the use of Reading Assistant™ with students identified as being at-risk in the area of reading. It also employed a multiple baseline, single subject design that included weekly progress monitoring so that individual participant results could be analyzed.

**Limitations and Directions for Future Research**

There were several limitations to this study and, therefore, the findings should be evaluated cautiously as results are only meaningful to the extent that they can be confidently interpreted. Some limitations are due to sources of threat to the internal and external validity of an experiment (Campbell and Stanley, 1963). Internal validity refers to whether the independent variable produced the observed effect on the dependent variable while external validity is defined as the degree that results can be generalized to other populations, settings, or target behaviors.

History is a threat to internal validity that relates to external events producing changes in the behavior of subjects during the experiment or between repeated measures of the dependent variable. The participants in this study were all receiving academic instruction in the area of reading outside of the intervention as part of their regular school day. Therefore, there is no way of knowing whether regular reading instruction was responsible for any improvements that were made in reading fluency and comprehension skills.
Another threat to the internal validity of this study is maturation. Maturation is a term used to describe internal changes to the subject during the course of the experiment or between repeated measures of the dependent variable. Although this study was relatively brief, it is possible that changes in subjects as a result of maturation may have occurred. Another factor that may have affected the internal validity of results was the differing use of the Reading Assistant™ program by participants in the study. This threat was minimized by providing structured training in regards to the use of the program as well as having direct supervision by an adult at all times while the participants were being exposed to the computer program. Regardless of the structure and supervision provided, it is likely that individual factors affected students’ interaction with the computer program.

Another factor to consider when interpreting the validity of the results is the single subject experimental design. Results were not compared to a control group and therefore it is unclear whether students not receiving the intervention would have made similar progress. Further, if the current study had not been limited in time due to the constraints of the school year, it would have been appropriate to wait for the baseline data to stabilize before beginning the intervention phase. The variability of baseline data for some participants made it difficult to analyze the data and determine whether a functional relationship had occurred using visual inspection.

In regards to external validity, the outcome of this investigation will only be generalizable to the extent that the demographic characteristics of the subjects match the population as a whole. The small sample size of this study negatively impacts the generalizability of the results. The sample only consisted of second and third grade
students from one rural elementary school in North Carolina. Participants were also not randomly selected from the population but were selected for inclusion in the study based on the school they attended and their reading level. These factors negatively impact the ability to generalize this study’s findings.

Future studies should investigate the utility of Reading Assistant™ with a different population of students to include varying ethnicities as well as grade levels. Additional research also needs to be conducted to determine whether Reading Assistant™ is a cost effective means of addressing reading fluency and comprehension and whether it is effective as either a supplement to a core reading program or as a targeted intervention. For those who did make gains in oral reading fluency and/or comprehension skills in the present study, there is not data to determine whether gains were maintained months after intervention implementation. Additional research is needed to determine if gains are maintained. Further, the effectiveness of this program may change if implemented in a natural classroom environment under less supervision. Additional research is needed to determine the effectiveness of Reading Assistant™ under less well-monitored classroom conditions. Future research could also examine the effectiveness of Reading Assistant™ during a period of time, such as during summer vacation, when participants are not receiving any other academic instruction in the area of reading. Finally, in the current study social validity was not assessed. Further research will need to be conducted to determine if educators find Reading Assistant™ to be acceptable, useful, and feasible for use within a school setting.
Summary

Reading Assistant™ incorporates evidence-based practices for struggling readers in a CAI format that allows for increased opportunities for individualized instruction. This study examined the effectiveness of the Reading Assistant™ on the oral reading fluency and reading comprehension skills of eight second and third grade students at-risk for reading failure utilizing a multiple baseline across participants design. Multiple sources of data were collected to determine the overall effectiveness of the Reading Assistant™ computer program. Taken as a whole, the data for this study suggest that Reading Assistant™ may have been an effective method for increasing the oral reading fluency and reading comprehension skills of only a few select participants and only to a modest degree. The effect size data do not provide a convincing demonstration that Reading Assistant™ had a substantial impact on the majority of struggling readers involved in this study. It is possible that Reading Assistant™ could serve as a supplement to a traditional reading program but may not be best suited as an intervention for struggling readers.

Research has consistently demonstrated that students with reading difficulties who are identified early and given appropriate intervention can acquire the skills needed to become skilled readers. Given the importance of targeting the critical skill of reading fluency, additional research is needed to establish the efficacy of Reading Assistant™ as well as other forms of CAI with at-risk readers. Further research should attempt to address the aforementioned limitations to further evaluate the usefulness of this computer program in appropriately addressing the reading fluency and comprehension skills of students.
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February 9, 2012

Margaret Bush
407 Rustic Ct
Pollocksville, NC 28573

RE: IRB Study #12-025: An Investigation of the Effects of a Computer-Assisted Reading Program on the Oral Reading Fluency and Comprehension of Elementary Students

Dear Ms. Bush:

This email serves as official documentation that the above referenced project was reviewed and approved via administrative review on 2/9/2012 in accordance with 45 CFR 46.101(b)(1). Continuing review is not necessary for this project. However, any modification to the project must be reviewed and approved by the IRB prior to implementation. Any failure to adhere to the approved protocol could result in suspension or termination of your project. The IRB reserves the right, at any time during the project period, to observe you and the additional researchers on this project. Please note that the MSU IRB is in the process of seeking accreditation for our human subjects protection program. As a result of these efforts, you will likely notice many changes in the IRB's policies and procedures in the coming months. These changes will be posted online at http://www.orc.msstate.edu/human/aahrpp.php. The first of these changes is the implementation of an approval stamp for consent forms. The approval stamp will assist in ensuring the IRB approved version of the consent form is used in the actual conduct of research. Your stamped consent form will be attached in a separate email. You must use copies of the stamped consent form for obtaining consent from participants. Please refer to your IRB number (#12-025) when contacting our office regarding this application. Thank you for your cooperation and good luck to you in conducting this research project. If you have questions or concerns, please contact me at nmorse@research.msstate.edu or call 662-325-3994.

Sincerely,

Nicole Morse
Assistant Compliance Administrator
APPENDIX B

SAMPLE AIMSWEB R-CBM PROBE
"Where are you going, Dad?" I ask excitedly. I wonder if something interesting is happening. "I'm going to search for some deer. Would you like to come along? We'll take a trek in the woods," replies Dad. "I love going for walks. Wait for me!" I reply. "I want to go too!" yells Mike, my younger brother. "Please help me tie my shoes!"

"Don't worry, Mike. I will help you. Dad always waits for both of us," I explain calmly. We live in the country with huge trees behind our house. During the different seasons of the year, my brother and I like to walk along the paths that go through the trees. Dad usually goes with us and teaches us things about nature. It's a fall afternoon and our shuffling feet make quite a racket through the dry leaves. Dad tells us to try to be quiet. He doesn't want us to scare the deer away.

"Shhhh!" says Dad. "Stop and listen!" My little brother and I stop, but we don't hear anything. "I hear something!" whispers Mike. "Over there!" he points. I look to where he's pointing and see a big, brown deer looking right at us! She isn't moving, but her head is up high. She's listening just like we are! The deer puts her head down, grunts, and stomps her front hoofs on the ground. We wait while Dad smiles and lifts his camera to his face. Click! ... whirr ... Click! Dad takes two pictures. Two smaller deer stand behind the doe! They are her baby fawns, born last spring. They are eating acorns off the ground. The fawns don't even see us! The doe snorts again and turns to jump away. The two little deer follow her. "That was really cool, Dad. Thanks for taking us with you," we say.
Data Collection Form: AIMSweb R-CBM

Participant Name: _____________________________

Person Completing Form ____________________________

Session Date: ________________ Time: _________ Passage Number: __________

Study Phase: _____ Baseline_____ Intervention _____ Follow-up

AIMSweb R-CBM Standard Directions for 1-minute administration
1. Place the unnumbered copy in front of the student
2. Place the numbered copy in front of you but shielded so the student cannot see what you record
3. Say: “When I say ‘Begin’, start reading aloud at the top of this page. Read across the page (Demonstrate by pointing). Try to read each word. If you come to a word you don’t know, I’ll tell it to you. Be sure to do your best reading. Are there any questions?” (Pause)
4. Say: “Begin” and start your stopwatch when the student says the first word. If the student fails to say the first word of the passage after 3 seconds, tell them the word, mark it as incorrect, then start your stopwatch.
5. Follow along on your copy. Put a slash (/) through words read incorrectly.
6. At the end of 1 minute, place a bracket (]) after the last word and say “Stop”
7. Score and summarize by writing WRC/Errors.

Familiar Shortened Directions:
“When I say ‘Begin’, start reading aloud at the top of this page.”

CWPM:_____
EWPM:_____
Comments:

APPENDIX D

SAMPLE AIMSWEB MAZE PROBE
"Where are you going, Dad?" I ask excitedly. I wonder if something interesting is happening (followed, shuffling). "I'm going to search for some (deer, stop, pink). Would you like to come along? (Who, Want, We'll) take a trek in the woods," (replies, eating, ground) Dad. "I love going for walks. (Her, Live, Wait) for me!" I reply. "I want (for, to, and) go too!" yells Mike, my younger (brother, clicks, headed). "Please help me tie my shoes!" "(We’ll, Deer, Don't) worry, Mike. I will help you. (His, Dad, If) always waits for both of us," (Me, I, We) explain calmly. We live in the (country, brother, wouldn’t) with huge trees behind our house. (During, wonder, always) the different seasons of the year, (my, so, us) brother and I like to walk (along, during, before) the paths that go through the (search, some, trees). Dad usually goes with us and (teaches, myself, stomps) us things about nature. It's a (her, love, fall) afternoon and our shuffling feet make (turns, quite, away) a racket through the dry leaves. (Dad, Deer, Puts) tells us to try to be (quiet, away, eating). He doesn't want us to scare (you, the, an) deer away."Shhhh!" says Dad. "Stop (and, puts, or) listen!" My little brother and I (both, snort, stop), but we don't hear anything. "I (yell, hear, you) something!" whispers Mike. "Over there!" he (snorts, offer, points). I look to where he's pointing (be, and, or) see a big, brown deer looking (during, goes, right) at us! She isn't moving, but (his, her, will) head is up high. She's listening (for, don’t, just) like we are! The deer puts (by, her, it) head down, grunts, and stomps her (away, tilted, front) hoofs on the ground. We wait (trees, while, from) Dad smiles and lifts his camera (at, me, to) his face. Click! ... whirr ... Click! Dad (likes, takes, today) two pictures. Two smaller deer stand (behind, smile, yells) the doe! They are her baby (paths, with, fawns), born last spring. They are eating (trees, acorns, behind) off the ground. The fawns don't (even, stop, use) see us! The doe snorts again
(hear, or, and) turns to jump away. The two (leaves, little, ground) deer follow her. "That was really (brown, deer, cool), Dad. Thanks for taking us with (the, you, me)," we say.

Adapted from: http://www.aimsweb.com/uploads/pdfs/Maze_Grade%203.pdf
APPENDIX E

DATA COLLECTION FORM: AIMSWEB MAZE CBM (INITIAL ADMINISTRATION)
1. Pass Maze passage out to student. Have the student put their name on the cover sheet. Make sure they do not turn page until you tell them to do so.

2. Say to the student: “When I say ‘Begin’ I want you to silently read a story. You will have 3 minutes to read the story and complete the task. Listen carefully to the directions. Some of the words in the story are replaced with a group of three words. Your job is to circle the 1 word that makes the most sense in the story. Only one word is correct.”

3. Go over practice test: “Let’s practice one together. Look at your first page. Read the first sentence silently while I read it aloud: ‘The dog apple, broke, ran after the cat.’ The three choices are apple, broke, ran. ‘The dog apple after the cat.’ That sentence does not make sense. ‘The dog broke after the cat.’ That sentence does not make sense. ‘The dog ran after the cat.’ That sentence does make sense, so circle the word ran.” (Make sure students circle the word ran) “Let’s go to the next sentence. Read it silently while I read it aloud. The cat ran fast, green, for up the hill. The three choices are fast, green, for. Which word is the correct word for the sentence?” Student answers fast “Yes, ‘The cat ran fast up the hill.’ is correct, so circle the correct word fast.” (Make sure students circle fast) “Silently, read the next sentence and raise your hand when you think you know the answer.” (Make sure student know the correct word. Read the sentence with the correct answer) “That’s right, ‘The dog barked at the cat.’ is correct. Now what do you do when you choose the correct word?” (Students answer) “Circle it.” Make sure students understand the task “That’s correct, you circle it. I think you’re ready to work on the stories on your own.”

4. Start testing by saying….. “When I say “Begin”, turn to the story and start reading silently. When you come to a group of three words, circle the 1 word that makes the most sense. Work as quickly as you can without making mistakes. If you finish the first side turn to the back of that page and keep working until I say ‘Stop’. Do you have any questions?”

5. Then say, “Begin” start your stopwatch.
6. Monitor student to make sure they understand that they are to circle only 1 word. If a student finishes before the time limit, record the time on the page.
7. At the end of 3 minutes say: “Stop. Put your pencil down.”

Completion Time:____ Words correct:____ Words incorrect:____
APPENDIX F

DATA COLLECTION FORM: AIMSWEB MAZE CBM
Data Collection Form: AIMSweb Maze

Participant Name: _______________________________

Person Completing Form: __________________________

Session Date: ________________ Time: _________ Passage Number: __________

Study Phase: _____ Baseline _____ Intervention _____ Generalization

1. Pass Maze passage out to student. Have the student put their name on the Cover Sheet. Make sure they do not turn page until you tell them to do so. Start testing by saying…..“When I say “Begin”, turn to the story and start reading silently. When you come to a group of three words, circle the 1 word that makes the most sense. Work as quickly as you can without making mistakes. If you finish the first side turn to the back of that page and keep working until I say ‘Stop’. Do you have any questions?”

2. Then say, “Begin” start your stopwatch.

3. Monitor student to make sure they understand that they are to circle only 1 word.

4. If a student finishes before the time limit, record the time on the page.

5. At the end of 3 minutes say: “Stop. Put your pencil down.”

6. Collect the Maze task.

Completion Time:_____

Words correct:_____

Words incorrect:_____

Comments:

APPENDIX G

READING ASSISTANT™ TRAINING CHECKLIST
# Procedural Integrity: Reading Assistant™ Training Checklist

**Participant Name:** ___________________________ **Date:** ______________

<table>
<thead>
<tr>
<th>Trainer’s Actions</th>
<th>Yes/No</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduced Program</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Had participant demonstrate knowledge of how to use a mouse</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Showed participant how to log onto program</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reviewed components of the Library screen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reviewed “Preview and Read Silently” activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demonstrated how to click on unknown words</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reviewed Glossary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reviewed how to complete guided reading questions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reviewed “Record My Reading” Activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Had student practice microphone check</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Had student practice reading story into microphone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reviewed “Take the Quiz” activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Review Selection Report and Fluency Progress Report</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demonstrated how to log out of program</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asked if there were any questions about the program</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>