

HELPING POOR READERS: A CASE STUDY OF A COMPUTER ASSISTED INSTRUCTION READING TUTORIAL

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Abstract

Reading is an essential skill for functioning in modern society, fundamental to achievement and success. Yet, an alarming proportion of students have significant difficulties with reading. Research indicates that computer assisted instruction (CAI) can provide an effective educational tool to help poor readers. This case study investigates the effectiveness of a CAI reading tutorial in helping poor readers improve their ability to read. The multimedia CAI program investigated supports the active cognitive participation of the learner, delivers multisensory instruction, provides timely, directed feedback, teaches phonics skills, and implements 100 percent mastery learning. The instruction is individualized and self-paced. Results of pre-post reading comprehension tests and interviews indicate that poor readers completing the CAI tutorial significantly improved their reading skills and the students and their teachers felt that using the CAI tutorial helped the students become better readers.

Keywords: Computer assisted instruction, CAI, reading instruction, poor readers, phonics, low-ability learners, mastery learning, multimedia

Introduction

Reading is an essential skill for functioning in modern American society, fundamental to individual achievement and success (Chall 1967; Carroll & Chall 1975; Lyon 1998; Snow, et al. 1998). The ability to read provides access to written information and is necessary for understanding and learning from text-based resources in all media formats. Consequently, teaching students to read is one of the primary objectives of the American educational system. Although twenty-five (25) to thirty (30) percent of students master reading relatively easily (Lyon 1998), an alarming proportion of students have significant difficulties with reading (Steinberg, et al. 1996; Donahue, et al. 2001). Despite the efforts of teachers, parents and several national educational system literacy initiatives over a number of decades (Calfee & Drum 1986; Steinberg et al. 1996), many students continue to have reading abilities far below those expected at their grade levels. In the Nation's Report Card for Fourth Grade Reading for 2000, more than 68 percent of the nation's fourth graders scored below the recommended *proficient* level (Donahue et al. 2001). That number jumps to more than 85 percent of fourth graders in high-poverty schools. Compounding the problem, poor reading skills adversely affect a student's other learning endeavors, often causing serious learning difficulties and resulting in low academic achievement overall (Bloom 1997). Consequently, it is imperative to find instructional methods and media to help poor readers develop and improve their reading skills and achieve reading proficiency. Yet, herein lies the problem. How do we help poor readers become proficient readers? What instructional methods and media are effective for poor readers? With proper design and application, computer assisted instruction (CAI) may be part of the answer (Hall, et al. 2000).

This case study was undertaken due to a lack of scientific evidence regarding the design and effectiveness of a CAI reading tutorial in helping poor readers improve their ability to read. The CAI was being implemented at a local Title I elementary school and the researcher was asked to help evaluate its effectiveness. In addition, anecdotal evidence indicated that poor readers (school age to adults) who were completing the CAI tutorial were experiencing large improvements in their reading comprehension skills. In one such case, a high school drop out increased his reading ability from a 2nd grade reading level to an adult reading level after completing the CAI in less than 60 hours of instruction. As a result, the case study was undertaken with three objectives: 1) to scientifically investigate if poor readers using the CAI significantly improved their reading abilities, and assuming the CAI was

effective, 2) to identify the instructional methods and strategies implemented in the CAI design, and 3) to theoretically explain the effectiveness of the CAI and thereby provide information on effective methods of designing effective CAI for poor readers.

The Background section will discuss the literature on learning theory and instructional methods important in the design and implementation of a CAI reading tutorial for poor readers. Next, the Case Study section will describe the details of the investigation of the multimedia CAI reading tutorial, Larrabee's Bridge to Adult Literacy (LBAL), including a description of the LBAL program and the case study methods employed. The Results section will report the findings of the case study and the Discussion section will conclude the paper with the implications of these findings.

Background

In considering how to design an effective CAI reading tutorial for poor readers, it is important to understand how poor readers learn. Thus, the active participation of the learner in developing mental schemas and multisensory perceptions in learning will be discussed. In addition, instructional design impacts the quality and quantity of learning (Newby, et al. 2000; Schunk 2000; Sweller 1999), so it is important to understand how the learning abilities of poor readers affect which instructional methods and techniques are effective for this population. Thus, the effectiveness of mastery learning, systematic phonics, and timely directed feedback, for poor readers will be discussed. Finally, it is important to understand the effects of using the CAI medium to deliver instruction and how CAI can be designed to implement effective instructional methods more effectively and perhaps improve learning for the poor reader. Thus, the benefits of using CAI to engage the learner and implement the aforementioned instructional methods and strategies for teaching poor readers will also be discussed in this section.

Active Cognitive Participation of Learner

In determining how to teach reading, we need to first consider how individuals learn to read. Learning is a complex mental process by which the learner gains knowledge, information, understanding or skill through inquiry, study, investigation, or instruction. Although some learning may occur without intention, learning and mastering tasks, skills and knowledge generally requires concerted cognitive effort by the learner (Driscoll 1994; Woolfolk 1998). In addition, learning is a unique process for each learner (DeCorte 1995, p. 40), affected by many instructional and learning factors. Understanding the learning process is important because the instructional method, techniques, technologies, and medium implemented impact the quality and quantity of learning (Newby et al. 2000).

The learner is an active participant and processor in the learning process. Constructivists emphasize that the construction of knowledge requires learner's active participation and cognitive effort (Bruner 1961; DeCorte 1995; Glaser 1991; Vygotsky 1978). Furthermore, Piaget (1980) stresses that the learner is required to be mentally and physically active in the dynamic processes of constructing knowledge. A learner cannot only receive information, but must process and make sense of it. The process of knowledge construction (learning) can be explained in terms of developing or constructing a mental model or schema and continuously refining the schema as new, pertinent information is discovered (Glaser 1991; Rumelhart 1980). Cognitive effort is required on the part of the learner to construct this schema, which represents the individual's understanding of the concept(s) or skills being learned. Information is evaluated and assimilated, and models are constructed and refined through the learner's experiences and active participation in the learning process (Rumelhart & Norman 1978; Sweller 1999).

Each individual has a finite amount of cognitive resources, in the form of working memory, available to process information (Miller 1956; Peterson & Peterson 1959). Each activity a person engages in consumes a portion of these cognitive resources and thereby reduces the resources available for simultaneous tasks. Cognitive load refers to the demand placed on limited working memory resources at any particular time, while cognitive effort refers to the active utilization of working memory resources to accomplish a mental task. Thus, reducing cognitive load frees up cognitive resources for learning.

To help poor learners learn to read, CAI needs to support the active cognitive participation of the learner in developing their mental schemas of reading. Research indicates that CAI can be designed to support the learner's active participation in several ways that result in significant positive learning effects, including the following: focusing the learner's attention on relevant information, cognitively engaging the learner with an interactive multimedia user interface, encouraging the learner to actively process information with interactive activities and questions, providing a novel approach to learning to read (Najjar 1998), reducing the learner's cognitive load (Sweller 1999), and delivering self-paced, individualized instruction (Bloom 1997; Newby et al. 2000).

Multisensory Learning

As humans, we know all that we know through our senses, obtaining and processing new information through our sensory perceptions (James & Galbraith 1985). There are three primary perceptual modalities of learning: visual (learning by seeing), aural (learning by hearing), and kinesthetic (learning by doing) (Wislock 1993). Learners have unique perceptual preferences for learning, which afford learners their most effective and efficient modality for learning (Wislock 1993). However, although learners often prefer using one perceptual modality as their primary channel of learning, processing and assimilating information from multiple perceptual modalities is thought to strengthen the development of our mental models. In addition, research has shown that participants can process more information in working memory when it is presented in a multisensory format (Peterson & Peterson 1959; Sweller 1999). Thus, a multisensory instructional approach is preferable to address the needs of all learners and to facilitate effective learning (Wislock 1993). CAI can be designed to deliver multimedia instruction, helping poor readers learn to read by providing a multisensory approach that: supports their perceptual preferences, allows them to process more information and facilitates the development of their mental models for reading. In addition, there is limited evidence that the use of instructional multimedia to engage and focus the learners' attention may be particularly beneficial in helping poor readers with comprehension (Najjar 1998).

Timely Feedback

Corrective feedback is a very important component in the learning process because it facilitates the learner's evaluation of their mental models (Guskey 1997; Marakas 1995; Anderson, et al. 1977). The effectiveness of feedback is a function of its content, structure, and timeliness. Guskey (1997) states, "The best feedback to students is immediate, specific, and direct, and it offers explicit directions for improvement" (p. 157). Feedback that provides knowledge of the correctness of response with an explanatory statement has a more positive learning effect than feedback that only provides knowledge of the correct response (Hall et al. 2000; Roberts & Park 1984). To be effective, the learner must cognitively process the feedback. Immediate feedback allows learners to easily access their relevant mental model(s) and confirm or refine that model as directed by the feedback (Rumelhart & Norman 1978). If feedback is provided too late, its value to the learner diminishes significantly. If feedback is not specific, direct and explicit, it may not be as effective

Although teachers may be able to give limited, one-on-one feedback to students in the classroom, it is impossible for a teacher to instantaneously evaluate the performance of and provide immediate feedback to a classroom full of students. Yet, timely feedback is integral to the learning process. Unlike a human teacher, CAI is capable of providing immediate, personalized feedback to each student based on each student's own performance. This is just not possible for the classroom teacher. In addition, research has shown that students prefer computer-mediated feedback to person-mediated feedback (Kluger & Adler 1993). In fact, person-mediated feedback may actually hurt the learning of students with low self-esteem or high self-consciousness (Kluger & Adler 1993), both characteristics associated with poor readers. Therefore, a well-designed CAI tutorial has the potential to benefit the learning process for all learners, and especially poor readers, by providing timely and individualized, directed feedback to each learner.

Phonics: An Expository Learning Approach to Teaching Reading

Choosing an instructional method is an instrumental decision in teaching reading because the instruction method directly affects a learner's educational progress by making it easier (or harder) to learn (Berliner & Rosenshine 1977; Cronbach & Snow 1977; Newby et al. 2000; Schunk 2000). The organization of the material and modality of presentation affect the learner's ability to understand and assimilate what is being taught. An instructional method should focus on helping the learner develop a mental schema (Rumelhart 1980; Sweller 1999). Since low ability learners have difficulty adapting to the learning environment, the learning environment needs to conform to their specific learning needs (Calfee & Drum 1986; Kleiman 1982).

Expository learning approaches prove to be more effective and successful learning strategies for low ability learners than discovery learning approaches (Calfee & Drum 1986). An expository learning instructional approach starts with an organized, systematic presentation of the knowledge rules the learner needs to acquire and apply, then uses examples to allow the learner to practice applying these rules to support the development and refinement of their mental model (Marakas 1995; Schunk 2000). In contrast, a discovery learning approach starts with examples and is designed to make the learner "discover" or induce the knowledge rules as a process of their own individual search (Marakas 1995; Bruner 1961). However, low ability learners cannot

construct the general rules from examples; they need explicit instructional guidance (Calfée & Drum 1986; Kleiman 1982). Consequently, poor readers require an expository learning approach to help them learn to read.

Phonics instruction is expository because it systematically teaches students about the relationships between letters and the sounds they represent (Barr, et al. 1983; Flesch 1981; Jorm & Share 1983). Strong evidence exists for the inclusion of formal phonics instruction in any reading program, especially those working with poor readers (Barr et al. 1983; Calfée & Drum 1986; Carroll 1976). Thus to improve their reading skills, poor readers need to receive formal, systematic phonics instruction (Flesch 1981; Lyon 1998). Computers are designed for systematic and repetitive activities. Therefore, a CAI tutorial can be designed to effectively deliver systematic, phonics instruction to poor readers, helping them develop the phoneme awareness and phonics skills they need to learn to read at a proficient level.

Individual Mastery Learning

Mastery learning refers to an instructional approach in which the learner is required to “master” the material to some designated criterion level (generally 80 to 100 percent) before progressing to more advanced material (Slavin 1987; Guskey 1997). The mastery learning approach dictates a highly structured, bottom-up, expository learning curriculum (Guskey 1997; Slavin 1987) that integrates well with systematic phonics instruction. In theory, mastery learning ensures that learners gain the prerequisite skills and knowledge needed from current studies and lessons to achieve future learning objectives (Guskey 1997). The theoretical premise is that if students master each of the required pieces of prerequisite knowledge, they will have the tools to master more advanced concepts supported by the prerequisite information. On the other hand, if learners do not gain the prerequisite knowledge for future challenges, they are prone to fail because they did not develop the necessary cognitive skills and information sets to succeed. Numerous studies have shown significant positive learning effects from mastery learning (Guskey 1997). In addition, research indicates that a mastery learning curriculum may be particularly beneficial for low ability learners (Slavin 1987; Guskey 1997). However, mastery learning instituted in the traditional classroom is commonly group-based mastery learning, which has shown limited learning effects (Slavin 1987). At the group level, time spent achieving mastery for low-ability learners means less time is available for other learners to progress to additional learning objectives (Slavin 1987; Fuchs, et al. 1985). This conflict makes it difficult for teachers to dedicated adequate time for poor readers to achieve mastery in the group-based setting.

A CAI tutorial implementing mastery learning principles can solve this problem by being designed to provide individual mastery learning, instead of group mastery learning. The CAI is able to provide personal tutoring for each student, imposing mastery learning on an individual basis while allowing each learner to progress at their own pace. Personal tutoring and individual mastery learning should result in better achievement for poor readers (Guskey 1997). Therefore, CAI can be designed to help poor readers improve their reading ability by providing individualized mastery learning based on their specific learning needs, thereby ensuring that the learner develops the prerequisite mental models for phoneme-awareness and phonics skills at each level before advancing. The next section describes the case study conducted.

Case Study

The purpose of this case study is to investigate the instructional effectiveness of a CAI phonics-based reading tutorial in helping poor readers improve their reading ability. Specifically, there were two research questions:

1. Does completing the CAI reading tutorial help poor readers improve their reading skills?
2. What instructional methods and strategies implemented in the CAI design contribute to the CAI's effectiveness?

Question 1 was investigated with a field study. Due to the circumstances of the field investigation, this multimethodological research was conducted as a pretest, posttest case study supported by interviews of students, homeroom teachers and the CAI lab reading specialist. Question 2 was investigated with a literature review and an in-depth review of the CAI design. This section will describe the CAI design, the participants, the research proposition and hypothesis, and the case study procedures. The results of the case will be presented in the following section.

The CAI Design

The CAI used by the students was Larrabee's Bridge to Adult Literacy (LBAL), an interactive, multimedia, phonics-based, mastery learning CAI reading tutorial directed at poor readers or non-readers from fourth grader through adulthood. LBAL is designed to provide personalized, self-paced instruction to many students simultaneously, acting like a private tutor for each. Each student completes a pre-assessment test, and based on the individual learner's performance, lessons are selected for a personalized plan of study. The CAI guides students through the specified lessons and related exercises, while the students control the pace of the reading instruction and their progress within the current lesson. LBAL is designed to be used five hours per week on a frequent and consistent schedule.

Phonics instruction is delivered via video-stream recordings of "Professor Larrabee" teaching each lesson, tasking students with learning exercises and providing feedback for each exercise. Specifically, the reading tutorial contains 47 interactive lessons, designed to teach the learner phonics decoding and encoding skills. Each lesson begins with a short expository instruction, followed by five or six multisensory exercises. Through video streaming technology, Professor Larrabee presents the instruction for the lesson. In general, the instruction teaches the name and sound of a letter(s) or phoneme, the production of the sound, (i.e., how to physically create the sound), how to write the letter(s) involved, and other pronunciation instructions, tips or memory aids for the lesson. The exercises provide practice and experience with the reading skills taught in the introduction in visual (pick the written words), aural (pick the pronounced words) and kinesthetic modalities (spell and/or write words).

LBAL provides immediate feedback to learners as they complete each question in each exercise in each lesson. Correct answers receive an immediate, randomly selected, positive affirmation such as, "Super!" or "That's correct." No explanation is provided. If an answer is incorrect, the learner is given three attempts to answer correctly. First, the learner is directed to "Try again." Each subsequent attempt, the CAI provides additional information to aid the learner. For example, a pronounced word may be pronounced with greater articulation. After the third attempt, the learner is told the correct response. The program imposes 100% mastery, requiring students to achieve 100% correct responses for each exercise in a lesson before progressing to the next lesson. Each lesson is designed to systematically build on the knowledge presented in the previous lessons. As directed by mastery learning principles, cumulative review tests are administered at intervals throughout the program. If learners miss questions, the relevant lessons are reassigned to the student. In addition, after completing each four lessons, the students' CAI is supplemented by brief teacher interaction that focuses on reading fluency, inflection and comprehension. In summary, the LBAL tutorial integrates instructional features to support active cognitive participation, multisensory learning, timely feedback, phonics instruction and mastery learning.

Proposition and Hypothesis

Instructional design impacts the quality and quantity of learning for poor readers (Calfée & Drum 1986; Kleiman 1982; Fuchs, et al. 1985; Najjar 1998). The literature shows that the following instructional methods and design features help poor readers learn: 1) engaging the cognitive participation of the learner; 2) delivering multisensory, interactive learning; 3) providing timely, directed feedback; 4) delivering systematic phonics instruction and implementing mastery learning. Although the literature indicates there is room for improvement, the design of the LBAL CAI tutorial incorporates each of the methods and features to a degree. Consequently, the researcher proposes the following:

Proposition 1: Completing the LBAL program will help poor readers improve their reading ability.

Hypotheses 1: Participants' posttest scores on the DRP exam will be significantly greater than their pretest scores.

Participants

The study was conducted at a Title I elementary school in a large city in the Southwest. Title I schools serve a high concentration of students living in poverty, and as a result, receive funds to provide special educational services for low-achieving and at-risk students. The 13 participating students were fourth and fifth grade students with poor reading abilities as determined by the independent assessments and observations of their homeroom teachers.

Procedures

Six homeroom teachers referred the participating students to the reading lab for help with their reading skills. Students attended the CAI lab up to 5 days a week, where they used the LBAL program 30 to 60 minutes per day. The time was coordinated with the students' teachers, and was generally scheduled to replace classroom reading instruction. Based on the LBAL pre-assessment, all students were assigned all 47 lessons. A special education teacher worked with the students in the CAI lab, providing directions, motivation and teacher interventions as required.

All participants were pretested and posttested with the Degrees of Reading Power exam (DRP). The DRP exam is a standardized, criterion-referenced test that measures reading comprehension. Two equivalent DRP forms were administered as pretest and posttest. The DRP tests have high internal-consistency reliability (Kuder-Richardson coefficient .93 to .94) and high short-term stability of alternate-form reliability (alternate-form reliability coefficients, $r \geq .86$) ("DRP Handbook" 1995). The participants all tested below average when pretested on the DRP. Eleven of the thirteen participants pretested at the first grade equivalent reading level. Nine of the participants scored in the first percentile, meaning that they performed better than less than one percent of the students in their grade level. Eight of the thirteen participants had not yet completed the LBAL program at the time of posttesting.

In addition to DRP testing, interviews of students, homeroom teachers and the CAI lab reading specialist were used to gain corroborating evidence and an understanding of the participants' improvements in reading ability. Student participants were individually interviewed regarding their perceptions of the LBAL program and their reading skills. The researcher conducted the student interviews orally and privately. The participant interview included nine objective items (rated on a Likert scale of 1 to 5, with 1 representing Strongly Disagree and 5 representing Strongly Agree) relating to preferences and perceptions on reading, writing and the program. The homeroom teachers were asked to complete a interview questionnaire regarding their observations of the participants' reading abilities and improvements observed in the classroom, as well as their impressions of the LBAL reading tutorial. The reading specialist teaching the CAI tutorial lab was also interviewed regarding her observations of each individual student's activities and performance in the reading lab. This interview was conducted privately in the CAI reading lab where the reading specialist could consult her notes and records.

Case Study Results

In investigating the LBAL CAI tutorial, several sources of corroborating data were collected: pretest-posttest DRP instructional scores and Normal Curve Equivalents, student interviews, homeroom teacher interviews and an interview of the CAI lab reading specialist. The findings are presented below. The research proposition and hypothesis are supported.

DRP Scores

DRP raw scores are converted to standardized DRP instructional scores (DRP Handbook 1995). These scores can then be converted to National Percentile Ranks (PRs) and Normal Curve Equivalents (NCEs). Paired samples statistics were run on the DRP instructional scores and the NCEs. The results are summarized in Table 1. The improvement in instructional DRP scores between pretest scores (20.61) and posttest scores (34.85) averaged 14.23. This statistically significant improvement in the students' DRP instructional score indicates that the students did improve their reading comprehension. Thus the hypothesis that "participant post-test scores on the DRP exam will be significantly greater than their pre-test scores on the DRP exam" is supported ($p < .001$).

NCEs are normalized standard scores of the PRs. NCEs represent students' performance relative to other students in the same grade at the same time of year (Fall or Spring semester). Therefore, the pretest NCEs are determined for the Fall semester and the posttest NCEs are determined for the Spring semester. Unlike PRs, NCEs have been statistically transformed to create an equal-interval scale, so they can be statistically analyzed (Harris & Sipay 1985). The mean NCEs for the thirteen participants significantly increased from 5.92 to 23.31, ($p < .001$). The significant positive change observed in the participants NCEs indicates that the students significantly improved their reading comprehension relative to other students at their grade level, at the end of the school year. Thus, the participating students moved up in the class rankings, indicating that they improved their reading comprehension a significantly greater amount than would be expected solely from maturation. If the improvement was due to maturation, the students' relative rankings would be expected to remain constant.

Table 1. Results of Paired Sample t Test on DRP Scores and NCEs

DRP Scores	DRP Pretest		DRP Posttest		Pretest-Posttest Difference Scores*	
Instructional DRP Score	Mean	20.61	Mean	34.85	Mean	14.23
	SD	8.38	SD	8.54	SD	8.83
	N	13	N	13	p	<.001
NCEs – standardized rankings within grade level	Mean	5.92	Mean	23.31	Mean	17.38
	SD	8.92	SD	12.36	SD	9.17
	N	13	N	13	p	<.001

*Differences represent increases in scores from pretest to posttest.

Teacher Interview

Six fourth and fifth grade teachers referred students to participate in the LBAL program. Four of these six teachers completed a written questionnaire/interview. The teachers were asked whether they observed improvement in the students referred to the computer reading lab. They were further asked to provide student-specific observations. All comments were positive, and most were very enthusiastic. In response to the question, “Have you seen improvement(s) in the students you have referred to the computer reading lab?”, one teacher exclaimed in writing, “Yes!!!!” Another exclaimed, “Yes, all of my (participating) students’ reading has increased 2 1/2 to 3 years of reading in less than a year!!” The teachers’ student-specific observations reported the following: better oral reading and word attack skills, increased spelling accuracy, improved writing, increased vocabulary, and improved self-confidence. One teacher wrote, “(Student’s) reading has increased from 1st to 4th grade. He is in 4th grade now and is going to 5th. His vocabulary has increased. His spelling has improved significantly!” Not all of these improvements were observed in every student, but the teachers’ responses reveal that they did observe noticeable improvement in each of their participating students, which the teachers attributed to the LBAL CAI tutorial. In the words of one teacher, “All the kids that participated in the program demonstrated improvement in their willingness to read aloud and their confidence.”

Interview with the Reading Specialist

Throughout the duration of the study, the reading specialist recorded field notes on observations of the students in the computer reading lab. At the end of the school year, the researcher interviewed the reading specialist regarding her observations and notes. Each student was discussed. The reading specialist reported that she observed improvements in all of the students that she believed were attributable to their participation in the LBAL program. In addition, her observations included rich information regarding the students’ performance, attitudes, abilities, behaviors and accomplishments. Some of these observations are reported below in the discussion of the student interview qualitative items.

Student Interviews

Eleven of the thirteen student participants were interviewed at the end of the school year. Eight of the eleven interviewed had not completed the program at the time of interview. Two participants were unavailable for interview because they moved before the interviews were conducted. The interview consisted of both objective and subjective items. One-on-one, oral interviews were conducted with each student to ensure that the students could understand the questions and thus mitigate errors that might result from poor reading comprehension skills, writing aversions or misunderstanding of how to respond to the items. The researcher explained to each student that the purpose of the interview was to obtain the student’s opinions regarding reading and the CAI program. To mitigate outside influence in their answers, the student’s were assured that their answers were confidential and would not be shared with teachers. The researcher stressed that she wanted the students’ true opinions in an attempt to reduce the potential for “pleasing” bias. The Likert scale was orally reviewed and a printed copy of the scale was given to the student for reference. The researcher read each question aloud and recorded the student’s responses. Students were encouraged to ask questions during the interview process if any items were confusing.

Student Interview: Objective Items

The student interview questionnaire included nine objective items, rated on a five-point Likert scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree or Disagree, 4 = Agree, and 5 = Strongly Agree. A five-point Likert scale was chosen because it has been shown to be more appropriate for the elementary grade age group than a larger scale. Refer to Table 2 for the items, response frequencies and mean responses.

Items 1, 2, 5, and 6 are general questions about the learners' attitudes toward reading and related activities. Items 3, 4, 7 and 9 investigate the participants' attitudes and perceptions regarding the LBAL program. Specifically, items 7 through 9 were designed to discover students' perceptions about whether participating in the LBAL program improved their reading skills, as well as their perceptions about their own reading ability. Item 6 was stated in the negative to provide a check for responses and understanding of the scale. Item 8 was also intended to be negatively worded, but proved to be a poorly constructed item. In fact, four of the eleven students interviewed did not respond because item 8 was too confusing. As a result, item 8 was disregarded. In addition, one student choose not to respond to item 9, resulting in 10 respondents for that item. Responses about reading attitudes and the LBAL program were expected to be positive (above a 3.0 average).

Table 2. Student Responses on Objective Interview Items

	Response Frequency*					Mean
	1	2	3	4	5	
I like to read.		2	2	4	3	3.727
I like to go to the computer reading lab.			2	6	3	4.091
I like to use the Larrabee program.			1	5	5	4.364
The Larrabee program is fun.			1	5	5	4.364
I like to write.		1	1	5	4	4.091
I do not like to read.	6	3	1		1	1.818
The Larrabee program has helped me become a better reader.		1		3	7	4.455
I do not read as well (or the same) as I always have.	2	2	2	1		2.286
I like to read more now than I liked to read before I started the Larrabee program.			2	2	6	4.400

*Likert scale: 1=Strongly Disagree, 2=Disagree, 3=Neither Agree or Disagree, 4=Agree, 5=Strongly Agree

As shown in Table 2, all but one of the positively stated items averaged above a 4, with item 1 (I like to read.) averaging 3.727. These ratings indicate that the participants liked to read and liked to write at the end of the school year. Of particular interest are the responses to items 7 and 9. The average responses for items 7 and 9 were 4.455 and 4.400, respectively. These high positive responses strongly indicate that the participants believe that the LBAL program helped them become better readers and increased their enjoyment of reading. These responses agree with the findings from the DRP test scores and the interview data reported below, providing support for the proposition that completing the LBAL program helps poor readers improve their reading ability.

Student Interview: Qualitative Items

During the interview, students were asked the six subjective items. The following presents each item, the intended purpose of each item and the participant responses .

1. Why did you start the Larrabee program?

The first question, "Why did you start the Larrabee program?" was asked to determine if the students self-identified as poor readers, in agreement with their teachers' assessments. They did. Nine of eleven interviewees blatantly stated that they needed help with reading. Responses included comments such as, "Because I didn't know how to read," and "I needed help on reading and writing." The reading specialist also confirmed their status as poor readers.

The remaining interview questions were directed at developing an overall picture of what the participants thought about the LBAL tutorial, including whether they believed that the CAI tutorial helped them improve as readers.

2. What makes the Larrabee program FUN or NOT FUN?

Participants revealed that the Larrabee program was fun at times and not fun at others. Several characteristics of the LBAL tutorial were identified as making the program fun. Some students liked using the computers. One student noted, "It's just fun using computers." This supports that the CAI is a novel approach. More prevalent, however, was the fact that the students felt the program helped them. The students experienced success with reading and received positive feedback. The following are representative statements by participants.

"It helps me. I like it."

"It's fun because when you get words right, he (Professor Larrabee) says things like, "Great job!" and "Nice job."

"(I'm) happy when you get to a different grade level of reading and/or move to a new lesson."

In addition, the reading specialist reported that the students expressed pleasure and excitement when they answered questions correctly and completed lessons. Students might smile or raise their arms in victory.

However, the program was not always fun. A few students commented that the program was not fun when they answered incorrectly or the lessons were "too hard." This agrees with observations of the reading specialist. The reading specialist reported that at times some participants got very frustrated with the program. A couple of students would get very mad and either throw their headsets, yell at Professor Larrabee, or even punch him on the computer screen. Yet, despite the frustrations, these same students thought there were fun aspects of the program. When interviewed, the student who used to punch the screen strongly agreed with the statement, "The Larrabee program is fun."

3. How has the Larrabee program helped you become a better reader?

Participating students identified the phonics instruction (the sounds of letters and how to sound out words) and personalized feedback as components of the program that helped them become better readers. Student comments included:

"He and Ms. ___ (the reading specialist) told me to sound it out. It taught me the different sounds for the letters and the sounds I did not know. Taught me how to sound out the words."

"By, if I get words wrong he'll say them again very slow, if I get them wrong again he'll write them down and come back to them."

"The computer helped me. It gives me another chance if I miss words, tells me if I still do not get it right and (then) I write it on a board."

All but one student agreed or strongly agreed that the Larrabee program helped them become better readers. Interestingly, the student who disagreed showed marked improvement in testing of reading comprehension even though she had not completed the program. Her DRP instructional score raised thirty-six (36) points out of 100, and she moved from the 1st to the 16th percentile in comparison to the reading comprehension of students at her grade level. This same student later stated that she would tell a friend, "I think it's (the Larrabee program) fun and it teaches me something." Thus, although she may not have considered herself to be a better reader, she did perceive that she was learning by using the program.

4. Name the 3 things you like/dislike most about the Larrabee program.

These two questions were asked to prompt students to identify specific features of the program that they liked and disliked. This information may provide insight into useful features, as well as ways to improve CAI tutorials. Understandably, students did not like specific lessons or exercises that were very difficult for them, took a long time to complete and caused frustration. They didn't like being wrong. The other primary complaint was computer problems. Students did not like it when computers locked up during lessons or were broken and not available for them to use. Although computer problems are independent of the CAI program content, technical problems do affect the attitude of the participants.

In discussing what they liked most about the Larrabee program, participants listed both specific features of the program and benefits from the program. Of course, individual students named different features, but, the participants as a group included every learning exercise in the list of features liked most. There was no consensus regarding which exercises were preferred. This makes sense since the different exercises engage different perceptual modalities and different learners have different preferred learning modes. Benefits identified as “things you like most about the Larrabee program” included characteristics such as: it was fun, it helped me read better and it taught me phonics rules. As one participant stated, one of the things she liked most was, “I now know rules that help me sound out words.”

5. *What would you tell a friend about the Larrabee program?*

This question was designed to reveal how the student might describe the Larrabee program to peers. When asked what they would tell a friend about the program, all the students had positive remarks that indicated they would recommend the program to peers. “(I would tell a friend) that they should go to the Larrabee program if they need help on their reading,” said one student. Many other participants made statements similar to, “It’s fun. You learn how to read.”

6. *Overall, what do you think about the Larrabee program?*

The purpose of this question was to capture participant opinions about the Larrabee program as a whole. It also provided a catchall for any general opinions or comments. The interview process revealed that this was probably a poorly worded question for the fourth and fifth grade audience. A number of students did not understand the question because they were unfamiliar with the word “overall.” Other students simply had nothing to add. The responses that were received were very similar to those given for the previous question, “What would you tell a friend about the Larrabee program?” One particular comment, however, merits mention. One student stated, “It (the LBAL program) should be discovered all over the U.S. and taken by people that can barely read.” Obviously, this student believed that the LBAL program is effective in helping poor readers learn to read.

In conclusion, the student interviews indicate that the poor readers using LBAL perceived that the program helped them improve their ability to read. This finding concurs with the improvement in the DRP scores and the observations reported by the teachers and the reading specialist. Thus, the triangulation of these different data sources supports the hypothesis that the participants significantly improved their reading ability, and the proposition that completing the LBAL program helped the poor readers make that improvement. Therefore, it follows that completing a CAI reading tutorial helped poor readers significantly improve their reading ability.

Discussion

This study has a number of limitations. First, due to limitations of the field investigation, if considered separately, the DRP data is a one-group pretest-posttest design and the interview data comprise a one-shot case study, as described by Campbell and Stanley (1966). Both of these designs have several inherent weaknesses (Campbell & Stanley 1966), but the researcher has attempted to mitigate these weaknesses by triangulating multiple types and sources of data to corroborate the findings. In addition, the DRP NCEs, which are normalized PRs, provide a relative comparison indicating real improvement. Although a testing effect is possible for the DRP, the threat is minimal since, 1) alternate test forms, with high alternate-form reliability were used for the pretest and posttest, 2) the tests were administered several months apart and had high short-term stability, 3) the students received no feedback (which would promote learning) on the pretest, and 4) poor readers are not good at discovery learning, making it unlikely that a significant testing effect existed. Second, the student interviews could have been improved. Since the primary objective of the student interviews was to collect the students’ perceptions of the CAI tutorial, the researcher conducted the interviews after the students had attended the CAI tutorial. However, four interview items were general questions about the learners’ attitudes toward reading and related activities. In hindsight, the researcher realizes it would have been preferable to also ask these questions before the students attended the CAI tutorial to measure attitudinal changes, as well as record the post CAI attitudes. In addition, of the nine objective student interview questions, only two were negatively worded, and one of these items was a poorly constructed item. The lack of negatively stated questions could lead to a positive response bias. However, many of the positive objective items are elaborated by subjective items, which should provide a check for response discrepancies. For example, objective item 7, “The Larrabee program has helped me become a better reader,” is elaborated by subjective item 3, “How has the Larrabee program helped you become a better reader?” Likewise, objective items 3 and 4 are elaborated by subjective items 4 and 2, respectively.

Despite the limitations, this study provides scientific evidence corroborating that poor readers using the LBAL CAI tutorial improved their reading skills. The 4th and 5th grade poor readers who completed this CAI reading tutorial improved their reading comprehension. Both the pretest-posttest DRP test data and the interview findings support this conclusion. Students experienced frustrations with the program, as would be expected in any complex learning process. However, this would not have occurred if they were not actively engaged and personally vested in the learning process. Moreover, the participants were excited about their successes. They were becoming better readers and they knew it. They were proud of their accomplishments and this was reflected in improved performance, confidence and attitudes in the classroom. Students who previously refused to read aloud in class began volunteering. Others proudly told classmates, teachers and parents about their progress. Three student made a speech at their fifth grade graduation to publicly thank the Larrabee program for teaching them to read. Parents also observed improvements at home, with some parents reporting how excited they were to see their children reading on their own for enjoyment for the very first time.

In addition, the study described the instructional design features of the CAI and used the research literature to explain, from a theoretical perspective, why these features are important in designing CAI to help poor readers improve their reading skills. These findings provide guidance to CAI design for poor readers and they may also provide some guidance to CAI design in other subjects for low ability learners. Several contributing features were discussed. First, students who are poor readers generally have poor phonics skills. The CAI tutorial's systematic and comprehensive approach to phonics allows each student to go at their own pace, focusing on learning the phonics rules which cause that student problems. Each lesson contains at least five types of multisensory exercises to develop and test the student's knowledge and understanding. The exercises are designed to engage different cognitive skills in multisensory perceptual modes, guiding the learner to develop a more complete mental model for the concepts in each lesson. In addition, the tutorial requires 100 percent mastery of each lesson, striving to ensure that the student fully understands each phonics concept before proceeding to succeeding lessons which will incorporate skills from the preceding lessons. Finally, the CAI reading tutorial helps students improve their reading skills because the computer can provide hours of individualized tutoring with timely directed feedback, unlimited patience and no perceived judgments of performance.

The combination of these features helps poor readers learn to read. However, this is not to say that the implementation of these features in the LBAL tutorial could not be improved. Based on the research literature, there are several areas for enhancement. For example, although the CAI provides immediate and directed feedback, the feedback could provide more information and explanation about the 'what' and 'why' of a learner's specific error. The mastery learning features in the LBAL CAI tutorial provide another example. When students make errors on the cumulative review tests, the tutorial reassigns previous lessons as the interventions. However, mastery learning theory indicates that it should be more beneficial to student learning to assign interventions which are structurally different from the original material (Guskey 1997). Thus, although the design of LBAL CAI tutorial was found to be effective for helping poor readers, the research literature indicates that an even better design is possible.

In conclusion, the results of this case study suggest several directions for future research. First, the researcher intends to conduct a quasi-experimental study to compare the performance of poor readers receiving CAI with a control group receiving classroom instruction or, if field conditions permit, using another CAI with different features. Further investigation of the specific instructional and CAI design features that support the poor readers is also planned. Which features do the learners perceive as being helpful? Which learning exercises and activities are most beneficial? The researcher will use the knowledge gained from this study to develop a more extensive interview questionnaire to investigate these and other related questions. Answering these questions should provide further insight into the design of CAI for poor readers.

References

- Anderson, R. C., Spiro, R. J. & Montague, W. E., (Eds.). (1977). *Schooling and the Acquisition of Knowledge*. Hillsdale, N.J., Lawrence Erlbaum Associates.
- Barr, R., Dreeben, R. & with Wiratchai, N. (1983). *How Schools Work*. Chicago, University of Chicago Press.
- Berliner, D. C. & Rosenshine, B. (1977). *The Acquisition of Knowledge in the Classroom*. *Schooling and the Acquisition of Knowledge*. Anderson, R. C., Spiro, R. J. and Montague, W. E. Hillsdale, N.J., Lawrence Erlbaum Associates: 375-396.
- Bloom, B. S. (1997). Foreword. *Implementing Mastery Learning*. Guskey, T. R. Belmont, CA, Wadsworth Publishing Company: xiii-xv.
- Bruner, J. S. (1961). "The Act of Discovery." *Harvard Business Review* 31: 307-311.
- Calfee, R. & Drum, P. (1986). *Research on Teaching Reading*. *Handbook of Research on Teaching*. Wittrock, M. C. New York, Macmillan Publishing Company: 804-849.
- Campbell, D. T. & Stanley, J. C. (1966). *Experimental and Quasi-Experimental Designs for Research*. Chicago, R. McNally.

- Carroll, J. B. (1976). Promoting Language Skills: The Role of Instruction. *Cognition and Instruction*. Klahr, D. Hillsdale, New Jersey, Lawrence Erlbaum Associates: 3-22.
- Carroll, J. B. & Chall, J. S., (Eds.). (1975). *Toward a Literate Society*. New York, McGraw-Hill.
- Chall, J. S. (1967). *Learning to Read: The Great Debate*. New York, McGraw-Hill.
- Cronbach, L. J. & Snow, R. E., (Eds.). (1977). *Aptitudes and Instructional Methods*. New York, Irvington/Naiburg.
- DeCorte, E. (1995). "Fostering Cognitive Growth: A Perspective from Research on Mathematics Learning and Instruction." *Educational Psychologist* 30(1): 37-46.
- Donahue, P. L., Finnegan, R. J., Lutkus, A. D., Allen, N. L. & Campbell, J. R. (2001). *The Nation's Report Card: Fourth-Grade Reading 2000*. Washington, D.C., National Center for Education Statistics.
- Driscoll, M. P. (1994). *Psychology of Learning for Instruction*. Boston, Allyn & Bacon.
- DRP Handbook(1995). Brewster, N.Y., Touchstone Applied Science Assoc.
- Flesch, R. (1981). *Why Johnny Still Can't Read*. New York, Harper & Row.
- Fuchs, L. S., Tindal, F. & Fuchs, D. (1985). *A Comparison of Mastery Learning Procedures among High and Low Ability Students*, Vanderbilt University, Nashville, TN.
- Glaser, R. (1991). "The Maturing of the Relationship between the Science of Learning and Cognition and Educational Practice." *Learning and Instruction* 1: 129-144.
- Guskey, T. R. (1997). *Implementing Mastery Learning*. Belmont, CA, Wadsworth Publishing Company.
- Hall, T. E., Hughes, C. A. & Filbert, M. (2000). "Computer Assisted Instruction in Reading for Students with Learning Disabilities: A Research Synthesis." *Education and Treatment of Children* 23(3): 173-193.
- Harris, A. J. & Sipay, E. R. (1985). *How to Increase Reading Ability: A Guide to Developmental and Remedial Methods*. White Plains, N.Y., Longman.
- James, W. B. & Galbraith, M. W. (1985). "Perceptual Learning Styles: Implications and Techniques for the Practitioner." *Lifelong Learning* 8: 20-23.
- Jorm, A. F. & Share, D. L. (1983). "Phonological Recoding and Reading Acquisition." *Applied Psycholinguistics* 4: 103-147.
- Kleiman, G. M. (1982). *Comparing Good and Poor Readers: A Critique of the Research*. Champaign, University of Illinois.
- Kluger, A. & Adler, S. (1993). "Person- Versus Computer-Mediated Feedback." *Computers in Human Behavior* 9(1): 1-16.
- Lyon, G. R. (1998). Overview of Reading and Literacy Initiatives [on-Line]. <http://www.nichd.nih.gov/publications/pubs/jeffords.htm>, National Institutes of Health, 9000 Rockville Pike, Bethesda, MD 20892.
- Marakas, G. M. (1995). *The Discovery-Learning DSS: Allowing for Discovery in the Decision Process*. Proceedings of the Twenty-Eighth Hawaii International Conference on System Sciences, Hawaii, IEEE Comput. Soc. Press.
- Miller, G. A. (1956). "The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information." *Psychological Review* 63: 81-97.
- Najjar, L. J. (1998). "Principles of Educational Multimedia User Interface Design." *Human Factors* 40(2): 311-323.
- Newby, T. J., Stepich, D. A., Lehman, J. D. & Russell, J. D. (2000). *Instructional Technology for Teaching and Learning: Designing Instruction, Integrating Computers, and Using Media*. New Jersey, Prentice-Hall.
- Peterson, L. R. & Peterson, M. J. (1959). "Short-Term Retention of Individual Verbal Items." *Journal of Experimental Psychology* 58(3): 193-198.
- Roberts, F. C. & Park, O. (1984). "Feedback Strategies and Cognitive Style in Computer-Based Instruction." *Journal of Instructional Psychology* 11(63-74).
- Rumelhart, D. E. (1980). *Schemata: The Building Blocks of Cognition. Theoretical Issues in Reading Comprehension: Perspectives from Cognitive Psychology, Linguistics, Artificial Intelligence, and Education*. Spiro, R. J., Bruce, B. C. and Brewer, W. F. Hillsdale, N.J., Lawrence Erlbaum Associates: 33-58.
- Rumelhart, D. E. & Norman, D. A. (1978). *Accretion, Tuning and Restructuring: Three Modes of Learning. Semantic Factors in Cognition*. Klatzky, J. W. C. R. L., Hillsdale, NJ: Lawrence Erlbaum Associates: 37-53.
- Schunk, D. H. (2000). *Learning Theories : An Educational Perspective*. Upper Saddle River, N.J., Merrill.
- Slavin, R. E. (1987). "Mastery Learning Reconsidered." *Review of Educational Research* 57(2): 175-213.
- Snow, C. E., Burns, M. S. & Griffin, P. (1998). *Preventing Reading Difficulties in Young Children*. Washington, D.C., National Research Council.
- Steinberg, L., Brown, B. B. & Dornbusch, S. M. (1996). *Beyond the Classroom: Why School Reform Has Failed and What Parents Need to Do*. New York, Simon & Schuster.
- Sweller, J. (1999). *Instructional Design in Technical Areas*. Camberwell, Victoria, ACER Press.
- Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Processes*. Cambridge, MA, Harvard University Press.
- Wislock, R. F. (1993). *What Are Perceptual Modalities and How Do They Contribute to Learning? Applying Cognitive Learning Theory to Adult Learning*. Flanery, D. D. San Francisco, Jossey-Bass Publishers. 59: 5-13.
- Woolfolk, A. E. (1998). *Educational Psychology*. Boston, Allyn & Bacon.