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Integration of Technology Into the Classroom: Effects on reading comprehension

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INTEGRATION OF TECHNOLOGY INTO THE CLASSROOM: EFFECTS ON READING COMPREHENSION

by

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TITLE: INTEGRATION OF TECHNOLOGY INTO THE CLASSROOM: EFFECTS ON READING COMPREHENSION

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Reading comprehension is critical to understanding written communication. Even when students are able to recognize words and fluently read text, they my not comprehend what is read. Learning to comprehend text is critical for students to be successful in school and future careers. As new technologies emerge, there is a push to integrate technology into the classroom to promote academic success among students. Furthermore, the No Child Left Behind Act mandates the use of technology in the classroom. This research review investigated peer-reviewed studies comparing the effects of computer technology as a supplemental tool to support and improve the reading comprehension of struggling and at-risk readers with equivalent non-technological or traditional print based treatments. Technology features investigated by the studies reviewed include various types of multi-featured electronic texts, computerized supplemental reading programs, a handheld text reader, virtual manipulatives, and using computers to create responses to reading printed texts. The various technologies were found to provide equal or greater benefit than traditional means for aiding struggling and at-risk readers with reading comprehension.

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Reading is defined by the National Assessment of Education Progress (NAEP) Reading Framework as a dynamic cognitive process that allows the reader to understand written text, interpret meaning, and use meaning according to the type and purpose of the text (U.S. Department of Education, National Center for Education Statistics, 2011). According to the NAEP report, "The Condition of Education 2011, in 1992, 29% of fourth graders, 29% of eighth graders, and 40% of twelfth graders were reading at proficient or above proficient levels (Aud, Hussar, Kena, Bianco, Frohlich, Kemp, & Tahan, 2011). To address this problem, the No Child Left Behind Act of 2001 (NCLB) stipulates that each child should receive a quality public school education and holds each state accountable for providing challenging academic content. Furthermore, it mandates that all students should be proficient in reading by the end of the 2013-2014 school year. Unfortunately, only 33% of fourth graders, 32% of eighth graders, and 38% of twelfth graders were reading at or above proficient levels in 2009, indicating minimal improvement in the reading ability of students since 1992 (Aud et al., 2011).

The question raised is, "What are schools and educational agencies doing to turn struggling readers into proficient readers?" One response is to incorporate technology into the classroom with text-reader software, talking or interactive electronic books, hand held text-readers, or any other computerized device providing interactivity or multimedia presentation (Manset-Williamson, Dunn, Hinshaw, & Nelson, 2008; Montali & Lewandowski, 1996). Teachers should take advantage of the interactivity provided by computer technology to help struggling readers for a variety of reasons. For example, many struggling readers are challenged by a lack of basic word reading and fluency skills that are required to access grade level material (Higgins & Raskind, 2005; Manset-Williamson et al., 2008), thus the material is inaccessible to the struggling reader. Incorporating computer technology into the classroom to accommodate

deficient reading skills provides the struggling reader with access to the material used for teaching comprehension skills (Higgins & Raskind, 2005; Manset-Williamson et al., 2008). Meanwhile, a sizable proportion of struggling readers have the word reading and fluency skills needed to read passages, but read with little comprehension (Higgins & Raskin, 2005; Oakhill, Cain, & Bryant, 2003). By providing visual and auditory presentation, or bi-modal presentation, of the information, reading comprehension skills can be improved (Montali & Lewandowski, 1996). Finally, technology used to accommodate skill deficits demonstrated by struggling readers allows for more independence than the traditional method of having an adult read the text aloud (Higgins & Raskin, 2005).

Given the requirements of NCLB, states also expect teachers to integrate technology into academic instruction in the classroom. For example, The Illinois Professional Teaching Standards (2010) indicate that a competent teacher will use technology in the classroom to address student needs, accomplish instructional objectives, and enhance student learning. Furthermore, teachers are expected to incorporate a variety of technology and digital-age media and formats to assist students in solving problems and constructing new knowledge in engaged learning environments.

This expectation for schools and teachers to incorporate technology into the education process is also mandated by a component of NCLB, the *Enhancing Education Through Technology Act of 2001 (EETT)* (2002). The primary goal of the EETT "is to improve student academic achievement through the use of technology in elementary schools and secondary schools" (2002, Sec. 2402(b)(1)). Therefore, schools should be using technology to teach reading skills to students, and support student acquisition of information when reading to learn. To be successful in this endeavor, teachers must be able to successfully match the appropriate

tool with the most effective pedagogy to achieve learning objectives (Sun Associates, 2010). But first, various categories of technology integration for addressing reading skills must be identified.

Categories of Technology Integration

Two main categories of technology integration have been identified: a) tools that serve as a tutor and increase skills, and b) tools that assist students in engaging in the learning activity (Sun Associates, 2010). These two categories are subdivided further to identify technology tools for improving and supporting reading comprehension, thus creating four categories: a) technology used as a stand-alone product or activity provides instruction independent of core curriculum; b) technology provides independent learning opportunities and additional skill practice and is designed to be used in conjunction with or as a component of the core reading curriculum; c) technology is embedded into the teaching process and core curriculum to enhance the instruction; and d) technology is used to accommodate for skill deficits occurring with at-risk students and students with mild disabilities who struggle in the classroom.

When technology is used as a stand-alone activity, students interact with software programs designed to provide instruction and practice in lieu of receiving direct instruction from a person. These programs, described as computer-based or web-based programs, interventions, or courses, are designed as intervention programs for struggling readers. Examples include *Reading Plus®, Fast ForWord®,* and *SuccessMaker®. Reading Plus®* is a web-based reading intervention program designed to improve silent reading fluency, comprehension, and vocabulary. The intervention includes differentiated reading activities, reading assessments, and progress monitoring (Taylor Associates/Communications, Inc, 2012). Fast ForWord by the Scientific Learning Corporation (2012) is a set of web-based products designed to increase the cognitive processes required for successful reading and address a wide range critical language

and reading skills. *SuccessMaker*® is described by Pearson (2012) as web-based instructional software that provides individualized instruction for mastery of reading and math concepts. The program is described as highly interactive and engaging for students. It also provides data for educational decision-making. All three of these web-based products are designed as stand alone programs to be used as interventions, are not components of core-curriculums, and are designed to teach skills to struggling readers.

Computer software also supplements teacher-centered instruction by giving students extra skill practice. Comprehensive teacher-led reading curricula such as READ 180 for grades K-12 by Scholastic (2011) and Voyager Passport Reading Journeys™ for middle and high school students by Cambium Learning Group (n.d.), are comprehensive reading programs with software components that provide extra practice. Moreover, online based programs, such as Accelerated Reader, and websites, such as VocabularySpellingCity.com, are included in this category. Accelerated Reader (Renaissance Learning, n.d.) provides online quizzes for students to take after reading library books, assigns individual reading levels, motivates students to read, and monitors students' reading and vocabulary growth. VocabularySpellingCity.com (Vkidz, n.d.) provides additional vocabulary and spelling practice and allows the teacher to customize the content so that the activities correspond with individual lessons taught from the core curriculum.

Another category for integrating technology into the classroom is to embed its use into the teaching and learning processes. In this situation, software is not being used to instruct or provide extra practice; instead, it is a tool for learning. Examples include incorporating interactive graphic organizers and maps (Lacina, 2006) or virtual manipulatives that can be used with interactive white boards, desktop computers, and lightweight tablet computers or other mobile devices. Interactive tools assist with planning, analyzing, organizing, and summarizing

information.

Finally, computer technology can be used to assist struggling students by accommodating skill deficits. The most prevalent form of technology for this purpose is audio recordings of books. The government first mandated that audio recordings of text be created during the 1930s (Library of Congress, 2006) so that individuals with visual impairments could independently access books and magazines. Now, with the accessibility of more advanced computer-based technologies, audio recordings can be combined with additional interactive elements to support word recognition, word meaning, and overall comprehension with a multisensory experience.

There has been little research focusing on the use of computer-based applications addressing reading comprehension skills (Savage, Abrami, Hipps, & Deault, 2009), therefore, the purpose of this review was to explore the effectiveness of using computer technology as a tool to support and improve the reading comprehension and vocabulary acquisition of students in kindergarten through twelfth grade, and to compare resulting outcomes with traditional means of teaching new skills and supporting skill deficits.

Method

A search was conducted to locate research studies investigating the effect of computer use in the K-12 school setting on improving and supporting the reading comprehension skills of students. Using the Education Resources Information Center (ERIC) Database via EBSCO, a general search for the terms "*reading comprehension*" and "*computer*" was conducted. The search mode was set on Boolean/Phrase with the option to apply related words selected. Search results were limited to peer-reviewed articles that included students in kindergarten through 12th grade range. In order to focus on recent technology innovations, results were also limited to articles published since 2001. This search produced 95 results.

Criteria used to determine inclusion in this review were: a) primary measures focused on reading comprehension as opposed to developing word-attack skills or reading fluency; b) methods used in the study compared a technology-based treatment with an equivalent non-technological treatment; and c) struggling readers, at-risk readers, and/or readers with an identified high-incidence disability participated in the study. Out of 95 results, 10 articles reported empirical studies that met all three criteria for inclusion in this review. These 10 articles were classified and discussed as follows: a) multi-featured electronic texts (De Jong & Bus, 2004; Ertem, 2010; Fry & Frosky, 2007; Korate & Shamir, 2007; Pearman, 2008; Twyman & Tindal, 2006); b) supplemental instructional software (Mostow et al., 2003); and c) embedded technology (Glenberg, Goldberg, & Zhu, 2011; Higgins & Rasking, 2005; Tancock & Segedy, 2004).

Criteria for inclusion in this review were based on various factors. First of all, word-attack skills and reading fluency play a major role in the ability to comprehend what is read (Savage et al., 2009). However, the focus of this review is on reading comprehension, not basic reading and word attack skills. Hence, studies in which the purpose of the technology was to develop word-attack skills and/or reading fluency did not meet the criteria unless they also targeted comprehension skills. Moreover, because other content area curriculums rely so heavily upon reading comprehension skills, especially for older students, studies that utilized content area materials such as science or social studies to study the effects of technology on reading comprehension were considered to meet the criteria for this review.

Due to the number of students failing to meet standards on state-wide mandated testing who are categorized as at-risk readers, and the number of students with high-incidence disabilities, such as mild learning disabilities or behavioral disorders, it is important to determine

how technology can assist in bridging the gap for these students. Therefore, only research studies specifying the inclusion of struggling readers or at-risk readers were selected for review. Because of negative effects of low socio-economic status on academic outcomes (American Psychological Association, 2012), research focusing on students in pre-K, kindergarten or first grade, who may not have enough reading experience to be identified as a struggling reader, were also included if a demographic characteristic, such as socio-economic status (SES), would increase the likelihood that a student might be identified as an at-risk or struggling reader in later years. Investigations that focused on the effects of technology on English Language Learners (ELL) or Second Language Learners (for international studies) or identified the majority of participants as ELL were excluded because it was difficult to determine whether increases in comprehension scores were due to an increase in familiarity with the language itself or an increase in comprehension skills and strategies.

Most of studies culled from the search did not meet the criteria for this review. Some compared the effects of one technology-based treatment with another technology-based treatment or compared the effects of the same technology-based treatment on various age groups. Others compared the effects of technology-based interventions designed to supplement the core curriculum with the effectiveness of the core curriculum alone. Articles such as these were deemed inappropriate for determining the effectiveness of using a technology-based treatment compared to an equivalent non-technological approach for meeting the needs of struggling readers.

Nineteen of the articles culled were reports produced by the What Works Clearinghouse (WWC). The What Works Clearinghouse is an Institute of Education Sciences, a division of the U.S. Department of Education that analyzes and reports on existing research for educational

interventions. The guidelines and requirements for the inclusion of studies in their reports are rigorous (see U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, What Works Clearinghouse (WWC), 2008, for details). Of the WWC reports retrieved, four summarized the effectiveness of instructional technology-based reading programs designed to target reading comprehension skills (2009a, 2009b, 2010a, & 2010b). However, they did not meet criteria for inclusion because the studies included by WWC compared the effects of students receiving core-reading instruction plus a supplemental computer-based reading intervention with students receiving core-reading instruction without an equivalent non-technology based supplemental intervention comparison..

Of the 10 studies that met the criteria for this review, six of the studies (De Jong & Bus, 2004; Ertem, 2010; Fry & Frosky, 2007; Korate & Shamir, 2007; Pearman, 2008; Twyman & Tindal, 2006) compared the effects of various types of multi-featured electronic texts with traditional texts on comprehension. Because the demands on reading change as students age and develop more advanced reading skills, these six articles were further organized by student grade level. One study (Mostow et al., 2003) compared the results of a specific computer program designed to provide independent supplemental reading instruction with the effectiveness of a certified teacher providing the same instruction. The final three studies embedded technology into the learning process: a) Higgins and Rasking (2005) evaluated the effectiveness of a hand-held device designed to aid independent reading; b) Glenberg, Goldberg, and Zhu, (2011) compared the use of virtual manipulatives with physical manipulatives to teach using imagery while reading; and c) Tancock and Segedy (2004) evaluated the use of technology to respond to printed texts.

Multi-featured Electronic Texts

A common method of technology utilized in research is multi-featured electronic books, or e-books. E-books are available on CD-ROM or as streaming media or other multimedia format for later viewing that can be downloaded from the Internet. The most basic e-book is a replica of the printed text in electronic format. Depending on the target audience and type of technology used to present the book, e-books might also include a recording of the text, animated pictures, or background noises, as is common in movies and cartoons, to accompany a story. Interactive features of e-books include hidden animated areas displaying extended information, movable virtual objects, and word dictionaries. Some interactive and non-interactive e-books allow page turns by clicking a navigation button just as pages would be turned in a printed book. Some non-interactive books with audio recordings automatically display the next page as the audio recording progresses.

For Kindergarten

Kindergarteners, also known as emergent or beginning readers, are just learning letter-sound combinations and to read basic sight words. At this stage of reading development, much effort put forth by the student while reading is on recognizing and sounding out words. Therefore, e-books designed for these emergent readers typically have an audio recording of the story with animated pictures. Interactive versions of e-books for emergent readers may have hidden areas in the animation identified as the story is read that will reveal explanations or more information. They also have page turn functionality so that readers can navigate and turn pages so that sections of the book can be read or listened to again.

Emergent readers lack the word attack skills to successfully read and comprehend the text of a story independently. Because of this, storybooks and picture books are often read to young

children, especially in classrooms with emergent and beginning readers. Electronic versions of picture books can be used to allow these young readers the opportunity to listen to stories as they would listen to an adult read a picture book to a group of children. De Jong and Bus (2004) compared the effects of a) listening independently to and exploring electronic picture books that did not display the text, b) listening to an adult read aloud picture books, and c) independently exploring printed picture books on the ability of students to recognize the pictures, to retell, or emergently read each story to an adult.

Using Sulzby's (1985) Emergent Reading Ability Judgments for Favorite Storybooks scale, De Jong and Bus (2004) identified 18 kindergarteners attending a school enrolling mostly Dutch families from low socioeconomic status in a small town in the Netherlands. These 18 students could include elements from multiple pages but demonstrated difficulty telling a complete story similar to the one in the book while using phrasing from the book. While they were not yet able to decode words, they were not suspected of having a learning disability. The study required all children to: a) listen to and explore an electronic picture book containing animations and sounds but did not display the text; b) listen to a second story read from a printed book by an adult; and c) explore a third printed book that was not read to them. The picture books used were all written by the same author and were available in closely matched printed and electronic forms. All conditions included three readings of the story and the students were given posttests for each story and condition.

For each posttest, the students were provided the same format of the book used during the treatment and were asked to read the story to an adult. Using verbatim transcripts of the students' emergent reading, de Jong and Bus (2004) tallied a) how many words student used from the original text, b) how many three or more word phrases were used from the text, c) the

number of pages in which the child's story was similar to the original story, and d) the number of pages in which the child told the main event.

Results indicated no statistically significant differences between scores for the electronic book and printed book treatments in which the story was read to the student. Furthermore, the scores for the two treatments were significantly greater than the control treatment in which the story was never read to the student. De Jong and Bus (2004) concluded that when students who are unable to decode text but are in the initial stages of story understanding and have had exposure to repeated adult led book readings, electronic picture books meet the development needs of students and provide an alternate means for providing them with opportunities for listening to stories.

As emergent and beginning readers improve their word attack and story understanding skills, they move from merely listening to a story with pictures, to following along with the text of a storybook while simultaneously listening to the story. Korate and Shamir (2007) investigated the use of an interactive educational e-book which highlighted text as it was read and provided clickable access to twelve pre-identified vocabulary words to support emergent literacy skills of 128 kindergarteners. The students participating in the study were from four low SES neighborhood schools and four middle SES neighborhood schools in Israel. The students were randomly assigned to three groups. Two groups were treatment groups. The students in the first treatment group worked independently with the interactive electronic version of the storybook. Those in the second treatment group interacted with and followed along in the story with an adult reading the printed version of the same storybook in a one-on-one setting. The third group did not interact with the storybook in either format and served as the control for measuring growth in vocabulary, word recognition, and phonological awareness.

The treatment group utilizing the e-book engaged in three 30-minute sessions with the e-book. The e-book featured automatic animated visuals as well as extra music and film effects and allowed the reader to control page turns. The e-book also highlighted text as it was read by the audio recording. During the first session, students used the book in 'Read story with dictionary' mode. This allowed the students to listen to the story and click on specific words when further explanation of its meaning was needed. Twelve pre-selected words from the story were used for the dictionary and were presented to the students at the beginning of this session. During the second session, the students worked with the book in 'Read story and play' mode that allowed students the opportunity to click on hot spots after reading the page. When a student clicked on a hot spot, the student was given more information that adds to the story but was not critical for understanding. Other hot spots would provide the name of the object that was clicked in a format designed to support phonological skills. During the third session, students spent an equal amount of time in each of the two modes.

Students in the second treatment group also engaged in three sessions with the printed storybook. Each student worked with the same adult in all three sessions. Each adult was given the same set of instructions to follow for reading the book, asking students questions about something in the book, and giving the students more information such as word meanings and information provided by hotspots in the electronic version of the book. Students were allowed to ask the adult questions and the adults answered all questions although they were not to elaborate with their answers.

After completing three activity sessions with the book, students in both treatment groups were asked seven comprehension questions about the story: four were knowledge based and three required making inferences. Results indicated no significant differences between the two

treatment groups or the SES groups. Students in both treatment groups demonstrated an overall 80% success in answering comprehension questions correctly. Furthermore, when given pre- and posttests on the vocabulary words used in the dictionary mode of the e-book, the students in both treatment groups made similar gains. Results confirmed Korate's and Shamir's hypothesis (2007) that students who independently used the e-book and those who followed along with an adult reading the book would earn similar scores for demonstrating an understanding of story content and learning the meaning of new words appearing in the story.

For Primary Grades

Once emergent literacy skills are developed and students are reading a greater amount of text independently, other interactive features of e-books become more appropriate. Pearman (2008) investigated the ability of fifty-four second graders attending an elementary school in a large rural school in the southeastern United States to provide oral retellings of text after independently reading storybooks in a traditional print format or an electronic CD-ROM format without having the book read aloud to them. The e-books used in this study contained pronunciations, graphics, sound effects, labels, contextual definitions, and the ability to select text to be pronounced by the computer. Students were categorized according to their developmental reading ability, identified as high, medium, or low, and then assigned two books to read. One book was an e-book and the other was a printed book. Students received training on how to use the interactive features of the e-book prior to independently reading the assigned e-book.

During each reading session, field notes were taken to record student behaviors. Then at the end of each reading session, each student gave an oral retelling of the story. The oral retellings were rated using Morrow's (1986) 10-Point Scale which credits students for including

elements pertaining to characters, setting, theme, plot episodes, resolution, and sequence of events. Results showed mean scores were significantly higher for students after reading an e-book than after reading a printed book. Furthermore, while scores were not significantly different between the two formats for the students in the middle and higher reading groups, scores were significantly greater for students in the lower reading group after reading the e-book. Field notes indicated that students identified as having attention-deficit- hyperactivity- disorder were more engaged and spent less time flipping pages and looking around the room while reading the electronic texts, which may have contributed to higher scores for the lower readers when reading the e-book. Also, of the 54 participants, 13 read the traditional texts silently but read the electronic texts aloud and 14 students used a cursor to follow the electronic texts but did not use a finger or other pointer to follow the printed text. Pearman (2008) interpreted these findings to suggest that the electronic text was more physically demanding for students to read. Regardless, findings support the conclusion that interactive features of e-books provide support allowing less skillful readers to concentrate on constructing meaning from the text.

For Upper Elementary

Students' needs change as they become older and text becomes more challenging. Likewise, the features of e-books deemed most appropriate for supporting older struggling readers change as well. Ertem (2010) studied the effects of reading a) an electronic storybook with interactive animation, b) an electronic storybook without animation, and c) a traditional printed storybook on the ability of seventy-seven 4th grade students to retell the story. These fourth graders were described as having the basic decoding skills necessary to read a story at the second or third grade level but lacking the comprehension skills to understand text. They were also identified as struggling readers by their scores on the Florida Comprehensive Assessment

Test (FCAT).

Only one story was used, and it was available in all three formats required for the study. Both versions of the e-book contained navigation tools for controlling page turns, page numbers, and a range of sounds and music. The only difference between the electronic storybook with interactive animation and electronic storybook without animation was the animated version provided clickable interactive picture-plays indicated by cued animations. Both electronic versions contained word pronunciation, definition, and narration functions but these features were turned off so that the students would not receive extra help with word recognition or word meanings while independently reading the electronic format.

The students were randomly assigned to three treatment groups, with each group reading a different format of the story. After reading the story, each student gave an oral retelling of the story, which was scored using Morrow's (1986) 10-Point Scale for telling the setting, theme, plot episodes, and resolution of the story. The treatment group of students who read the electronic storybook with animation earned the highest mean score for retelling the story. Mean scores for both electronic treatment groups were greater than the mean scores for the print treatment group; however, only the scores for the electronic storybook with animation treatment group were significantly greater than the traditional print treatment group. Based on these scores, Ertem (2010) concluded that animation might be a beneficial support for helping struggling readers to construct meaning from narrative text.

For Middle School Students

As students enter middle school grades, more emphasis is placed on independently reading informational text such as that found in science and social studies textbooks. In an effort to examine the effects of adding pop-up dictionaries to electronic social studies text, Fry and

Grosky (2007) worked with 129 6th - 8th grade students in various social studies classes and experimented with using a printed textbook, an electronic text with no additional features, and an electronic text with a pop-up dictionary. Outcome measures were based on student scores from comprehension tests covering the text that was read. The teachers were asked to select three passages, each from a different chapter in the textbook, for students to read independently. Two electronic versions of these passages were created for use in the study. The first electronic text was devoid of interactive, animated, and graphically enhanced features. The second electronic text included the addition of a pop-up dictionary.

The order in which students used the various formats was determined by their class schedule and availability of the computer lab. Using a different treatment condition for each passage, the students read the assigned text in the prescribed format and then took a paper and pencil comprehension test. The comprehension tests contained two parts. The first part consisted of 10 multiple-choice formatted questions about information and terminology in the text. The second part contained a cloze formatted passage taken from the reading material with 10 missing words to be filled in by the student. Anecdotal notes were also taken to document student use of the pop-up dictionary.

Overall, test scores were significantly higher when students used the pop-up dictionaries than when they used the non-interactive online text or the printed text. Furthermore, it was reported in the anecdotal notes that struggling readers utilized the pop-up dictionary more often than stronger readers. Therefore, Fry and Grosky (2007) concluded that the use of electronic text with a pop-up dictionary, and no other animated or interactive features, is a helpful intervention for supporting reading comprehension of middle school students in social studies and offers one path to improving overall reading comprehension.

For High School Students

There is a lack of research studying the effects of e-books on reading comprehension of high school students. According to Fry and Gosky (2007), much of the technology research for secondary students has focused on other elements of learning. Twyman and Tindal (2006) utilized the features of electronic text to compare the effects of using an electronic text with audio and pop-up glossary against using the adopted printed textbook on the reading comprehension and problem-solving skills of high school students with learning disabilities in a concept based social studies class. The 24 eleventh and twelfth grade students participating in the study were identified with learning disabilities in reading and writing and attended self-contained U.S. History classes for students with learning disabilities. Students were assigned to the control or experimental group based on their class schedule and availability of the computer lab.

The electronic text used in the experimental group allowed students to have the computer read selections aloud while they followed along. Students were able to click on difficult words to see the glossary entry or hear the pronunciation for the selected word. The control group used similar chapters selected from the school district's adopted printed textbook. Both groups also participated in teacher led instruction focusing on comprehension strategies and review covering the concepts in the text.

Three curriculum-based measures (vocabulary, maze, and problem-solving essay) were administered to assess content knowledge and problem-solving skills. Vocabulary measures administered as pre- and posttests required students to match 14 definitions to the correct word. Concept maze measures were administered three times and used passages from other texts covering the same concepts as what had been taught in class. Eight words deemed conceptually

important were deleted from each passage and replaced by a series of words for the student to circle the correct word. The essay tests required students to summarize and explain information from the text. Students in the experimental group composed their essays on the computer whereas the control group composed their responses on paper. A pretest and posttest were given. The pretest covered previously taught material to control for prior knowledge and writing skill and the posttest covered concepts from the material used during treatment.

When comparing the mean pre- and posttest scores for the vocabulary tests, there was a greater increase in mean scores for the experimental group than the control group; however, the differences in scores were not significantly different. Both groups also made gains from the pretest to the posttest for the maze test, with the experimental group making greater gains, but the differences were not significant. The change in scores on the essay tests followed the same trend as the two objective tests in that the experimental group made greater gains than the control group. However, on this measure, differences in gains were nearly significant. The teachers who participated in the study noted that students in the experimental group were more participatory and engaged in the lessons and activities than those in the control group. Twyman and Tindal (2006) concluded that student use of electronic text with audio and glossary features was as effective, although not significantly more effective, than using a printed textbook when learning history concepts, acquiring new vocabulary, and developing problem-solving skills for high school students with learning disabilities.

Supplemental Instructional Software

Some software programs exist to help students become better readers by supplementing instruction. They may be used as computer based components of a mixed-methods comprehensive literacy program or function as a stand-alone program providing additional

instruction and extra practice.

Project LISTEN's Reading Tutor

Project LISTEN's Reading Tutor program employs automated speech recognition and programmed responses, along with vocabulary instruction. In an effort to improve the *Reading Tutor* software, Mostow et al. (2003) compared the effects of a) students using the *Reading Tutor* software program in addition to receiving core-curriculum reading instruction, b) students receiving reading tutoring from a human in addition to core-curriculum reading instruction, and c) students receiving only the core-curriculum reading instruction on the reading skills of 131 second and third graders identified as struggling readers by their teachers.

Students in the two treatment groups were removed from classroom instruction to receive 20 minutes of tutoring each day. Schedules were rotated so that students did not miss instruction in the same class each day. The Woodcock Reading Mastery Test and oral reading fluency tests were given as pretests and posttests to assess effects of the three conditions on word attack, word identification, word comprehension, passage comprehension, and oral reading fluency skills.

Overall, both treatment groups made greater gains in word comprehension and passage comprehension than the control group and the greatest gains were made by the Reading Tutor group. Mostow et al. (2003) reported surprise at how similar the results of the three groups were. They summarized that the Reading Tutor produced similar or greater gains than staying in classroom instruction and rivaled additional tutoring provided by certified teachers in word and passage comprehension for third graders. This conclusion supports the idea that computer software can be used as a viable alternative to provide additional instruction in reading comprehension.

Embedded Technology

Text Readers

Systems combining optical character recognition (OCR) systems with speech synthesis are used in software designed to read to people with visual impairments as well as support those with reading disabilities. OCR systems are typically used on desktop computers and require a scanner to digitize text documents. More recently, portable handheld OCR devices allow the user to scan printed text a word or line at a time and listen to synthesized speech read the text that was scanned. One such device is called the Quicktionary Reading Pen II. It is a handheld OCR device featuring speech synthesis, small screen, speaker with an ear phone jack, and dictionary functions. Higgins and Raskind (2005) compared the effects of students a) reading traditional printed passages using the Quicktionary Reading Pen II and b) reading traditional printed passages without the Reading Pen on comprehension test scores for 30 students in grades four through twelve.

Students received training using the Reading Pen, followed by two weeks of practice using the Reading Pen and its features, prior to testing. Students were tested on passages while using the Reading Pen and on different passages without the Pen. When using the Pen to assist with decoding, students' scores jumped an average of five standard points. Higgins and Raskind (2005) noted that the students not only read more accurately using the Pen but they were able to move on to read more difficult passages with good comprehension.

Virtual Manipulatives

Another way to embed technology into reading instruction is to use virtual manipulatives. Manipulatives may be used to teach reading comprehension and vocabulary to young readers by connecting word meanings with pictures and objects. *Moved By Reading* is a two-part

intervention designed to teach the skill of mapping words and phrases onto experiences. The first part requires students to read a few lines of text and then act out the text using manipulatives. The second part teaches students to imagine using the manipulatives. Glenberg, Goldberg, and Zhu (2011) compared the effects of a) the *Moved By Reading* intervention using physical manipulatives, b) the *Moved By Reading* intervention using computers to manipulate virtual objects, and c) repeatedly reading text aloud on the ability of first and second grade students to answer 10 yes/no comprehension questions about the text.

Each child participated in two sessions. During the first session, all students were taught how to use the electronic text, what the names of objects in pictures were, and how to recognize signals to use a manipulative or re-read critical text. They were then instructed to read four passages. Upon seeing the signal in the text, students in the virtual manipulative group would use the mouse to manipulate images of objects, students in the physical manipulative group would look away from the computer and move the physical objects or toys, and the students in the re-read aloud group would re-read the critical text as instructed. After reading two passages, the students were asked 10 questions about the passages and responded verbally with a yes or no answer. Students then repeated the process with two more passages and another set of comprehension questions. During the second session, students in the manipulation treatment groups were instructed to imagine the manipulation of toys while reading each passage of text. Students in the re-read aloud group were told to read the text silently with no additional instructions. All students were given two passages to read and then asked another set of comprehension questions. Afterwards, students were given two passages containing a different scenario to read. Again, students were asked comprehension questions after reading these two passages. Each student took a total of four comprehension tests over the course of the two

sessions.

Mean scores for students in the computer manipulation group were greater than the mean scores for students in the other two groups. Furthermore, they were significantly greater for the computer manipulation group compared to the re-read aloud group on the first day and on the test for the familiar scenario on the second day. Scores for the physical manipulative group where similar to scores for the re-read aloud group. Glenberg et al. (2011) concluded that manipulation of virtual toys and text-relevant images was as effective, and slightly more effective, than having students manipulate physical text-relevant toys, and overall, more effective than re-reading text aloud. They also found that the intervention helped students answer inferential questions and supported students' memory of the text that was read.

Enhancing Research and Responses

Most studies included in this review utilized computer technology during the reading process. One study took a different approach and compared the effects of a) using computers to create responses to text and b) using paper and pencil activities to create responses to text on comprehension test scores (Tancock and Segedy, 2004). The study was conducted with a class of 15 second graders at an elementary school in the Midwest. The students were divided into to two groups based on scores from an informal reading assessment to create comparable groups with high, average, and low ability readers. All students were assigned a text they could read independently and listened to directions for completing a response activity. The students were given the choice to read the text individually or to partner read with a peer. After completing the reading, both groups went to the computer lab to complete the response activity. The students in the experimental group used a computer to research information and create their response activity, whereas the control group used printed books to research information on the same topics

and provide their response using paper-based activities. Response activities for the computer group included a) using *Kid Pix* to create a story map, b) typing a written response, or c) using software to do research and create a flipbook or a mini-poster. The control group used paper, pencils, and crayons to create the same type of responses.

Once time for completing the response activity had passed, the students took a written test requiring them to write answers for six comprehension questions requiring the recall of information from the text that was read. The control group outscored the experimental group on every comprehension test. The teacher created a rubric to also score the quality of the response activities. While the experimental group demonstrated more interest in the assignment, the control group consistently scored higher on all response activities. Tancock and Segedy (2004) attributed these findings to the observation that students using the computers contributed more time and effort to using the computers and sharing how to use the computers than thinking about the text. The newness, or novelty, of the computer activities may also have distracted the students from focusing on the content of the activities.

Conclusions

Overall, studies reviewed indicate the effects of technology-based approaches for addressing reading comprehension and vocabulary skills are positive. Of the 10 studies reviewed, four studies (De Jong and Bus, 2004; Korat & Shamir, 2007; Twyman & Tindal, 2006; Mostow et al., 2003) demonstrated that technology-based approaches are as effective as using non-technology based approaches. Furthermore, five studies (Pearman, 2008; Ertem, 2010; Fry & Grosky, 2007; Glenberg et al., 2011; Higgins & Raskind, 2005) showed evidence of computer-based approaches yielding better results than non-technological approaches. Only one study (Tancock & Segedy, 2004) reported lower gains for the technology based treatment group.

A trend can be identified among these studies using electronic texts. First of all, interacting with electronic picture books, regardless of features, for emergent readers were found to have similar effects as listening to an adult read a storybook (De Jong and Bus, 2004; Korat & Shamir, 2007). However, once students develop some independent reading skills and reach second grade, interactive e-books with pronunciations, graphics, sound effects, labels, and contextual definitions offered more support and resulted in students demonstrating a greater ability to retell what they had read (Pearman, 2008). Greater gains were also produced for fourth graders, even when narration and pronunciation features were turned off (Ertem, 2010). These findings support that multi-modal presentation of text support student reading comprehension of stories. The interactivity available via computers provides modes of presentation that printed books cannot provide.

Instruction becomes more focused on other content areas as students reach middle school. Struggling readers facing the expectation to independently learn from reading need tools to help them read. Fry and Grosky (2007) found that interactive electronic textbooks with pop-up dictionaries and narrations were a beneficial tool for struggling students to use when compared to using the traditional textbook. However, when the same features were provided with the addition of narrated text for high school students with learning disabilities receiving instruction in a self-contained classroom, the effects of the interactive textbook were not as great, although still comparable (Twyman & Tindal, 2006).

Use of handheld text readers and virtual manipulatives also provide support for readers. Handheld text readers with dictionaries support decoding, word recognition, and vocabulary deficits to allow for comprehension of more difficult passages (Higgins & Raskind, 2005). While virtual manipulatives support word meaning, they can also be used to promote passage

comprehension and memory of what is read by teaching students to use imagery when reading (Glenberg et al., 2011).

When computer technology provides the same research proven support that humans have provided and adds various modes of interactivity, students better understand what they read with less reliance upon others for assistance. Regardless of whether students are learning to read, reading for entertainment, or reading to learn, the addition of interactive elements in electronic texts helps the struggling read by accommodating for the readers' skill deficits.

Outcomes differ when computers are used to create a response to reading printed text. When second graders used computers to conduct further research and organize information, the computers were a hindrance for the students (Tancock & Segedy, 2004). However, when high school students identified with learning disabilities used interactive textbooks and were asked to answer extended problem-solving response questions, the students using the computers to type their answers were more successful summarizing and explaining their answers than those receiving instruction using printed textbooks and writing their responses with pencil and paper (Twyman & Tindal, 2006).

In summary, computer technology was found to be beneficial supplemental tool for supporting reading comprehension of struggling readers across all grade levels. It was found to be most beneficial when used to support struggling readers during the reading process. These results bring merit to utilizing computer technology to support students receiving special education services. The Individuals with Disabilities Education Act (IDEA) (2006) mandates that students be educated in the least restrictive environment and provides funding to support the use of technology to maximize accessibility to the general education curriculum. Tools such as multi-featured electronic text and hand-held OCR readers provide independent accessibility to

texts used in general education curriculums for students with disabilities who are struggling readers.

Implications for Practice

In order to be in compliance with NCLB and EETT, teachers and schools must incorporate technology into the classroom and the education process. As schools explore reading curriculums and other technology-centered reading programs and materials, they must evaluate the purpose and requirements of the technology components. Various factors should be considered:

- What is the purpose of the technology component? Is it to instruct, support, provide extra practice, or assess?
- Will the entire class need to move to the computer lab, or is it designed as a center activity so that only a few computers are needed in the classroom? Are tablet computers available for use in the classroom?
- Do the school's computers meet the minimum requirements for using the technology components, and are all peripherals (e.g. headphones and microphones) available?
- What training will be needed for staff and students?
- How will student outcomes be affected if the technology component is not used?

Each purpose for technology brings about its own set of factors to be considered. When computer programs are designed to provide instruction, it is important to ensure that students are able to understand and respond to the software with minimal frustration. Software programs with recorded speech can be difficult to understand when using older, or less sophisticated, technology, and visual cues are needed to accompany the audio recordings. When the student finds the technology frustrating to use, the student would be better served by working with an

adult or peer.

When teachers search for electronic texts, the appropriateness of various features should be determined by the purpose of the activity and the needs of the student. For independent reading, animations with clickable text presenting an audio recording of unfamiliar words found in storybooks such as those on www.starfall.com, for example, would be sufficient. However, for fluency support and following along with text, an audio recording with highlighted text, such as is found on www.tumblebooks.com, might be determined to be more appropriate. When supporting comprehension in other academic subjects, the addition of virtual manipulatives and interactive dictionaries would be appropriate for supporting the reading of more challenging content.

One concern for schools is the cost of computer technology. Developing effective computer software and electronic material is expensive, which means additional costs for the initial purchase of the equipment and materials as well as the cost to keep the equipment up-to-date. However, as less expensive tablet computers become available, it may become more feasible to integrate computer-based supports and interventions on a larger scale. Fortunately, government mandates such as the EEFT and IDEA make the provision for sources of funding for the purchase of educational technology.

Furthermore, necessary training for staff and students to use the equipment and materials must also be considered. Training for staff can be expensive, but as research indicates (Mundy, Kupczynski, & Kee, 2012), teachers who are not comfortable using technology will be less likely to effectively incorporate computer technology into their classrooms. Even when staff receives the necessary training and the latest technology is accessible, the overall outcome and effectiveness must be considered. For example, a struggling reader lacking necessary skills to

use a computer independently will require training so that he/she can successfully use the computer (Tancock & Segedy, 2004)., but a struggling reader who has the computer skills but is easily distracted by the technology or distracting to others might be better served by using a non-technology based solution. Teachers must consider the individual needs and abilities of each student when selecting technology-based tools for instructional activities.

Accessibility of computers must also be considered. If every child needs access to a personal computer and the computer lab is not available, then incorporating technology is not so feasible. This situation occurred when Fry and Gosky (2007) and Twyman and Tindal (2006) planned and conducted their studies. They were working with students in multiple classrooms, but the computer lab was not available for use by every class due to other classes in the building needing to use the lab too. One possible solution to this problem is for schools to invest in table computers that students can use at their desks in their classrooms. Not only do tablet computers provide access to computer technology without the interference of scheduling conflicts, they also allow for technology to be fully integrated for all students and become a part of the regular routine.

Another consideration is novelty. When computer technology is integrated irregularly and is not a part of the classroom routine, students may not get enough experience with the technology for the novelty to wear off. As documented by Twyman and Tindal (2006) and Tancock and Segedy (2004), students must receive training to use the technology and have enough time to work with it for the novelty to wear off and for students to feel comfortable using the technology.

Future Research

There continues to be a limited amount of current research isolating the effect of using

computer technology to improve reading comprehension of students (Savage et al. 2009). This may be due to the fact that much of the educational software designed for young students focuses on traditional drill and practice approaches (Shamir, Korat, & Barbi, 2008; Williams, Rouse, Seals, & Gilbert, 2009). The limited number of studies identified for review, as well as the limited number of participants in these studies, necessitates further research to adequately determine the effects of computer technology on reading comprehension. Three issues guide suggestions for future research: a) e-books show promise for promoting comprehension, b) much research on computer-based reading programs exists, and c) much of the instructional reading software is designed to address basic reading skills.

First, e-books show promise for promoting comprehension of text for students of all ages. Questions can be raised about the extent to which students are remembering and understanding what they read and to what extent readers rely on the extra features not available with printed text. How much do students rely on animated graphics and accompanying sounds to derive meaning from the passage?

Meanwhile, the effect of computers in the home of low-income families with young children should also be examined to determine if additional time spent looking at and listening to storybooks by young children has an effect on the development of emergent literacy skills. Studies should also explore the age or development level that would be most appropriate for adding text to narrated interactive picture books for emergent readers.

Studies examining the use of e-books with animated and interactive features such as animated graphics, interactive hotspots, and sound effects focused on reading comprehension outcomes for students in primary grades. The few studies found for older students used e-books that contained dictionaries, glossaries, and pronunciations. One study also provided narration of

the text. However, there were no studies found that included the use of animated graphics, sound effects and other interactive features in e-books for older children. Studies found examining e-books for older children varied the reading ability of the electronic text (Marino, Coyne, & Dunn, 2010), or used an e-book for both control and treatment conditions to study the use of other comprehension strategies and tools (Manset-Williamson et al., 2008; Meyer et al., 2010; Stetter & Hughes, 2011).

Most of the current research using e-books to address reading comprehension target younger students (De Jong & Bus, Ertem, 2010). Furthermore, struggling readers in upper grades have many of the same struggles and reading deficits as younger students (Ertem, 2010). However, it cannot be implied that the features of a particular type of electronic book designed for the younger reader will be just as effective for the older struggling reader. Given that students in upper elementary, middle school, and high school are expected to read to gain knowledge across all content areas, it is critical to identify which features of technology best support these struggling readers so that they can focus on learning content. More studies are needed that compare using e-books with a variety of features against using static, printed text for children of all ages.

Second, much research exists comparing supplemental computer-based reading programs to core reading programs without a nontechnology-based equivalent supplementation. Many studies have been conducted on programs such as *READ 180* (WWC, 2009a), *SuccessMaker* (WWC, 2009b), *Reading Plus* (WWC, 2010b) and *Fast ForWord* (WWC, 2007; WWC, 2010a). The studies included in these WWC reviews document the effect of using a computer-based reading program to supplement the core-reading curriculum. These studies focus on the effects of using software to supplement core instruction without comparing the software to a

supplemental instruction without the use of technology. A similar study compared an individualized computer tutoring software, *Alphie's Alley* with an embedded multimedia program called *Reading Reels* (Chambers et al., 2008). The results showed that adding Alphie's Alley augments the *Reading Reels* program but the effectiveness of the computer tutoring software was not compared to an equivalent non-technology piece. Studies examining these supplemental computer-based interventions do not isolate the effects of the technology or rule out the possibility that more is better. These studies do not provide the information needed to determine if students are better off receiving individualized instruction and practice from technology compared to working with a teacher. Future studies isolating the effects of reading programs such as these are needed to make this determination.

Thirdly, some studies that explored the effects of using computer technology on reading comprehension used instructional software that was also designed to provide individual instruction for word-attack or fluency skills (Blythe, 2006; Chambers et al., 2008; Higgins & Raskind, 2004; Savage et al., 2009; Torgesen, Wagner, Rashotte, Herron, & Lindamood, 2009). While most of these studies showed positive effects on reading comprehension, it is not possible to distinguish whether the growth in reading comprehension was due to an underlying improvement in word-attack, phonics, fluency skills or other skills that affect reading comprehension. Few studies focus on using computer technology as the sole treatment for comprehension skills and strategies.

Even though computer technology has become commonplace in society and education (U.S. Department of Education, 2002), it is important to determine its effects on the development of life skills such as reading comprehension. Just because something is commonplace or accepted does not automatically imply its use is appropriate or best for meeting a specific goal or

targeting a specific skill. While there is much research that has been conducted using computer technology, more is needed to properly ascertain its effects on supporting and improving reading comprehension.

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