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Comparing the Effect of Two Types of Computer Screen Background Lighting on Students' Reading Engagement and Achievement

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Declaration of Originality

I do hereby declare and attest to the fact that this is an original study based solely upon my own scholarly work here at Lindenwood University and that I have not submitted it for any other college or university course or degree here or elsewhere.

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Abstract

With increased dependence on computer-based standardized tests to assess academic achievement, technological literacy has become an essential skill. Yet, because students have unequal access to technology, they may not have equal opportunities to perform well on these computer-based tests.

The researcher had observed students taking the STAR Reading test (Renaissance Learning, 2009) and noticed a variance in scores in relation to classroom performance. The researcher intended, therefore, to explore variables that may affect the performance of students on a computer-based reading assessment. The researcher tested two different technology-related variables as students took a summative exam, the STAR Reading test. The purpose of this study was to explore how changes in visual stimuli affected the process of reading and student reading behavior. This quantitative study sought to ascertain whether changing the computer read-out to a black screen with white lettering made a difference in student engagement and comprehension among students in grades two through six during a computer-based adaptive test.

The research site was one K-6 elementary school in a large suburban school district. The participants of the study were 316 children in grades two through six. One hundred and sixteen students were randomly sampled for student engagement data analysis.. The researcher conducted a stratified random process to further select data for analysis. Students were exposed to both color display background variables throughout the study process. Teacher observers collected tallies on student engagement behaviors during the test-taking process.

The researcher calculated the mean level of student engagement on each of five observed behaviors. The researcher also collected reading comprehension data for five subsequent benchmark sessions throughout the year. The engagement results of this study failed to support the hypothesis, which stated that elementary student behaviors during testing would verify a measureable difference in engagement when either a black or white display screen was presented. The results of the reading comprehension test also failed to support the hypothesis, which stated that there would be a measureable difference in elementary students' scores while taking computer-based tests when the computer screen was set to either black or white background.

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Chapter One: Introduction

With the spread of Internet use causing the world to seem smaller than ever before, education is in the midst of a transformation. The ability to innovate is becoming increasingly important because it gives workers and organizations a competitive edge in the new global marketplace. Williamson and Yin (2011) stated, as America recovers from the recent recession “innovation is more important than ever” (p. 1). The measure of a nation’s potential for innovation is the skills of its students. During the National Summit of Education Reform (2012), former U.S. Secretary of State Rice (2005-2009) and former Chancellor of New York City Schools Klein (2002-2010) declared that the state of American education had become a national security issue (Krieg, 2012).In their keynote addresses, Rice and Klein suggested that the American dream would soon become an American memory unless educators began to better prepare children for college and careers. Rice (2012), referring to the American creed that hard work plus determination equals success, suggested that, in a world that is changing so quickly which values innovation so highly, hard work may no longer be the determining factor in success.

According to a report by the Pacific Policy Research Center (2010) in Honolulu, Hawaii, students in the 21st century cannot expect to find traditional manual labor or skill-based jobs upon graduation. Many jobs are relocated overseas to reduce payroll costs (Lach, 2012, para.15). Because unskilled labor can be easily outsourced, workers of the 21st century must be skilled: they must be able to communicate effectively, collaborate, and solve problems in an ever-changing global market. They must also be able to use technology to solve complex problems creatively (Pacific Policy Research Center, 2010, para.1).

Technological literacy skills are necessary to compete in today's economy. As Jones-Kavalier and Flannigan (2006) stated, "In our 21st century society—accelerated, media-saturated and automated—a new literacy is required, one more broadly defined than the ability to read and write" (para. 2). This new form of literacy is termed "digital literacy." One form of digital literacy increasingly required of today's students is the ability to perform on computer-based standardized test. These tests, which are products of the revolutionary digital technologies, are increasingly used to measure and assess the effectiveness of schools. Indeed, major educational policy decisions are made based upon the results of computer-based reading tests; thus, it is important to understand and address the challenges associated with testing on a computer (Jones & Flannigan).

Wang, Jiao, Young, Brooks, and Olson (2007) described computer-based testing as the new way to assess student performance, displacing paper and pencil tests. The benefits of computer-based testing include ease of scoring, flexibility in scheduling, cost-effectiveness, and immediately reportable results (Wang et al, 2007). In addition, students may benefit from the variety that the technology can offer when reading. For example, students can highlight text, change font size, and change font color, when using a computer. According to the researcher's experience and studies by Chen and Wang (2003), Kragness (2007), Kretzchmar, Pleimling, Hosemann, Fussel, Bornkessel-Schlesewsky, and Schlesewsky (2013), and Rose (2010), some students read more quickly, and with better comprehension, when there is an increase in the font size or the jump length between words in text, or a change in color overlays.

On the other hand, computer-based testing may not necessarily measure the actual knowledge of the student if the technological experience of the student is limited in any way (North Central Regional Educational Laboratory [NCREL], 2012). This study sought to investigate one of the variables that may impact student performance, specifically contrast on computer background displays. The researcher hoped to discover whether or not changing the screen display from a white background with black lettering to a black background with white lettering would make a difference in student reading comprehension or student engagement in a computer laboratory setting.

Background of Study

The researcher, a reading specialist in a K-6 suburban elementary school, decided to test two different technology-related variables as students took a summative reading comprehension exam. The summative reading comprehension exam, the Renaissance Learning STAR Enterprise Reading test, was used by the school district to measure the effectiveness of the teaching and learning in district schools, as measured by student scores. The researcher noticed that students were changing the color of the background screen when taking the Renaissance Learning STAR Enterprise Reading test. The quantitative experimental design of this study intended to examine whether or not changing the color of the background computer display screen, and the color of the text lettering, contributed to a significant difference in student engagement and/or student reading comprehension, as measured by the standard score and represented by the raw score of the Renaissance Learning STAR Enterprise assessment.

Importance of reading proficiency. Every two to three years, a generation of children in grades kindergarten to third grade fails to learn the literacy skills necessary for future learning and success. Feister (2010) wrote that reading proficiency measured at the end of third grade could be a predictor of students' risk of failing to graduate high school in the future (p. 9, para. 1). As a reading recovery teacher and instructional coach, the researcher scrutinized the current practices and trends in education in an effort to address the critical issue that every student needs to learn to read proficiently by the end of third grade. There was a sense of urgency to the work of teachers, principals, and curriculum specialists who are tasked with meeting the needs of students, providing best practices in instructional strategies, and assessing the achievement of students for decision-making purposes at the classroom level. Data teams of teachers, reading specialists, coaches, and administrators met weekly to gather data, strategize, adjust their instructional practices, and provide feedback to students as needed.

Computer-based testing. Many school districts, including the one where this research took place, transitioned to computerized testing of students, which meant that, in many cases, students were no longer working with pencil to complete paper-based tests (Missouri Department of Elementary and Secondary Education [MODESE], 2012). Instead, students were viewing test questions on computer screens. These benchmark assessments were summative, and produced scores. The students in this study took a computer adaptive exam called the STAR Reading test. In preparation for the 2015 statewide Common Core State Assessment, known in Missouri as Smarter Balance, the school district study site decided to prepare students for the high-stakes computer-based testing experience.

One factor in the move to computer-based testing was the implementation of the Common Core State Standards (CCSS). These national standards specified the curriculum in all states that did not opt out, and those districts involved used computer-based tests to assess how well students and districts were fulfilling Common Core requirements. At the time of this writing, at the study site school district, teams of teachers, reading specialists, coaches, and administrators met to discuss and assign the Common Core State Standards of English Language Arts and Literacy (2010) to curriculum units of study. The researcher's district prepared for this task by providing the standards, which were "research and evidence based, aligned with college and work expectations, rigorous and internationally benchmarked" (CCSS, 2010, para. 4). The administrators of the suburban study site school district implemented a computer-based assessment to inform teachers of the academic achievement of students in reading and mathematics.

Students' unequal access to technology. The researcher was fully aware that students in the study site school had different experiences with technology. Some students did not have a computer at home, and others had only limited computer access. Students' unequal technology experiences or access was evidenced and reported by parent surveys collected in 2012. According to the 2010 U.S. Census, 40% of households with incomes lower than $25,000 per year had Internet access, compared to 93% of households with incomes over $100,000 per year (U.S. Census Bureau, 2010). This proportion held true at the research site. Crawford, former science, technology, and innovation policy assistant to President Obama, referred to this phenomenon as the Digital Divide (Crawford, 2011).

Whether students have access to technology matters deeply. Barton (2004) noted that the lack of experience urban students may have in regards to computer experience was a major factor against them. Crawford (2011) stated that in 30 years, minority students who were African-American and Latino would constitute 50% of the American work force, and these students were at great risk of lacking the skills necessary in future jobs. According to Crawford, “If we want to be competitive in the global economy, we need to make sure every American has truly high-speed wired access to the Internet for a reasonable cost” (para. 27). Along similar lines, Rice (2012) stated that zip code was a predictor of student success, indicating that gross inequalities in access to education existed in America at the time of her statement (para. 12).

Rise in remediation. The larger problem of technology access and unequal privileges was reflected in the trend of the rising popularity of remedial courses. As a reading specialist for K-12 and an adjunct professor at the junior college level, the researcher witnessed a dramatic rise in community college remedial course enrollments. In 2011, the Coordinating Board of Higher Education (CBHE) in Missouri reported, “Thirty-six percent of 23,969 public high school graduates entering in-state public colleges and universities in fall 2010 enrolled as freshmen in at least one remedial course in the basic academic subjects of English, mathematics, or reading” (MODESE, 2011, para. 3). In addition, the reading levels of students at the researcher’s junior college, as measured by the Gates MacGinitie Reading test during the fall semesters of 2011 and 2012, ranged in reading level from 4.0 to 8.0 grade level at the beginning of coursework. Many of the students at the researcher’s junior college were also former students in neighboring school districts surrounding the study site school. These facts should promote leaders at the elementary, middle school, and high school levels to reconsider their current strategies for preparing students to succeed. Preparing students for computer-based testing was one of the strategies discussed at the research site for this study, and providing students with technologies to improve performance was of great interest to the educational staff at the study site school in 2013.

Reading and the Brain. Researchers have studied how the brain processes or reads stimuli. Edelman's (1987; 1993) theory of Neuronal Group Selection (TNGS) helped to explain how the brain forms neural pathways, clusters, and areas to process information. Zeki's (1993) research showed that when presented with differences in light and color, the brain's processing of information is very specific in orientation. When the individual neurons and neural networks fire, they produce images, memories, and conscious thought. The present study investigates the possibility that, if the background color of a test-taker’s computer screen is changed, the appearance and organization of visual material affects the brain's ability to engage with and comprehend that information. One variable of interest to the researcher involved the use of color overlays on computer screens. She observed one strategy which sometimes served to alleviate students’ reading difficulties in the areas of decoding and comprehension was to lay a color-filtered lens over the reading text.

The eye is influential on how the brain processes stimuli while reading. With the introduction of the iPad and eBooks, such as Kindle, opportunities to aid readers' fluency and comprehension expanded greatly when different applications on the new devices were added (Kretzchmar et al., 2013). The researcher has personal experience with a close relative who had difficulty reading as a third grader because the eyes strayed from the printed page. However, as an adult, when the individual changed the background display screen of the iPad, the adult noted an immediate improvement in an ability to focus on the printed word and to retain information. This adult read with fluency and comprehension. The researcher has observed this same phenomenon in a school setting among children who appeared to be unmotivated and off-task while tested in a computer laboratory setting.

Purpose of the Study

The purpose of this study was to explore how changes in visual stimuli affected the process of reading and student reading behavior. This quantitative study sought to ascertain whether changing the computer read-out to a black screen with white lettering made a difference in student engagement and comprehension among grade 2 to 6 students during participation in a computer-based adaptive test, STAR Reading assessment. The researcher measured the effects on test-takers of background lighting on a computer screen, testing both a white background with black lettering and a black background with white lettering. Students' reading engagement was gauged through teacher tallies in five major areas of positive engagement. These five behaviors involved the "demonstration of the absence of disruptive or negative behavior" (Trowler, 2010, p. 5). The five major areas of positive student engagement included student posture, repeating of words on the screen, hand position on the mouse, eyes on the screen, and finger-pointing.

In 2011 and 2012, the effectiveness of the study site schools and teachers were monitored and measured using the reading and math scaled scores of the STAR Reading and Math tests. These benchmark assessments provided the school district with predictors for future student performance on the Missouri Assessment Program (MAP) test. At the time of this writing, the MAP transitioned into the computer-based Smarter Balance Assessment.

Rationale

The researcher, an instructional coach and reading specialist, had observed students taking the STAR Reading test (Renaissance Learning, 2009) and noticed the scores varied widely in relation to the academic performance of students in classrooms. The researcher intended, therefore, to explore variables that may affect the performance of students on a computer-based reading assessment. Because computer-based testing was a relatively new phenomenon, particularly in elementary schools, much could be learned about student engagement and comprehension during testing situations by comparing the effects of computer screen backgrounds and lettering (white background with black lettering versus black background with white lettering), as measured by test scores on the computer-based adaptive test, STAR Reading assessments.

Studies similar to this design measured the effects of other variables such as jump length, speed of reading, and color spectrum contrast (Askwul, 1985; Cushmen, 1986; Gould & Grischiwsky, 1984). However, this researcher uncovered no other studies focused specifically on the effects of positive and negative contrast (black-on-white screens versus white-on-black screens) upon elementary school students' engagement and achievement. Since technology has become thoroughly embedded in the assessment process of elementary schools, it has become essential to study the effects of technology on reading engagement and comprehension. The present study contributes to this need by exploring the impact that manipulation of computer screen display contrast has upon student engagement or achievement during computer-based testing.

In addition to the long-term need for an understanding of how best to design and administer computer-based tests, the study site school district expressed an urgent short-term goal. The district planned to prepare students for a computerized assessment called the Smarter Balanced Assessment (Smarter Balanced Consortium, 2012), to be administered during the 2014-2015 school year. The 87.5% of the students at the research site eligible for free and reduced lunch, supported the district supposition that many students in the school did not have a computer at home. The district addressed this concern in the 2010-2011 school year by purchasing computers, updating the Internet access bandwidth, and buying a product from Renaissance Learning called STAR Reading Enterprise.

Brain Function

Sylwester (1995) investigated how the human brain seeks to make sense of its surroundings. When people encounter a situation, problem, task, or communication of some kind, they do not merely sit back and passively receive information. Rather, their brain tries to make sense of what is there and to make the information meaningful (Weiss, 2000). A question to be asked is based on how a person perceives what is in front of him or her. It is important to understand how readers look at print. It is also important to understand how the human brain organizes what it perceives into a schema, a pattern that allows the brain to make sense of what it encounters. It is also necessary to understand the ability of the human brain to focus and organize material and to understand how this mental work is affected by the appearance and organization of the material to be perceived (Sylwester). One remarkable attribute of human thinking is when a person attacks a text and attempts to make it meaningful, he or she almost simultaneously focuses on aspects and construct patterns (Caine & Caine, 1994).

Different stimuli such as movement, color, or contrasts of black and white, differences in light, either radiant or reflective, trigger the brain to fire neural networks, and these firings make physical changes in the brain (Zeki, 1993). Sensory experiences change the brain's neural networks (Zull, 2002).

Zeki (1993) pointed to the brain's function of reading or reacting to the different stimuli such as movement, color, contrast of black and white background, differences in the amount of light, and the presence of radiant or reflective letters and background, all of which trigger-fire neural networks and thus make possible physical changes in the human brain. Zull (2002) showed that sensory experiences change the brain's neural networks, which is notable because the interface that people read may make a difference in their ability to build neural networks. Vitale (1982), in a book titled *Unicorns are Real*, reported in her research:

> There are many children who do not learn in school or who experience difficulties understanding new concepts as they are introduced in school. As their parents and teachers, we should interpret their disinterest, confusion, or lack of comprehension as signals that the methods we have been using, for whatever reasons, just are not working. We must ask, ‘Why isn't the material reaching the student?’ There's a big difference in the way we formulate the problem: in the first case we are treating the student as the problem; in the second, the method is the problem. (p. vii)

Vitale’s (1982) remarks are notable because the interface that people read may make a difference in their ability to build neural networks. Reading on the printed page is different from reading on a computer screen. When one reads on a screen, the reader is faced with continuous luminance of light. The eye and brain react differently to radiant light versus reflective light, appearing in human brain wave patterns and neurological responses. According to Geske and Bellur (2008), "The source of light and color of light will all impact where the information is processed in the brain, the neuron firing patterns and the brain wave patterns of the subject" (p. 401). Vitale’s information is related to the investigation of this study into the effects of color background and text change on student achievement and behavior.

Research Question and Hypotheses

This researcher intended to explore whether changing the background color of the computer display screen would make a difference in reading comprehension and/or student engagement among student test-takers in grades two through six. The researcher chose not to include K-1 students because these students did not take the STAR test during the entire school year, which would have mirrored the participation of the older students. The student population in grades two through six took the STAR test a total of seven times throughout the year, as part of standard benchmark protocol and district expectations. The experimental group consisted of 116 elementary students in grades two through six who took the test on a white computer display screen with black lettering. The control group consisted of 116 elementary students grades two through six who took the test on a black computer display screen with white lettering. Each group exchanged protocol and took the test on alternating computer display background colors every other testing session. The reading comprehension scores and student engagement tally scores were compared.

The research question was, How was student reading engagement and comprehension during computer-based testing affected by the contrast of the display screen background to letters on the display?

The following hypotheses were investigated in this study:

H_{01} - There will be no measurable difference in the scores of students who take computer-based tests with the computer screen display set to black lettering on a white screen versus white lettering on a black screen.

H_1 - There will be a measurable difference in the scores of students who take computer-based tests with the computer screen display set to black lettering on a white screen versus white lettering on a black screen.

H_{02} - Teacher tallies of student behaviors during the administration of computer-based tests will not verify a measurable difference in student engagement with the computer screen display set to black lettering on a white screen versus white lettering on a black screen.

H_2 - Teacher tallies of student behaviors during the administration of computer-based tests will verify a measurable difference in student engagement with the computer screen display set to black lettering on a white screen versus white lettering on a black screen.

Limitations

This study had several limitations. First, the study extended over a short period of time, thus restricting the amount of information collected. The study lasted for one school year, as students participated in the administration of the STAR reading test within five benchmark periods. The data collection was limited to this period. A second limitation the study restriction to one elementary school in grades two through six. The school was located in a low socio-economic area, where economic and ethnic diversity did not exist regionally. A third limitation of the study was its lack of accountability for students' reading levels and literacy skills. The visual tallying of student engagement did not necessarily provide information on students' metacognition or thinking while testing. Furthermore, the persons taking the tallies may have suffered fatigue during the 35-minute sessions, causing them to miss certain student engagement behaviors. A related limitation included the fact that the ratio of students-to-teachers making tallies may have resulted in teachers missing some behaviors. Another potential factor was this study did not consider the way in which student motivational levels may have varied during testing to then affect engagement. Finally, some students may have worn corrective lenses in their glasses, which could have affected perception of the background and lettering on the computer screens.

Definition of Terms

Background display screen. In this study, the term background display screen refers to the black or white background color of the computer monitor. The term monitor is often used synonymously with computer screen or display. The monitor displays the computer's user interface and open programs, allowing the user to interact with the computer, typically using a keyboard and mouse ("Background Screen Display", 2013).

Computer adaptive tests. Tests that are designed to adjust their level of difficulty—based on the responses provided—to match the knowledge and ability of a test taker. If a student gives a wrong answer, the computer follows up with an easier question; if the student answers correctly, the next question will be more difficult. Considered to be on the leading edge of assessment technology, computer-adaptive tests represent an attempt to measure the abilities of individual students more precisely, while avoiding some of the issues often associated with the ‘one-size-fits-all’ nature of standardized tests (“Computer Adaptive Tests”, 2013).

Criterion referenced tests. A test which, according to Cohen and Spencer (2010), “provides a description of a student’s knowledge, skills or behavior in a specific range of well-defined instructional objectives” (para.1). A criterion test is not normed in comparison to performance of other students (Cohen & Spencer, 2011, para. 1).

Scaled score. A scaled score (SS) is useful for comparing student performance over time and across grade levels. A scaled score is calculated based on the difficulty of questions and the number of correct responses. Because the same range is used for all students, scaled scores can be used to compare student performance across grade levels. STAR reading scaled scores range from 0 to 1400. All norm-referenced scores are derived from the scaled score (“Scaled Score”, 2012).

Student engagement. Harper and Quaye (2009) defined engagement as being “more than involvement or participation; it requires feelings and sense-making as well as activity" (p. 5). For the purpose of this study, student engagement is defined as the cognitive behavior exhibited by the student during a testing session. The five behaviors which are considered manifestations of student engagement are as follows: student posture, repeating words on the screen, hand position on the mouse, eyes on the screen, and finger-pointing.

Student Growth Percentile (SGP). A norm-referenced quantification of individual student growth derived using quantile regression techniques. An SGP compares a student's growth to that of his or her academic peers nationwide. SGPs range from 1 to 99, and interpretation is similar to that of percentile rank scores; lower numbers indicate lower relative growth, and higher numbers show higher relative growth. For example, an SGP of 70 means that the student's growth from one test to another exceeds the growth of 70% of students nationwide in the same grade with a similar beginning pretest (STAR reading score) ("Student Growth Percentage", 2011).

Tier 1 intervention. Targeted lessons that everyone in the classroom receives as part of regular instruction. Lessons are aimed at supporting students' learning. The teacher supports student learning objectives by offering modeling and teaching aimed at addressing specific areas of difficulty (RTI Action Network, n.d.).

Tier 2 intervention. Lessons especially designed for students who are struggling in the focus area. Not everyone in the classroom receives Tier 2 intervention lessons. Tier 2 students often need extra practice and tailored lessons to meet their particular learning needs (RTI Action Network, n.d.).

Summary

As standardized testing increasingly required students to read words on computer screens rather than printed on paper, it was important to analyze the variables associated with reading comprehension and student attention on screens versus on paper. Prior to this study, large-scale student assessments were administered on paper. Starting in 2015, in Missouri, and in other states across the nation, students will take the state test administered through the Smarter Balanced Assessment Consortium (2012), a computerized adaptive test which is administered on a computer screen. According to Guskey (2007), these large-scale assessments will be used to rank schools and students and hold teachers and schools accountable for preparing students for career and college readiness. The importance of this study is to analyze variables that may affect the students' reading comprehension and engagement when reading on computer screens. As school districts in Missouri and across the nation move toward computer-adaptive testing, it is important to study the variables associated with computerized testing and their effects on school-aged children. Further study and future research may explore the reliability and validity of these computerized reading assessments on student reading comprehension and engagement, as other variables are explored through research. In summary, the problem statement reflects educators' need for timely research that explores the effects on the reading process of manipulating computer technology. This study investigated whether student reading engagement and comprehension during computer-based testing was affected by the contrast of the display screen background and letters on the display.

The proceeding chapter, Chapter Two, will review various theories of learning in general and of learning to read, in particular. Additionally, the chapter will discuss student engagement, including methods for keeping students engaged and variables affecting student engagement. Next, the chapter will review various studies on reading on screens; these studies examine variable such as luminance, color, and contrast, and the variables' effects on reading comprehension, reading speed, and attention. Finally, the chapter will give a history of assessment and technology.

Chapter Two: The Literature Review

Introduction

At the time of this writing, educators were under a tremendous amount of pressure to ensure that all students were reading on grade level. The researcher, an instructional coach, worked with data teams in the school of study to assess student levels of reading progress. The purpose of this study was to investigate the effects of color and contrast of computer screen displays on the reading comprehension and reading engagement of elementary school children.

This chapter will discuss a range of literature that illuminates the present study. First, it will review various theories of learning in general and of learning to read, in particular. The theories of literacy development include behaviorist, constructivist (humanist), and cognitive processing paradigms. Next, the chapter will discuss student engagement, including methods for keeping students engaged and variables affecting student engagement. Later, the chapter will describe various studies on reading on computer screens; these studies examine variables such as luminance, color, and contrast, and these variables' effects on reading comprehension, reading speed, and attention. Finally, the chapter will give a history of assessment and technology so that the reader can understand the political and legislative context in which computer-based testing gained prominence.

Theories of Learning

From a baby's earliest moments in its mother's arms, it begins to read the world. Babies read faces and take everything in with all of the senses, but especially the sense of sight. Walden and Ogan (1988) showed that infants at different stages of development read and react to parental cues in different ways by using their senses; the researchers refer to this early form of reading as "social referencing." In this way, parental reactions and facial expressions teach the child about the world (p. 1230). It is clear that learning to read is a natural human process.

Over the centuries, philosophers, psychologists, and other scholars offered various theories of how humans learn to read. The early works of Plato and Aristotle from the fourth century B.C.E., the theories of Structuralism and Unfoldment from the 18th century, the Behaviorist theories first advanced in the 1920s, the Constructivist theories of the 1930s, theories of Literacy Development developed between the 1930s and 1980s, Social Learning Perspective theories from the 1970s, Cognitive Processing theories that were popular from the 1970s through 1990s, and the Neuroscientific theories of the 21st century, all give insights into how people learn to read. Each theory is a reflection of contemporaneous discoveries in psychology, biology, and other sciences.

Tracey and Morrow (2012) wrote about several early learning theories as they relate to reading in their book *Lenses on Reading*. According to Tracey and Morrow, in the fourth century B.C.E., Plato and Aristotle wrote about learning as an exercise of the mind. Aristotle believed that "learning is a matter of strengthening, or disciplining, the faculties of the mind, which combine to produce intelligent behavior" (p. 21). Aristotle wrote about learning and intelligence as a process of association. Aristotle believed that connections and associations such as similarities, differences, and events occurring at contiguous times tend to be associated and support the memory and new discoveries (Boerre, 2000). Other theorists, such as French philosopher Jean-Jacques Rousseau (1712-1778), Swiss educational reformer Johann Heinrich Pestalozzi (1746-1827), and

Freidrich Froebel (1782-1852) believed that children's natural curiosity supported learning naturally over time (Boerre, 2000, p. 24). Rousseau wrote, "Learning is done through trial and error, experimentation through concrete medium" (Encyclopedia of Philosophy, 1967, p. 221). Similarly, Pestalozzi believed that any child, whether poor or rich, could learn if given opportunities to explore and if elements were broken down into logical sequences (World Book Encyclopedia, 1997). Froebel, along with Rousseau and Pestalozzi, believed that children learn through the senses. Froebel's early works, expressed in the Unfoldment Theory, inspired the development of kindergarten as a sort of laboratory in which young students would play and use their senses to explore nature and learn about the world (LeBlanc, 2010).

The early theory of Structuralism was more specific. In contrast to Froebel's work, Rousseau and Pestalozzi believed that learning takes place through exploration in nature, in contrast to the Structuralist belief that disciplines could be broken down into parts. Structuralism branched off into different disciplines. The linguistic theory of Structuralism, as it relates to linguistics of the mid 20th century, was based upon the works of Ferdinand de Saussure and Claude Levi-Strauss, two European researchers of language. Both began with the premise that language is a system of symbols and signs. Strauss further believed that cultural influences of language, and indeed culture itself, is a system of relationships and key structures and components of linguistic processes, as stated in the definition of structuralism in the *Merriam-Webster Dictionary* (2013).

The psychological theory of Structuralism was most concerned with perception and introspection (Cherry, n.d). Perceptual processes were researched by German psychologist Wilhelm Wundt and his American assistant, James Cattell, in the late 1870s at the world's first experimental psychological laboratory, located in Leipzig, Germany (Cherry, n.d.). According to Tracey and Morrow, Wundt and Cattell "pursued the study of perceptual processes by investigating aspects of the reading process such as letter and word recognition, legibility of print, and span of attention" (Tracey & Morrow, 2012, p. 28). The researchers of the Structuralist movement studied each element of the reading process through the course of experimentation. Venezky's (1975) focus was on general psychological functioning rather than on reading itself.

In the late 1800s, experimental psychologists began to study reading systematically. James Catell developed an experiment that measured the speed of naming letters and words, and compared the differences in reaction times for different letter-print types and investigated the processing differences of both (Venezky, 1975). From 1880 to 1908, when Huey published his book *The Psychology Pedagogy of Reading* (1908; 1968), the main focus of experimental psychology was the study of reading processing. Once Huey's book was published, and with the introduction of behaviorism, the focus of experimental psychology was not the study of mental processes during reading, but rather on testing and measurement. In 1950, experimental psychology revisited the reading process during reading through various experiments. Venezky (1975) commented that some researchers studied the "control of eye movement, the strategies involved in word recognition, the amount and types of overlapping processes, the role of subvocalization, the nature of the eye-voice span and the optimal methods for reading instruction" (Venezky, 1975, p. 33). These experiments continue as researchers seek to discover optimal methods for teaching reading even today.

Theories Related to Reading and Literacy

Behaviorist Theory. From about 1900 to 1950, behaviorists such as Pavlov, Watson, and Skinner developed theories that influenced people's understanding of literacy and learning. These behaviorists were interested in how reinforcement, reward, and shaping all played a role in student learning, and their theories are influential even today. At the same time that Pavlov and Watson were studying Classical Conditioning, which involved stimulus and response theory, Huey (1908, 1968), an educational psychologist and early reading researcher, was studying the physiological processes of the eye during reading. Huey was one of the first researchers to study this process, along with Emile Javal (1839-1907), a French oculist, whose view of eye movement in reading Huey disproved. Israel and Monaghan (2007) wrote that Javal believed the eyes continued in one, smooth, continuous movement. In Huey's eye movement research and his experiment using string and a subject's eye, he discovered that the reader's eye does not move in a smooth, continuous, straight line, but rather in a series of jerks and fixations later termed a "saccade" (Israel & Monahan, 2007, p. 162). Huey believed that "reading is a complex process that involves the eyes, eye movements, [and] the physiology of the brain and the workings of the mind" (Luria, 1979, p.41). Israel and Monaghan noted that Huey was concerned that reading fatigue, the effect of light or glare, and the differences in print, greatly affected readers' mental capacity as they read. Huey (1908, 1968) viewed reading as a meaning-making process, in line with the Constructivist views of educational psychology developed in the later part of the 20th century.

Humanist-Constructivist Theory. Constructivism, or the humanistic approach to learning, is based on the premise that knowledge is constructed through experience. Tracey and Morrow (2012) noted that, as it related to reading, constructivist educators "view the reading process as one in which the reader constructs his or her own messages while reading" (p.76). According to Askew (n.d.), constructivism is a philosophy of learning in which individuals attempt to understand the world based on experiences in their environment. Children and adults adapt with "rules" and "mental models" as they encounter new experiences. Learning is the adjustment and accommodation made when learners reflect on the new experience.

In 1908, constructivist Huey wrote that "reading [is] the art of thought-getting and thought manipulating" (Huey, 1908, 1968, p. 237). Indeed, Israel and Monaghan (2007) stated that "meaning-making and comprehension is the goal of reading" (p. 166). According to Israel and Monaghan, Huey's contribution to reading research, as expressed in his book *Psychology and Pedagogy of Reading* (1908, 1968), was to shed light on the reading process in the contexts of linguistics, health, inquiry learning, print features such as paper quality and font differences, and the great differences in reading materials used in schools versus in homes. Huey's contemporary, John Dewey (1859-1952), had similar views on learning through inquiry. Dewey, one of the first humanist (or constructivist) theorists, believed that children learn best when presented with real, authentic problems, and that learning is a constructive, collaborative process (Tracey & Morrow, 2012, p. 61). The learner constructs meaning by incorporating background knowledge into new learning investigations (Constructivism, 2012). According to the constructivist perspective, children solve problems and learn or construct new understandings through inquiry or active curiosity.

Constructivist theories abound in the field of education; among them are: Metacognitive Theory (Brown, 1978; Flavell, 1970), Psycholinguistic Theory (Goodman, 1969; Smith, 2012), Schema Theory (Anderson & Pearson, 1984), Transactional Reader/Response Theory (Rosenblatt, 1995, and Whole Language Theory (Goodman, 1967). Each of these theories seeks to explain the knowledge of the reader and the metacognitive processes involved in reading. Language, inquiry, searching for meaning, reflective thinking by the learner, and the study of reader miscues or mistakes in reading are all involved in these approaches. In the constructivist view, reading moves from the whole to the part, rather than from the part to the whole, as in phonetic approaches to reading (Geissen, n.d.).

Metacognitive theory. This theory concerns the thinking that one does about one’s own thinking. According to Smith (2012), metacognitive processes take place when “we reflect on whether we know something, whether we are learning, or whether we have made a mistake” (p. 29). Clay (2005) referred to this process as “self-monitoring” (p.361). Van Keer and Vanderlinde (2010) studied metacognitive processes of good readers and concluded that proficient readers are more aware and reflective during text reading than less capable readers. Following metacognitive theory, Duffy (2002), as well as Van Keer and Vanderlinde (2010) concluded that teachers should provide explicit instruction related to reading strategies that help readers to comprehend texts (Tracey & Morrow, 2012, p. 72).

Psycholinguistic theory. The theory of constructivism is associated with a specific view of the reading process. Clay (1995 explained that, in the constructivist view, good readers are always thinking about and reacting to the texts they are reading. They make sense of this complex process and stay engaged. They" use their prior knowledge and experience, known vocabulary, and language structures in addition to reading strategies to process the meaning of the text "(p. 48).

Psycholinguistic researchers in the field of education developed a model of reading that involved three cueing systems. Goodman (1969) theorized that good readers use graphophonic, syntactic, and semantic information to interact with texts during reading processing (p. 9). Goodman described reading as a psycholinguistic and interactive process, one in which the reader compares miscues or mistakes with the actual text on the page during the reading process. This process of analyzing errors during oral reading described how readers are constantly interacting with texts during the comprehension process (p. 9).

In the same era, Chall (1967) and Gough (1972), as well as LaBerge and Samuels (1974) presented their cognitive processing theories, which were linear and bottom-up. In other words, students went from letters to words, processing texts in incremental steps through phonics. In contrast, Rumelhart's (1977) Model, according to Tracey and Morrow (2012), is an Interactive Cognitive Processing Model. In the investigator's experience, this model is similar to the design of a computer program, wherein each component of cognitive processing checks on the others to make sense of the text in problem solving. A reader may read a newspaper all the way to the bottom of the page only to discover that he or she was not paying attention. This is an example of using the visual processing system only. The reader may have read the words and read them correctly, yet did not use prior knowledge or make meaning of the text. Worded another way, the reader might be reading the words, but the words do not make sense.

Clay (2005) supported the three-cueing system model of reading. The three-cueing systems in reading are the graphophonic, syntactic, and semantic systems. Letters and words are part of the graphophonic system. This is simply the graphophonic, semantic and syntactic processes that readers balance as they decipher the message of text the author has written (Clay, 2005; Hart & Risley, 1995). The graphophonic system is essentially the sequencing of the letters that make up the words. Adams (1990), Clay (2005), and Hart & Risley (1995), all described how readers process letters in the graphophonemic system. Readers pick up visual information or stimuli with their eyes and send the message to the brain, where it is deciphered. Adams (1990) stated that the semantic system is the prior knowledge of the reader and the pictures or experiences the reader already carries around inside of them to bring to the text to make meaning. Earlier, Chomsky (1957) defined that the syntactic system is the order or structure of the language. The reader predicted the unknown word using the word order and prior knowledge of the language to decipher and comprehend the text. When all three systems work together simultaneously, the reader is balanced and is able to easily read the text and understand the message.

The structure of the language or grammar is the syntactic system, and the meaning or message of the author as it relates to experience is the semantic system (Chomsky, 1957). Clay (2005) explained that good readers use all three systems simultaneously to extract meaning from the text (p. 112). When confronted with an unknown letter or word, good readers use all three systems, the visual, the grammatical, and other meaningful cues such as picture clues, or other words or personal experiences in the text, to aid the reader in figuring out the unknown word. Good readers are active readers. Clay (1995) stated that this active process of reading, which uses schema or prior experience, known vocabulary, the structure of the reader's language, and learned reading strategies helps readers to comprehend text (p. 48). In essence, Clay (2005) concluded that good readers have to use all three systems in balance in order to be considered a fluent reader with a self extending system of visual, structural, and meaningful cues (p. 112).

When the systems are not in balance, Stanovich (1980), in his Interactive-Compensatory Model, theorized that if one system is failing to solve the problem, other systems will compensate to make sense of the story. This goes along with Rosenblatt's (1995) Transactional Reader/Response theory. Rosenblatt, and later Clay (2005), believed that readers are active. In fact, Rosenblatt wrote that readers have a transactional relationship with texts. Rosenblatt explained that readers bring their experiences to the text, and reading itself is an experience that brings thoughts, feelings, and cognitive responses after the reading takes place. She called these responses *efferent* and *aesthetic* responses. According to Rosenblatt, efferent responses are the facts and figures, and aesthetic responses are the thoughts and feelings of the reader after reading the text. Rosenblatt and Clay both believed that reading is focused on making meaning of what is read.

Hughes (2007) described reading differently than Clay, as a coordination of four-cueing systems rather than three, as Clay believed. Hughes asserted that we read, write, speak, and listen all at the same time. The difference in Hughes's view was that of pragmatics. Readers know the purpose and function of reading in addition to the other three cues mentioned above: graphophoneme knowledge, syntax, and semantics or meaning.

Schema theory. Anderson and Pearson (1984) and Rumelhart (1980) explained schema theory as an active process in which the reader continuously reviews past learning experiences and links new pools of knowledge to what has already been learned. Throughout the process of trying to comprehend a text, the reader forms, tests, and revises hypotheses. This process is constructive because the reader actively engages in the text and constructs and revises new information at the point of difficulty. This process of constructing, testing, and revising hypotheses is a cycle of reading processing.

Transactional/Reader response theory. Anderson, Hiebert, Scott, and Wilkinson (1985) described reading as a process of creating meaning from a text. Eisenwine, Fowler, and McKenzie (2000) noted, “When people read, the reader reconstructs the intended message from the visual image” (p. 170). The process of converting letters to words using visual information, phonics, grammar, the relationship of words to vocabulary and memory, and the use of schema, or prior knowledge in relation to the subject is very complex” (p. 170). Leipzig (2001) defined reading as a “multifaceted process involving word recognition, comprehension, fluency and motivation. Readers learn how to integrate these facets to make meaning from print” (p. 1). Clay also included motivation as part of her definition, stating that readers are motivated to learn how to coordinate word recognition and comprehension fluently.

Theories of Literacy Development

Chall. Jeanne S. Chall (1983, 1996), Professor Emerita of Reading from Harvard University, defined reading in terms of developmental stages. Chall's stages of reading development included two major stages: "Learning to Read" and "Reading to Learn." In the first stage, which typically spans grades one to three, the student progresses through the stages of Pre-reading, Initial Reading, and Confirmation Fluency. Then, in what Chall calls the Reading to Learn stage, which typically extends from grades four to six and beyond, the student begins to recognize words automatically, freeing up attention to read for meaning. Eventually students can read to understand multiple viewpoints and learn new information, and they can construct and evaluate ideas while reading (Steeves, Barnhart, & Heffernan et al, 2011). According to Resnick and Weaver (1979), Chall was known for her assertion that decoding skills are important in the reading process, and she emphasized phonics in addition to reading language rich in vocabulary.

Piaget. Like Chall, Piaget (1977, 1983), a leading researcher in educational psychology, also described the learning development of children in stages. Piaget theorized that children create cognitive structures or mental "maps" for understanding and responding to reasoning (p. 2), physical experiences within their environments ("Constructivism", 2012). Garner (2007), another researcher, described cognitive structures as "the basic mental processes people use to make sense of information" through comparative thinking, symbolic representation, and logical Piaget's (1983) cognitive structures were described in developmental stages from infancy to adolescence. The first stage described by Piaget was known as the sensorimotor stage, which extends from birth to age two. Children at this stage rely on senses alone to learn about their environment. The Pre-operational stages (ages 2-7) and Concrete stage (7-11) are the next learning stages (Sprenger, 1999). Language development is an important development in the preoperational stage. Children at this stage are essentially egocentric and are unable to comprehend other perspectives and conserve information. According to Piaget (1983), in the concrete stage, children rely solely on what is observed and experienced concretely and are unable to understand abstract concepts. The last stage in Piaget's (1983) model is the formal stage, in which children are able to think abstractly, hypothesize, solve problems, and make plans for courses of action in future events.

Cognitive Processing

Smith (2012), a leader in the Whole Language movement, described reading yet another way, as a process that is both visual and non-visual. Like Clay (2005), Smith described reading as a psycholinguistic process where the eye picks up information and sends it to the brain (p. 73). Smith (2012) focused on the visual aspect of the reading process, noting that the visual processing system is limited:

> No single nerve fiber runs directly from the eye to the brain; instead, there are at least six interchanges where impulses along one nerve may start, or inhibit, propagation of a further pattern of impulses along the next section of the pathway. At each of these neural relay stations, there are large numbers of interconnections, some of which determine that a single impulse arriving along one section may set off a complex pattern of impulses in the next, while others may relay the message only if a particular combination of signals arrive. Each interconnection point is in fact a place where a complex analysis and transformation takes place. (p. 76)

Clay (1995) and Smith (2012) agreed that readers use "prior knowledge" in the non-visual processing system (Clay, 1995, p 126.; Smith, 2012, p. 19). Zull (2002) called this prior knowledge a "neural network" (p. 92). When readers link the already known and experienced information to the unknown information, learning or comprehension occurs.

Smith (2012) described a phenomenon known as tunnel vision in which readers become confused. Tunnel vision occurs when the neural pathway becomes bogged down because too much information is overloading the neural circuit. The nerves in the eye can only send one kind of signal, a fired signal or an absence of signal. When too much visual information stimulates the nerve, the visual system becomes overworked, and tunnel vision is the result (p. 76). An intriguing example can be found in commercials with subliminal messages. When items are displayed during a commercial and are seen by the observer, yet when not in context of the commercial, the observer does not remember the items displayed for a brief few seconds. As Smith made clear, the phenomenon of observation takes time.

At every interval, the brain processes information sent down the neural pathway. Decisions are made during the processing of visual information. Visual information seen is sent at a much faster rate than the brain's decision-making center can process it. Because the brain processes information much more slowly than the eyes do, the visual information sent down the eye's neural path may be lost, resulting in the reader becoming confused or failing to recognize or "see" all of the visual information presented (Smith, 2012, p. 82).

Other Cognitive Processes that Affect Reading

Reading and Memory. Smith (2012) stated that this is much like when a reader has to work at sounding out the text; sometimes the brain is unable to store the information because too many decisions interrupt the signal. According to Smith, the sensory store inside the brain may be a place where the information is temporarily kept while the brain is processing visual information (p. 83). As the brain sees the text and the eyes shift, gaze, or blink, the old information is erased and new information is arriving to be processed. Smith called this phenomenon “masking” (p. 84). Smith also described seeing as “episodic”; in other words, because the eye is in constant motion or tremor, the retinal cells are always firing (p. 84).

Collewijn and Kowler (2008) stated that, given the research of the previous 10 years (1998 to 2008), there is little evidence to support the conclusion that microsaccades and fixational eye movements help with oculomotor function or vision. The view of these researchers is that attention and the movement of objects may play a role in reading, but that more research is needed in this area of cognitive neuroscience. Martinez-Conde, Otero-Millan, and Macknik (2013) described vision processing as an evolving theory of how saccades and microsaccades impact vision and indicated that it is the newest area of vision research. Martinez-Conde et al. (2013) theorized that, as the eyes fix on objects, the constant tremoring prevents the image from fading from view.

As images appear on the retina, the eyes move at the same rate as the impulse. Smith (2012) described the process as follows:

> The eye movement that is really of concern in reading is a saccade, which is a French term which means “jerk”. The more interruptions and fixations, the less

> information is processed and stored in short-term memory. With too many interruptions, the overload causes confusions and information is lost. (p. 84)

According to Fischer (2012), the eye requires three to five saccades or snapshots per second in order to focus or see the visual field. Huey (1908; 1968) described the movement of the eye as a series of jerks and fixations. Our eyes jump across the page from left to right and from up to down, and between the jerks, our eyes fixate on information. Normally, readers of English read from left to right, sweeping across the text in successive jerks and fixations. In this process, the eye may also perform a regression, which is the opposite way the eye normally moves in reading from left to right. In this movement, the eye may sweep right to left to study the text in order to process it accurately (Smith, 2012, p. 84). Reading teachers see this when students are problem-solving a word. For example, the student knows "cake" but comes across the word "bake." The reader may notice the "–ake," backtracks to the "b," and processes the letter "b" by going back to the beginning of the word to process and transfer the known word "cake" to the now newly processed and formerly unknown word "bake." This happens instantaneously and automatically in proficient readers, especially those reading at or above a second grade level.

Smith (2012) explained that when children have many regressions, this is a signal that they are having difficulty with the text material. In normal reading, saccadic movement is fast (p. 85). When readers slow down to study the problem, regressions are indicating that the text complexity is too difficult. Smith stated that, arguably, the better the reader, the fewer fixations occur. In other words, the reader sees more in one fixation, and comprehends that text in fewer fixations, than readers who are having difficulty (p. 86).

Good readers see more visual information in one glance than do inexperienced readers. Readers with more experience use less visual information and more non-visual information than beginning readers. When readers experience difficulty, the reader slows down and fixates on more visual information (Smith, 2012, p. 88).

Engagement is important to reading. Walker (1999) said that 21st century learners will place as much importance on using technology as 20th century learners did when emphasizing the importance of learning how to read and write.

Allington and Gabriel (2012) stated that children need six core elements of instruction in order to become successful readers. First, every child should have free choice of books and choose books to read that are of interest. Second, children should learn how to make the text match and should practice reading accurately. Children should read texts to understand, and be encouraged to write and talk about what is read. Lastly, children should have the opportunity to listen to fluent models of reading. All of these components will help improve children’s level of reading fluency and comprehension (p. 10).

Reading and Attention. If a reader does not have prior knowledge about the text, the reader will be less inclined to attend to the message. The reader will likely get bogged down in the visual system of the text and will not understand the information the author is trying to present. Attention to detail will be lost and understanding will be compromised when the author is unable to connect to the material presented. Bucko (1998) wrote, “The brain of an elementary school student must be active and alert to maximize learning” (p. 2).

Shanahan (2012) stated that teachers need to emphasize and teach close reading, that is, to analyze a text in order to come to “terms with what it says, how it says it, and what it means” (Shanahan, 2012). Miller (2010) also noted that, in order for students to become good readers, they must read and read and read (p. 30).

Sprenger (2009) described the biological factors associated with reading. When children exercise, the dopamine that is released sends neurotransmitters to areas of the brain that promote a sense of wellness and sustained attention. This helps students to perform better, and they may have increased performance on assessments due to this increase in focused attention.

Many theories have been formed in attempts to explain literacy development. Over the years, psychologists, neurologists, and other scientists have made new discoveries and developed new theories about learning in general, and about learning to read in particular. Theories of literacy development have been formulated according to various perspectives, including Behaviorist, Constructivist, Psycholinguistic, and Neuroscientific paradigms. Moreover, biologists and ophthalmological researchers have explained the function and physiology of the eye when reading. Learning to read is an extremely complex process, and as technology evolves, new understandings and discoveries may give rise to improved methods by which teachers can best help teach struggling students to read.

Definitions of Student Engagement

In the age of high-stakes testing, student engagement is coming under scrutiny as school districts are required to meet high demands in testing and accountability. Urban schools in particular are experiencing low student engagement. According to Goodwin (2000), “This lack of engagement [is] especially pronounced for adolescents and minorities attending schools in metropolitan areas” (p. 2). The achievement gap of students in urban areas as compared to students in suburban settings is evident. In the present study, student engagement on a white or black screen is being analyzed as it relates to student preference of white or black background.

According to Rallis and Macmullen (2002), the introduction of the Common Core State Standards has forced teachers and school community members to analyze all of the factors associated with lack of student achievement. Feldman and Tung (2001) stated that today teachers are analyzing their teaching, and teams are looking at data. Student engagement throughout the learning process is one factor being analyzed as well. During the testing process, students are now required to take an assessment on a computer.

Newmann (1992) described engaged students as those “who make a psychological investment in learning” (p. 2). He added,

> They try hard to learn what school offers. They take pride not simply in earning the formal indicators of success (grades), but in understanding the materials and incorporating or internalizing it in their lives. Engaged students are intrinsically

> motivated—that is, motivated from a desire for competence and understanding or simply from a love of learning, rather than a desire for a good grade, teachers' approval or acceptance into a good college. (p. 2)

Greenwood, Dinwiddie, Bailey, Carta, Dorsey, Kohler, Nelson, Rotholz, and Schulte (1987) stated that the kind of engagement that enhances task performance is not measured by time spent on or attention paid to a lesson, but rather by level of active engagement in academic tasks; an engaged student is one who actively works on math problems, reads materials at a high level of concentration, and focuses on accomplishing goals (p. 152).

Behavioral, Emotional, and Cognitive Engagement

There are three types of academic engagement, all of which are linked to higher levels of learning and student engagement: behavioral, cognitive, and affective (Fredericks, Blumenfeld, & Paris, 2004). Boykin and Noguera (2011) described behavioral engagement as the behaviors related to paying attention in class, asking questions, asking for help, and participating in classroom discussion. Cognitive engagement comprises the mental processes involved in understanding concepts, issues, and problems. Students who are cognitively engaged try hard to learn the skill at hand, and they use critical thinking and higher-order processing to understand and solve problems. Affective engagement is defined as a student's thoughts and feelings about, and reactions to, the learning at hand (p. 42).

In a similar model, Harper and Quaye (2009) identified the three aspects of student engagement as behavioral, emotional, and cognitive. Their definition of behavioral engagement consists of attendance and involvement as well as the absence of negative or disruptive behavior. Harper and Quaye defined cognitively engaged students as those students who are invested in their own learning, who seek to go beyond what is expected, and who are motivated by challenges. Emotional engagement, according to Harper and Quaye, is observed in student displays of enjoyment, interest, and expressions of feeling a sense of belonging.

Students' lack of engagement may affect student achievement results. Teachers are now monitoring student engagement in order to increase test scores as the introduction of high-stakes testing has raised the bar of achievement expectations. Engaged students are intrinsically motivated, do not give up easily, and enjoy their work. The three types of engagement can be explained as behavioral (the activities the students demonstrate), cognitive (their active engagement in thought), and affective (their emotional connection and feelings about their learning activities). Attendance is a part of engagement the sense of team and belonging is also part of the definition of students' engagement. According to Greenwood et al. (1987), the kind of engagement that optimizes task performance is not defined in terms of time spent on the task or attending to the lesson, but rather in terms of how cognitively and actively engaged the student is in completing and accomplishing tasks. In terms of behavior, this would mean that students are actively reading, pointing, writing, completing math problems, and so on. Emotionally, students have an investment in the task and are enjoying the positive experience of being actively involved in the work. Cognitively, the students are thinking about the problem, offering solutions, deciphering, transferring knowledge, and applying what they have learned to the task at hand (Boykin & Noguera, 2011).

According to Newmann (1992), engaged students make a psychological investment in learning. They try to learn what school offers and are relatively unconcerned about earning certain grades. They enjoy understanding and learning the material, incorporating it into their lives, and internalizing it. Engaged students are intrinsically motivated to learn. They yearn to understand and competently learn the material for the love of learning, rather than for the sake of an external reward such as grades, teacher approval, or peer recognition.

Assessment and Student Engagement

Authentic performance tasks. Three categories of classroom assessment exist, each of which has its own purpose (McTighe & O'Connor, 2006, p. 13). Summative assessments essentially summarize the learning at the end of the lesson series. Diagnostic tests, or pretests, are given at the beginning of the lesson series and are not always graded. The diagnostic test is used to gauge where a student's understanding falls so that instruction can be planned accordingly. Finally, formative assessments are given along the way and are ongoing. They provide feedback to teachers so that they can change or tweak their instruction to meet the needs of their learners (McTighe & O'Connor, 2006, p. 13).

According to Brandt (1997), authentic performance is "the ability to do things that are valued in the adult world" (p. 5). McTighe and O'Connor (2006) stated,

> Educators should frame the standards and benchmarks in terms of desired performances and ensure that the performances are as authentic as possible. Teachers should then present the summative performance assessment tasks to students at the beginning of a new unit or course. (p. 14)

By giving the summative assessments first, the educator is helping to frame and clarify the learning target for both the teacher and the learner (McTighe, 2006. pg. 14). Davies (2011) found through her research that when students are involved in the classroom assessment process, their engagement in learning multiplies, they are more motivated, and they achieve more. A summative evaluation is more likely to be successful since the students have encountered and mastered the learning because they are performing or producing a product. Teachers can design curriculum to generate student involvement, thus providing a wide range of evidence of student learning, which involves students deeply in control of their own summative evaluation. In addition, the performance task provides evidence that the student understands the information or process, and lastly, by presenting the summative assessment at the beginning of the instruction, the teacher sets a target or goal for the student to meet in accomplishing the learning objective (McTighe, 2006, p. 15).

Schlechty (1994) agreed with Brown and Marzano (2009) that students should be attracted to their work. When they are, they will persist in working despite challenges or obstacles, and they will take visible delight in its accomplishment. Stiggins (2007) maintained that students will exert maximum effort to perform and produce when there is a clear purpose for their learning, when the student knows exactly what he or she must understand and be able to do, when the student has a clear achievement target that points to what success will look like, and when the task is directly related to the achievement target. Communication with the student is essential during learning because the learner needs to be informed continuously with descriptive, not judgmental, detail as to how well he or she is accomplishing his or her work.

Strong, Silver, and Robinson (1995) discussed the intrinsic internal drive to actively engage in work. These innate human tendencies are described through an acronym, SCORE. “S” stand for “success,” because humans have an innate need for mastery; “C” is for “curiosity,” because there is a basic human tendency to understand; “O” stands for “originality,” which is the need for self expression; “R” refers to “relationship” because of the basic human need for relationships and involvement with others; and “E” refers stands for the “energy” that, together with all the other drives, leads to engagement (p. 8).

Authentic assessment. According to Guskey (2007), a standardized test is designed specifically to establish a ranking of schools and students for purposes of accountability. Thus, such a test is not an authentic assessment of individual students’ understanding and learning. They are inauthentic because they do not require students to demonstrate understanding by engaging in a performance or creating a product. Guskey pointed out that an assessment must be inauthentic if a student can perform poorly even after spending hours preparing, only because a gap exists between what she prepared for and what was actually on the assessment. An assessment is authentic and valid insofar as it represents exactly what the student is expected to understand and be able to do.

An example of an authentic assessment can be found in Schnitzer’s (1993) description of an authentic performance assessment she developed at Gateway High School in Aurora, Colorado (p. 32). Schnitzer, along with her colleague, developed a decision-making matrix for a science class following the McRel assessment model. This model consists of 14 “complex thinking processes,” namely “comparison, classification, structural analysis, supported induction, supported deduction, error analysis, constructing support, extending, decision-making, investigating, systems analysis, problem solving, experimental inquiry and invention" (p. 32). Using this model, the students had to solve a hostage crisis by analyzing the various choices offered and assigning weighted points for each decision made. Students had to work in cooperative groups to discuss possibilities and choose the decision with the highest points. The results were surprising, as "doing nothing" in the hostage crisis was the highest point decision. Using a matrix and rubric, the students were able to manipulate choices, and much to their surprise, they came up with several solutions. The exercise of manipulating the information made the point that decision-making is highly complex and that the ramifications for each decision have implications for other choices (p. 34).

Another form of authentic assessment is work sampling. In this approach, educators design instructional objectives for teaching and learning as well as for evaluation. The data from instruction are used for assessment. The documentation is a combination of the students' work; the teacher's detailed records of student performance, which are linked to national, state, and local standards; and the teacher's and students' reflections on classroom activities (Meisels, 1996, p. 65). Work sampling involves developmental guidelines and checklists, portfolios, and summary reports (Meisels, 1996, p. 60). Observations are compiled and documented. In 1995, Meisels' study of work sampling was shown to have high interrater reliability and validity using a checklist and summary reports of student portfolio ratings of 100 kindergarten students (Meisels, 1996, p. 65).

Rubrics are another assessment tool. There are two kinds of rubrics, holistic rubrics and analytic rubrics. Holistic rubrics list a series of criteria, and the criteria are analyzed as a whole. Analytic rubrics, on the other hand, are assessed on each criterion in the assignment (Mueller, 2014). Analytics rubrics are often used for scoring performance assessments, papers, and projects. Brookhart (2010) considers rubrics that evaluate individual criterion using a descriptive scale to be analytic, and such analytic rubrics “provide expectations for individual criteria at each performance level”(p.47). Brookhart (2010) stated that higher-order thinking can be demonstrated in one of the rubric trait scales. This promotes the use of problem-solving and reasonable thought in logic and reasoning skills. As students develop higher-order reasoning abilities, they often delve into the exploration of inquiry.

Jones (1986) stated that cognitive instruction is based on the model of learning that is emerging from cognitive science, which Resnick (1984) said is a loose association of psychology, linguistics, and computer science. From schema theory, comprehension is understood to be an active and constructive process in which the reader is constantly reviewing what is known, linking new information to prior knowledge, forming and testing hypotheses about the meaning of what is read or the problem to be solved, assessing appropriate study strategies, and revising concepts and ideas as new information is acquired (Jones, 1986, p.7).

Inquiry and problem-solving. The STAR assessment is neither authentic nor higher-order. The assessment does not require the student to create a product, nor does it ask the student to perform a task. This assessment is a summative assessment of the reading skills necessary at each grade level. Students are required to read and understand the material as question complexity and text level increases in difficulty (Renaissance Learning, 2012). Some of the questions are higher order in that students must be able to understand and choose between answers; however, the mere fact that the test is multiple-choice means that complex questioning that encourages higher-order thinking is impossible.

Fostering Student Engagement. Reeves (2007) reported that student engagement in learning is absolutely essential if a teacher is to provide feedback during instruction to ensure improvement and academic success. He pointed to findings that showed that effective feedback not only informs students about performance but also offers a path to improvement while the activity is still current. Reeves cited the sport of cross-country running as a prime example of an activity in which students are encouraged to engage. Runners throughout this competition are receiving continuous feedback attached to incremental benchmarks or goals throughout the running course. Each step provides encouragement to continue to the next step and eventually to the ultimate goal. In this sport, the feedback is immediate and ongoing because the runners are continually engaged in striving toward reachable, incremental goals.

According to Reeves (2007), schools often provide little engagement because no feedback is offered other than an examination, which provides a final grade for a lesson or learning episode. Contrast this with a sporting event or musical performance where the reaction of a coach and spectators provides a continuous incentive to continue with engagement in the activity. The standards to be met are clear and consistent, the feedback is instantaneous, and every error is quickly followed with feedback and the opportunity to correct. Reeves asserted that if students who can perform on the playing field, in the auditorium, or in the theatre are not successful in the classroom, it may be due not to a cognitive deficit but rather to a lack of accurate, timely, and specific feedback.

Marzano and Brown (2009) discussed the use of five key instructional factors that increase student engagement in the classroom. These factors are the use of high energy, missing information, self-system, mild pressure, and mild controversy or competition. When students are actively moving, with fast-paced intensity, student engagement increases. Because humans have an innate urge to reach completeness or closure, teachers can use this need to increase engagement by having student complete missing information. Developing an interest for students on the subject matter increases motivation to learn and engagement, as does mild pressure in the form of games and competitions. When presenting information in a controversial or competitive nature, most students will find this interesting, and engagement will increase, as long as the controversial and competitive nature of the presentation is non-threatening.

History of Reading Screen Studies

The introduction of new technologies brings a new layer of complexity to the study of reading processes. Reading on a computer display screen, tablet, or e-book is different than reading on the traditional paper medium. The screen studies discussed in this section illustrate some of the differences between reading on screens versus paper through variables in the perceptual processes such as luminance, color, and contrast of the display screen. Studies that explored the affective processes of motivation and preference are also discussed. The outcomes of these experiments measured the effects of the perceptual and affective processes of reading on reading speed and comprehension (Korbin, 2003; Chen & Wang, 2003; Jabr, 2013).

Jabr (2013) discussed the differences of reading on screens versus paper and concluded that many studies since the 1990s have determined that reading on paper is more advantageous to the reader. Readers comprehend, navigate, and retain more information when reading on paper, and they also find it more comfortable than reading on screens. In relation to the present study, lumination of text on the screens of ipads, eBooks, and computer screens play a notable role in straining the reader's eyes. This is a phenomenon called Computer Vision Syndrome. The American Optometric Association (2013) defined computer vision syndrome as "a group of eye and vision-related problems that result from prolonged computer use. Many individuals experience eye discomfort and vision problems when viewing a computer screen for extended periods" (para.1).

LCD vs. CRT Screen Types, Speed, Jump Length, Print Type and Color

Chen and Wang (2003) reported variables that may affect reading performance on a computer leading display. Leading display is "an internet homepage design method for presenting dynamic information on visual display terminals" (p. 249). The variables tested in this study were visual display terminal screen type, Chinese print type, text and background color combinations, speed, and jump length of the characters. Chen and Wang tested two types of visual performance technologies, also called VDT workstations, which are known as cathode ray tubes (CRT) and liquid crystal displays (LCD). Less research has been conducted on LCD screens, as these screens are newer. I n former studies, Wang et al. (2007) found that "screen type had no significant effect on subjects' searching performance for leading display" (pg. 6). In this study, screen type was one variable tested. In the study described by Chen and Wang, two types of Chinese typography were tested. True type (or print) and Kai type (or script) were variables in the study described. In previous studies by Shieh (2008), true type was found to show more accurate identification results than Kai type. Color of background displays were also defined and tested. Color is a variable when reading text on an Internet homepage. According to Chen and Wang, color provides attractiveness and makes reading on a display more pleasant. The colors of the background displays in this study were white-on-black, black-on-white, blue-on-white, red-on-white, blue-on-yellow, and green-on-white. Green (2004) stated poor color choices for background displays notably hindered readers' ability to read accurately and created visual discomfort, especially if the colors were at the extremes of the color spectrum, namely red/blue combinations. In Chen and Wang's study, the luminance difference comparing text to background colors was an important factor in text/background color result combinations. In the aforementioned study, a mathematical formula defined the luminance contrast of text to background color. Speed was also presented differently in the study by Chen and Wang in that as the speed of paragraphs are presented, reading performance may be affected. Two speeds of 250 wpm and 300 wpm were used in this study. Jump length was the last variable tested in this study. Jump length can be defined as the amount of spacing between characters. In previous studies by Juola, Tiritoglu, and Pleunis (1995), as jump length increased, reading performance improved. This study tested all of the variables using various combinations.

The results of the study indicated that the factors influencing the reading performance of the subjects with significance were jump length of the characters and the text/ background color display. There were no significant results in screen type, speed or typography. When the jump length was combined and analyzed using the Tukey multiple test analysis, text background display in combination with higher jump lengths showed a significant difference in readers' performance (Chen & Wang, 2003).

Comprehension and Speed

Korbin (2003) focused on student reading engagement and comprehension during computer-based testing and how these are affected by the contrast of the display screen background and letters on the display. In her study, Korbin discussed the research on the reading comprehension differences of participants who took both a paper-and-pencil test and a computerized reading comprehension assessment. The study was primarily a qualitative study using “verbal protocol analysis” (p. 115), or a verbal questionnaire, about the explanations of answering test item questions. In this study, Korbin explained “verbal protocols were used versus response speed and eye fixation measures because verbal explanations tell more about cognitive processes, the subject of the study” (p. 116). Korbin stated, “Former studies analyzed mean total scores or individualized item scores (or both) obtained by examinees on parallel computerized and paper and pencil versions of the same tests” (p. 116). In her analysis, Korbin recognized that comparing scores is not enough because there are various variables or constructs that skew results and offer no means for comparison (p. 116). Korbin said

> Computerized assessments give examinees an unfair disadvantage because working memory interferes with the cognitive processes necessary to answer test questions. . . . Paper-pencil tests do not require examinees to use working memory processes. This interference may make the comparison invalid because they are not comparing the same variable. (p. 116).

According to Korbin (2003), there were several limitations to the study. First, thinking out loud may distort or affect the cognitive processes under study and overload working memory (p. 116). When using a computer, the examinee may experience visual fatigue and distraction and may require more attentional resources when decoding. Decoding detracts from reading comprehension. Using a computer may also overload the working memory (p. 116) and prevent the examinee from reading the entire passage, because the examinee may have to scroll down. According to Dillon (1992), “Scrolling may weaken a reader’s visual memory, which may affect the reader’s ability to search for and locate information in the passage” (p. 24). Computerized tests may not allow the reader to see the entire text at one time (Korbin, 2003, p. 116). Paper -pencil tests may give the examinee an unfair advantage because they have the opportunity to underline and mark text. This will help the examinee answer questions more accurately. In all,

> it was hypothesized that the three constraints introduced by computerized reading comprehension tests- the difficulty reading text from the screen, the inability to underline or mark text, and the inability to see the entire passage at one time- introduced irrelevant cognitive processes into the test, causing an extraneous cognitive load. (Korbin, 2003, p. 118).

It was hypothesized, then, that the examinees taking computerized tests would have less to say. A significant difference of utterances would exist comparing the paper pencil test takers utterances to computerized test taker utterances (Korbin, 2003, p.118). In essence, the computerized examinees would answer fewer questions than the paper-pencil test takers because their working memory would be on overload (Korbin, 2003, p. 118). In addition, the paper-pencil test takers would have more to say about “rereading, paraphrasing, monitoring, understanding, making inferences, identifying important information, and integrating text” because they had more to look at and refer back to as compared to examinees reading split text on computer screens with less opportunity to mark text (Korbin, 2003, p. 118).

Korbin (2003) found the paper and pencil test takers had a significantly greater number of utterances. This demonstrated that the reading comprehension processes using paper and pencil were significantly greater than participants taking the computerized test (Korbin, 2003). When students were able to underline or mark the test, this physical manipulation helped them explain their reading processes with greater efficiency (Korbin, 2003). The findings of this study suggested that computerized tests may actually measure reading comprehension better because readers cannot rely on underlining and marking text, thus relying on deeper processes of comprehension (Korbin, 2003, p. 135). However, Korbin (2003) found that “this study does not offer strong evidence that the mode of administration alters the constructs assessed by a reading comprehension test” (p. 135)

The study described above is used a process similar to the one used in the present study. The present study is based on the effects of manipulating the background and lettering on a computer screen on student reading engagement and comprehension. The researcher attempted to answer a question based on whether manipulating the above variables would have a measurable effect on student engagement and comprehension when in a testing situation. The previous article also considered the comparison of results from paper and pencil testing versus computer-based testing and contained reactions from students to each method of testing. In the present study, the researcher selected five student behaviors, which she judged as positive when students were engaged in computer based testing. She and the teacher participants tallied the evidence of these behaviors during specific testing times.

Connell, Bayliss, and Farmer (2012), in their mixed-methods study, analyzed the effect of eBook readers and iPads on reading comprehension and reading speeds when compared to printed materials. Participants were also surveyed as to their perceptions of the effectiveness of technological devices in an academic setting. As eBooks, Kindles and iPads have emerged, studies on these devices have been few. Earlier studies have explored effects of computer scrolling on CRT and LCD screens that have background lighting. eBooks have been studied in relation to their usage and effects on reading comprehension of special education students; however, these studies were conducted on CRT computer monitors only. The present study measures whether or not there is an effect on reading comprehension and reading speed when presented with the same reading material on an eBook reader with e-ink display (Kindle), an iPad with background lighting on an LCD screen, or 8.5”x11” paper. Connell et al. found that there was a significant reading speed difference comparing eBook and iPad to paper. Students who read on paper read significantly faster. Connell et al. concluded that reading on paper is faster than reading on a tablet or eBook reader. Connell also asked students about their reading preference for academic reading. Students preferred paper for academic reading and eBook and iPad for recreational reading.

Luminance

Mitzner and Rogers (2006) explored the effects of age and luminance contrasts as it relates to reading speed and comprehension. Legge, Rubin, and Luebke, (1987) stated that luminance contrast is “the relationship between the luminance of text and the background on which it is represented" (p. 2002). The luminance contrast was defined in the table as red, green, and blue. This quantitative study examined two experiments. In the first experiment, the readers, older versus younger participants, were given a set of 40 sentences presented on different levels of increasing or decreasing luminance contrasts from low to high or high to low. All participants were screened for vision acuity. The study results supported the alternate hypothesis that older adults showed a significant difference in the ability to read fast and comprehend when luminance contrast were at lower levels. In experiment 2, given the differences in contrast levels, the readers were next presented with a word predictability exercise. A reading cloze exercise was given, and older and younger readers were presented with a series of 40 sentences that varied in predictability and luminance contrast levels. The results showed that the older readers compensated more and maintained their comprehension and word predictability even when luminance was low as compared to younger adults who did not use the strategy of context as successfully.

Another qualitative study by Rose (2010) explored the differences of on screen reading versus paper. Several similarities and differences were noted in this study. According to Rose, subjects found it difficult to find information due to scrolling inefficiencies and the inability to mark and notate on screen texts versus paper was another issue. Subjects preferred to notate on paper texts versus reading on a screen. While the storage of digitized files and text offered convenience, the three dimensional task of holding and paging through a book was preferred. Another challenge with on-screen reading was the difficulty of focusing in light due to flickering and luminance. Other distractors with on screen reading included pop ups, access to the Internet and

Facebook, and animations in the margins. Subjects noted the pleasure of reading printed materials, such as books, in a leisurely manner while reclining. Subjects also remarked that reading in an upright position such as a chair detracted from the amount and attention given to the reading task at hand (Rose, 2010).

Color and Contrast

An early study by Simmers (1988) compared the effects of the foreground and background colors of white green or yellow with black text on a microcomputer display. He studied the color and contrast combinations' effects on reading speed, comfort, and brightness. Simmers found that reading speed and comfort were not significantly different for any of the color combinations. Contrast and brightness showed significant results for the 15 visually handicapped junior and senior high school students in the study. Students preferred the darker background; however, the data showed that on a CRT display, reading rate was faster for the lighter background displays.

In another quantitative study, Kragness (2007) measured the effects of reading comprehension and speed by changing the background screen color of an LCD screen from black text on white background to black text on yellow background. Participants were given a comprehension test following the test-retest design method. For example, the reader took the reading test with black text on white background, and then took a similar test with black text on yellow background. The results of this study indicated that there was no significant difference in the reading comprehension results of the two differently colored backgrounds. Kragness discussed the limitations, which were that the number of lines of text of the yellow background screen differed depending on the number of words in each question. In addition, the amount of text for each selection was limited and may not reflect a real world application of using a yellow background overall. Other color combinations may also yield a different result that this study failed to demonstrate.

Luminance and Attention

Geske and Bellur (2008) also studied the effects of reading on a computer with a CRT screen versus printed materials. In this quantitative study, Geske and Bellur used EEG to compare the bottom-up visual processing measured in alpha levels to top-down visual processing measured in beta levels that naturally occur during the reading process. As it relates to reading, bottom-up processing involves decoding the visual information at the text level. Beginning readers concern themselves with sounding out the words and "figuring out" the written text. Top-down processing involves background knowledge of the reader and the information in memory that the reader brings to the text in comprehension. This study intended to show that preference of reading medium affects attention and the brains ability to attend to print. Geske and Bellur chose 34 subjects between the ages of 18 to 25 to participate in this study. "In this study attention was operationalized as a decrease in alpha wave (8-13Hz) activity and as an increase in beta wave (13-30 Hz) activity" (p. 412). The results of this study showed that there was a significant difference in the alpha and beta measurements between the print and CRT screen. Geske and Bellur (2008) noted "flicker or luminance presented to the parietal lobes requires more 'work,' or processing for CRT screens. The reader is having to expend more 'neural energy' to gather information" (p. 417).

According to Geske and Bellur (2008), the participant reading on a computer screen may be experiencing difficulty in reading the text, called cognitive overload, or the reader may have an interference which is causing difficulty in processing the information, possibly interference due to the luminance of the screen itself (p. 418). Thus, Geske and Bellur's study indicated that readers attended to print more easily than computer screens, and this may be a result of the flicker effect on brain processing (p. 399).

In comparison to Geske and Bellur (2008), Kretzschmar, Pleimling, Hosemann, Fussel, Bornkessel-Schlesewsky, and Schlesewsky (2013) found that luminance contrast was a contributing variable, particularly in older adult reading. This quantitative study measured the comprehension of younger and older adults on paper as compared to eBooks and/or tablet computers. The subjects of this experiment were college students ages 21-34 and retired senior citizens 60-77 years of age. This experiment used EEG to measure theta activity. According to Tzur, Berger, Luria, and Posner (2010),

> The human brain theta rhythm has been related to the operation of a generic mechanism involved in error detection processes of different types (e.g. detecting incorrect motor responses or incorrect arithmetic equations). This theta activity seems to be sensitive to error salience or magnitude, that is stronger theta activity is found with larger or more deviant error (e.g. 1+2=8) than with smaller or less deviant ones (e.g. 1+2=4). (p. 758)

For the purposes of this study, theta activity measurements were taken when errors were detected in reading by the older or younger adult reader using an EEG or electroencephalograph machine. Eye-tracking instruments measured the duration and number of fixations that readers experienced on the three different reading presentation mediums: paper, eBook (Kindle), or tablet computer (iPad2). Participants read three nonfiction, three scientific, and three fictional texts on each of the three devices. Participants were also asked which presentation medium they preferred. Interestingly, even though the older adults preferred the paper medium, the results of this study found that there was no overall difference of reading comprehension between the two subgroups of young versus elderly readers on the three different mediums. However, there was a difference in the age groups on fixation duration and theta activity. Older readers showed a significant difference in fixation durations and demonstrated a lower theta activity on tablet computers compared to paper and eBooks. Younger readers did not show a significant difference in fixation durations or theta activity for either device. Older readers had faster fixations than younger readers on the tablet computer. Older readers also experienced a higher level of theta activity on the paper medium and eBook reader than on the tablet or iPad 2. This finding suggested that the older readers had less difficulty reading on the tablet computer, even though they preferred to read on the paper medium. Kretzschmar et al. (2013) noted, "Contrast sensitivity decreases with age, and degraded contrast conditions lead to longer reading times, thus supporting the conclusion that older readers may benefit particularly from the enhanced contrast of the tablet" (p. 1).

Scoptic Sensitivity Syndrome: Light-Sensitive Reading Difficulties

Irlen (1991) described Scoptic Sensitivity Syndrome as a perceptual problem (rather than a vision problem) in which the sufferer has difficulty reading because the light refraction off the page interferes with the processing and visual perceptions of the letters on the page. Irlen described how white background often competes with black lettering and produces perceptual differences of the text. Letters may jump, blend together, dance, show bright lights, blink, or fade away. Irlen described various reading methods that may help students, such as using color overlays to reduce the light and glare from light and glare that interferes with their reading. Irlen's work is particularly relevant to the present study because the white background interference of Scoptic Sensitivity Syndrome may be alleviated when readers are presented with black computer display backgrounds.

Irlen's theory of Scoptic Sensitivity Syndrome is not accepted by all doctors in the field of ophthalmology. According to Rickelman and Henk (1990), the symptoms of photophobia, background accommodation, visual resolution, span of focus, and sustained focus cannot be measured during a routine eye examination. Photophobia is a general sensitivity to brightness, intensity of light, glare, and fluorescent light. Difficulties with background accommodation include the inability of the eyes to accommodate from black to white and white to black contrasts. Symptoms and difficulties with visual resolution include distortions in visual print features. The Scoptic Sensitivity Syndrome symptom described as span of focus involves seeing groups of words clearly, and sustained focus involves the performance of visual tasks for long periods of time without difficulty (p. 166).

Assessment and Technology

Legislation, Technology, and its Effects on Student Reading Achievement

Legislation added to the scheduled reauthorization of the Elementary and Secondary Education Act (1965) required American schools to achieve specific goals in reading, writing, and mathematics by the year 2014. This act, termed the No Child Left Behind (NCLB) Act, stipulated that the effectiveness of schools in reaching achievement goals was to be measured by standardized tests administered throughout the states

(NCLB, 2002). In 2010, new "Race to the Top" legislation was passed, as the eventual replacement for NCLB (NCLB, 2002) due to concerns about the No Child Left Behind Act (2002). In his television program on PBS, Moyers (2003) cited several reasons for opposing NCLB, including the fact that some schools were being unfairly labeled as failing. Moyers stated that the goal to have 100% of students reading proficiently by the year 2014 was not feasible. NCLB had narrowed the curriculum so that schools became commodities rather than institutions to promote civic responsibility and the socialization of American citizens. Moreover, the testing companies made millions of dollars due to the demands for testing (Moyers, 2003). The NCLB legislation created a demand for data-driven instruction. The data needed make to changes in instructional practices was necessary to update student information systems within school districts. NCLB assigned responsibility for data collection, management, and analysis to school personnel. It required that improvements in instruction aimed at increasing student achievement be based on the data. Data was to be used as a measure to drive curriculum reform and to increase collaboration among educators, especially reading specialists (Bonk, 2010).

In 2009, President Obama signed into law the America Recovery and Investment Act, which contained an initiative termed the Race to The Top Challenge, a competitive program under which states would be awarded grant money to implement four reforms described by Richardson (2009) as follows:

> [word missing] internationally benchmarked standards and assessments that prepare students for success in college and the workplace; recruit, develop, retain, and reward effective teachers and principals; build data systems that measure student success and inform teachers and principals how they can improve their

practices; and turn around the lowest performing schools. (p. 24)

The Race to the Top Legislation was intended to emphasize the need for improvement in the results attained by schools in the United States. It added to the emphasis placed by the NCLB Act (2001) on data-driven instruction. The data necessary to make changes in teaching and learning required real-time updates in student information systems. Teachers were held responsible for collecting, managing, and analyzing data in their classrooms. Data collected served as a means of assessing effectiveness of teaching and learning and as a measure to provide funding for curriculum reform (Bonk, 2010).

The National Assessment of Educational Progress (NAEP) is a testing instrument administered to students in United States schools to compare the state of the American educational system to international education systems, which take a test with similar items. The test serves as an example of the nation's report card in writing and mathematics and has been redeveloped to encompass the Common Core State Standards. The National Reading Panel was created from the NAEP in 2010. It was composed of experts in assessment and education throughout the United States who came together to make recommendations in light of the large-scale assessment to be administered to the nation's students. As reported by the National Institute of Child Health and Human Development (NICHD), the panel did make statements regarding technology (NICHD, 2000). The studies on technology reported that the use of technology for reading instruction was a positive result. Since technology can support speech-related programming, this use of technology offers promise in the area of reading instruction (NIHCD, 2000). Technology can support reading instruction by highlighting text to emphasize vocabulary and anchor words. The use of a computer as a word processor to include writing in the aspect of reading instruction is also positive. Two areas where there is more research needed in the area of reading instruction are the use of speech recognition technology and incorporating internet applications into reading instruction.

According to the National Assessment of Educational Progress (NAEP), “emerging technologies may have the greatest potential to impact the future of assessment.” As educators use computers to assess their students, the validity of the assessment should be considered. In other words, teachers may find that computerized assessments may not match observation of daily achievement in the classroom. Dooley, Landauer and Lochbaum (2009) called this face validity. Another pitfall to using technology is that, often, computerized assessments do not have enough sample questions to assess a critical skill accurately. Another limitation is that computerized assessments do not teach students anything, and there is no actual benefit to the learning process (Dooley et al., 2009, p. 45).

Dooley et al. (2009) also asserted, compared to teacher-made tests, computerized tests are more able to provide individualized feedback to students. Other technologies can provide adaptive tests where questions become harder or easier based on the response of the students on the computerized assessment (p. 45).

Norm-Referenced Tests. Like the traditional STAR assessment, the Enterprise assessments are norm referenced and use computer adaptive testing to provide the most reliable information in the shortest amount of time. Each test can be administered in 15 minutes and may be repeated as often as necessary throughout the school year. STAR Enterprise connects assessment with instruction through research based learning progressions (PR Newswire US, 2011, para. 2).

This is done by charting student scaled scores for reading and math. STAR Enterprise also provides instructional planning reports and progress monitoring and growth reports to help teachers plan instruction. “Star Enterprise features reliable predictive statistics, link to state and Common Core State Standards, and learning progressions for detailed instructional planning guidance” (Renaissance Learning, 2012).

Summary

As technology in education evolves, the researcher believes that educational researchers should carefully scrutinize the face validity of computerized assessments because decisions based on these test results affect children on a daily basis. Student performances on computerized reading assessments are used to make important decisions such as curricular and instructional planning and funding decisions. Thus, the researcher believed that it is imperative that all variables that may either enhance or hinder student achievement on computerized assessments be critically scrutinized through rigorous scientific research methods.

During the researcher’s work in a metropolitan suburban school district in the Midwest, questions about the variables that affect computerized testing of children have surfaced. In this suburban school district, which is in a socio-economically highly disadvantaged area, the children seem to perform better in the classroom on individualized reading assessments such as running records, in comparison to the computerized STAR Enterprise Reading test that is administered throughout the entire school year. This fact suggests that computer-based testing practices warrant a closer look. This closer look is particular urgent because of the testing scheduled for the 2014-2015 school year. In that year, the entire state of Missouri will administer the Common

Core State Test known as Smarter Balance. This is a computerized assessment of the Missouri Assessment Program. The researcher, in response to this upcoming assessment, wanted to find a way to enhance or help children in the area of reading.

Specifically, the researcher was concerned with the different contrasts that can be used on the computer screen display. In the researcher's previous observations of older students, she had seen that some children preferred black computer background screen displays over white computer background screen displays. During computerized testing on the STAR Enterprise Reading test, the children were changing the color of their computer screens according to personal preference. The researcher wanted to know if this would help or hinder the child's computerized reading test results. In addition, the researcher also wanted to know whether changing the color of the background screen made any difference in student engagement during the reading process.

In the chapter to follow, Chapter Three, the researcher will describe the experimental study conducted at the research site in order to measure and compare the reading comprehension and student engagement of students in grades two through six while participating in the administration of the STAR Enterprise Reading test.

Using a quantitative experimental design, the researcher will present a quantitative analysis of the results found to be relevant to student achievement in reading on a computerized assessment with differences in computer background screen display. The researcher will also present a quantitative analysis of the results found to be relevant to student engagement in reading on a computerized assessment with differences in background screen display.

Chapter Three: Methodology

Background

On December 3, 2013 the international educational community received the results of the Program for International Assessments (PISA) test. According to the results of the 2012 PISA, American 15-year-olds, represented by the randomly selected states of Florida, Massachusetts, and Connecticut, scored in the average range in reading and mathematics, as compared to other 15-year-olds internationally represented by the Organization of Economic Cooperation and Development (OECD) (OECD, 2013). Since President Obama's *Race to the Top* initiative (2009), the nation's focus had been on testing and measurement. Data collection on a computer is faster than more traditional methods and teachers and administrators were able to make informed educational decisions at the student, classroom, school, and school district level more efficiently with the technology-based method. Computerized assessments were introduced to meet the data demands for information, evaluation, and, eventually the restructuring of public schools and school districts. More research was needed at the elementary school level in the area of computerized testing measurement. Important decisions about teaching and learning must be carefully weighed and data must be carefully gathered and measured for accuracy. The young, 21st-century child needed to adapt early to technology. Measuring the academic progress of young children on a computer was an additional challenge for educational researchers. Measuring academic growth at young ages may or may not measure the actual learning progression of young children given such factors as maturity, experience, understanding, eye-hand coordination, attention, and focus (Huey, 1908;

Clay, 1991; Lyons, 2003). Various factors and variables, when testing elementary students on a computer, must be researched.

The present study, conducted in a lower socio-economic Missouri metropolitan-suburban school district, was one of the few studies, at the time of this writing, to analyze the effects of reading comprehension and student engagement of elementary school children when reading on computer screens with contrasting computer background displays. The purpose of this experimental study was to determine if a black screen with white lettering contributed to a difference in grades two through six regarding student engagement and comprehension during a computer-based adaptive test, Renaissance Learning's STAR Enterprise Reading Assessment. The researcher intended to measure the effects of background lighting on a computer screen, white background with black lettering and black background with white lettering, on students' reading engagement as evidenced through teacher tallies on five major areas of positive engagement. As technologies emerged, educational researchers critically analyzed the effects of different variables associated with computerized testing when young children take tests on a computerized assessment.

Reading Test

During the 2011-2012 school year, students at the research site took the Renaissance Learning’s STAR Enterprise Reading test in grades two through six. This test measured the reading comprehension scores of students in grades two through six. Students in grades K-1 took an Early Literacy STAR Reading test. For purposes of this study, reading comprehension and student engagement behaviors were recorded during the administration of the test for grades two through six only. The researcher explored this test because the reading texts of the test were displayed on one computer screen with text only. The Early Literacy STAR Reading test contained pictures and changing the background screen display for this test would make a comparison invalid due to the contextual differences. The Early STAR test also only measured the phonetic knowledge, not reading comprehension skills. This study was designed as a quantitative experiment. The researcher intended to investigate how student reading engagement and comprehension during computer-based testing was affected by the contrast of the display screen background and letters on the display?

The hypotheses were stated as follows:

Ho1 - There will be no measurable difference in the scores of students who take computer-based tests with the computer screen display set to black lettering on a white screen versus white lettering on a black screen.

Ho2 - Teacher tallies of student behaviors during the administration of computer-based tests will not verify a measurable difference in student engagement with the computer screen display set to black lettering on a white screen versus white lettering on a black screen.

The Research Site

The research site was one K-6 elementary school building in a large suburban school district. There were 489 students enrolled in the school in grades K-6. Three hundred and sixteen students in grades two through six participated in the research study. Average class size was approximately 23 students per classroom. The school also contained two special education self-contained classrooms and one special education resource room. Students who received special education through the resource room were part of the study. The special education resource students took the STAR Enterprise Reading Assessment with their regular education classroom. Students in the other two self-contained special education classrooms were not part of the study because most of these children did not take the test.

The study site school also offered orchestra, band, art, music, and physical education classes, as well as gifted programming located at the district administration center one day per week. The school was located in a low socio-economic area with a reported student population that was 81.5% free and reduced lunch. Racial demographics were 89% Black, 4.3 % White, 1.5% Hispanic, and 2% percent of other decent. The 2012 Communication Arts results for grades 3-6 were as follows: 19% Below Basic, 54% Basic, 20% Proficient, and 7% Advanced on the yearly MAP assessment (MODESE, 2013).

For the six years prior to this study the study site school was in level 5 restructuring. Level 5 restructuring meant the school did not meet Adequate Yearly Progress projections of the state department for the previous six years. Under the guidelines of the Missouri Department of Elementary and Secondary Education (MODESE), schools that did not meet the state benchmark of progress in the areas of reading and math were given the title, *In Need of Improvement*. For each year the school was *In Need of Improvement* there were consequences for not meeting state assessment expectations. The administrator and building leadership team of this research site wrote a restructuring plan during the fifth year, 2010-2011, of *In Need of Improvement* status. Because the school did not meet the state accountability benchmark for Communication Arts and Mathematics in 2012, the district had to implement the restructuring plan written in 2010-2011. The district administration was required to remove the school principal in the spring of 2012. A new principal was appointed for the school year of 2012-2013.

Instrumentation

STAR Reading Enterprise was an adaptive, computerized reading assessment with a 35-question reading test administered five times per year as a benchmark assessment. Students read passages silently and answered multiple choice questions based on the reading. The reading passages were leveled by Lexile level and benchmark cut scores. As students took the test, the correctness of each answer determined the next question to be asked. When a student correctly answered a question, the next reading passage would become more difficult. If the student incorrectly answered a question, the next reading passage would become easier. In this way, student reading ability and performance was measured by performance on test questions. This benchmark assessment was a tool used to give the students of the district experience in taking computerized assessments. According to NCREL, North Central Regional Educational Laboratory, “To fully realize the educational opportunities that 21st century skills can bring to students, education leaders must formally incorporate them into the mainstream of school curriculum, instruction and assessment” (NCREL, 2003, p. 73). This assessment addressed the need for district students to use technology; it also provided information to teachers about areas for reading improvement and remediation in instruction. The test was highly consequential in the public school system.

The Troubled History of STAR. One reason the researcher was concerned about the upcoming tests was administration of the test has gone poorly in the past. The STAR Reading test did not come to the district without controversy. Many reading specialists in the district (Calcari, Stephens, & McCaleb, personal communication, September 28, 2012), noticed that the skill level of district students on the test did not always match the reading skill level of students in the classroom. The administration of the test was also a challenge. Kindergarten and first grade student scores were catastrophic on the first administration of the STAR test in 2010. Approximately 40% of students who could not read at all performed well or proficient on the test, while 37% of students who could read well performed poorly or below basic (Data Team Minutes, October 3, 2012). For the researcher, the instructional coach, and the reading specialist, these results raised questions. The test was administered again, and the researcher began to wonder about the many variables that affected the results. The researcher wondered if the student's level of computer expertise or lack of experience, as well as attention span of students, played a role in the variance of test results from one benchmark to another. If important teaching and learning decisions were based on the results of the computerized testing then research to test different variables that could possibly enhance or capture the best result of reading comprehension should be explored. The researcher decided to manipulate the contrast polarity when elementary students in grades two through six took a test on a computer display screen and to also monitor student engagement when this variable was manipulated or changed from white computer display screen with black lettering to black computer display screen with white lettering. This was tested in order to gather information to decide the best results for remediation and reading improvement purposes.

During the first year, the teachers were administering the assessment to classes as a whole. In the beginning of the year, students in kindergarten and first grade did not know where to look (Woepke, Kirksey, & Shockley, personal communication, October 3, 2012). The students had to answer questions by using a mouse and clicking on a number that matched the picture they wanted to choose. The students had to listen, formulate which answer of four choices was best, choose the number corresponding to the choice, and click the mouse to indicate their answers. The test was also timed, and many students timed out before clicking. If they did not choose an answer, then the answer was wrong. This was very difficult for students with no experience on a computer. The scores in kindergarten and first grade were noticeably below expectations and did not align with the letter identification and sound tests administered by the classroom teachers at the beginning of the year (Data Team Minutes, Oct. 3, 2012). In addition, the researcher noticed that students were not engaged in the test. Students were looking all over the room, talking to one another, and touching each other.

Students in grades two through six did not perform much better than younger students in the first year of implementation. The researcher observed that teachers did not follow test administration directions. Through informal observation, the researcher noticed that teachers had students sit down and begin the test without direction. Students were not assigned to a computer. Students also were in close proximity to their peers and were often distracted. Even though students were answering questions on different places in the test and had different test questions, students often looked on a neighbor's computer. The researcher also noticed that teachers did not monitor their students taking the test by walking around. The teacher often gave students directions to start and then sat at a free computer and surfed the web, emailed colleagues, or graded papers during the STAR test administration (Watkins & Botello, personal communication, September 28, 2012), As the year progressed, the STAR scores did not improve greatly. For example, the average first and second grade student Early STAR scores jumped, on average, less than 50 points in four weeks. When the students switched at mid-year to the STAR Reading test as part of standard protocol, the scores reversed, and students who were once considered proficient as measured on the Early STAR test were now considered below average in reading on the STAR test (Instructional Leadership Team minutes, September 29, 2012). While some students did make improvements, the overall success of the test administration was questionable. Each test seemed to measure different skills. The Early test measured letter and sound knowledge. The STAR Reading test measured reading comprehension, and students had to apply their knowledge of letters and sounds in reading actual words on the printed computer screen. The students at the researcher's site came from a socioeconomically depressed area in a suburban school district. Ninety percent of the students were on free or reduced lunch, and the school was 90% diverse. Seventy five percent of students are in the Basic to Below Basic categories as measured on the latest state assessment, the Missouri MAP test (MODESE, 2012). The school was in the midst of level 5 restructuring, which meant that the building was in jeopardy of losing its administration to a state takeover unless major changes were implemented at the district level (Team Friday minutes, Oct. 5, 2012).

In 2012, the district removed the principal from the researcher's elementary study site school because the district Missouri Assessment Program (MAP) scores did not meet Adequate Yearly progress expectations. The researcher began to reflect on every variable in the school that should matter in terms of student achievement. Low socioeconomic status was not an excuse for poor student performance. Determination and focus became the forefront of thought. With the implementation of the CCSS and the computerized assessment, the researcher began to study the variables that could make a difference in achievement and success. The new administrative leader brought new skills with a data team process and shared leadership. Goal setting and transparency became the norm at the study site school (Team Friday Minutes, November 16, 2012).

The reality of computerized assessments was rapidly approaching, and the stakes were high. These technological assessments measured the effectiveness of schools at the district and state level. If schools were being compared using technological assessments, then leaders must ensure that the validity and reliability of the administration of these assessments were high. The researcher began to think of possibilities for advancing students and giving them an edge when testing on a computer. The practice needed to be streamlined and reevaluated. The researcher felt that the students did not have buy-in to the assessment process and that improvements to the assessment process should have been considered (Data Team minutes, November 21, 2012).

The researcher remembered using color overlays to help some students with reading disabilities (Irlen, 1991), and began to wonder: Could the screen change variable affect the test results? Would the lighting, angle, lack of experience, motivation, attention, and color make a difference? With this reflection came an observation made at the study site school. The researcher noticed that the children in the older grades were already changing the background screens on the computers (Kandel, personal communication, November 21, 2012). The teachers were not paying attention to the children as they took the test and simply allowed them to change the screen without permission. The researcher began to wonder whether the variable of screen color might affect a student's engagement and reading comprehension scores. Some teachers had previously set goals for reading scores with students, and these students may have been those who progressed throughout the year. The researcher, as instructional coach, decided to change the background color of the screen to see whether it made a significant difference in student engagement and performance.

Reliability and Validity. The researcher was concerned with the reliability and validity of the testing instrument during the administration of the Renaissance Learning STAR Reading test during the 2011-2012 school year. Even though this test was not the measure used for state accountability purposes, this test did project the expected result of school test scores on the Missouri MAP assessment. The researcher questioned certain variables that may have affected the results of reading scores when young elementary school students took a reading test on a computer. The researcher also noticed certain student behaviors during the administration of the Renaissance Learning STAR Enterprise Reading test on a computer. One such behavior was that older students were randomly changing the background color of the computer screen display during reading testing. All regular elementary school classrooms in grades two through six took the Renaissance Learning Enterprise assessment the first time as part of standard protocol throughout the school year of 2011-2012. Special education students enrolled in regular elementary school classrooms took the test with their grade level homeroom teacher. Students took the same Renaissance Learning Enterprise assessment again in 2012-2013, the year of the study. During the administration of this experimental design, all participants received the same treatment, but with different computer screen displays as part of the independent variable.

Instrument: Renaissance Learning STAR Enterprise Assessment

Renaissance Learning provided technology-based school improvement and student assessment programs to local school districts nationwide (Renaissance Learning, 2012). Renaissance offered Reading STAR Enterprise, an adaptive test. These assessments were norm referenced tests which use computer adaptive testing. The STAR Enterprise Reading assessment provided reliable and timely information so teachers could make decisions about teaching and learning. STAR enterprise connected assessment with instruction using a research-based result called a learning progression (Renaissance Learning, 2012).

The research site of this study was one of 17 elementary school buildings in the district that uses Renaissance Learning's Reading STAR Enterprise assessment as a formative assessment tool for instructional planning purposes. Teachers collected reading data, set instructional goals, and planned daily reading lessons based on the information this reading assessment provided. Essentially, the learning progressions provided by Renaissance's Reading STAR Enterprise assessment, map out student scores so teachers may plan lessons and instruction that is aligned with the student results of skills driven data. The STAR Enterprise assessment was linked to Common Core State Standard and provided teachers with a screening report, growth reports, and real time data based on student's performance on the test. The test was adaptive which means the test gets easier or harder based on the previous answer of the student. The adaptability of the test measures the zone of proximal development of the student, thus making the number of necessary questions to assess the skills lower.

Data Collection and Analysis

The Renaissance Learning STAR Enterprise assessment occurred four times beginning in January and ending in May, 2012. There were four benchmark periods. The testing session for the STAR Enterprise Reading test occurred within a one-week window for grades two through six. The benchmark windows selected for the study were within the months of December, February, March, and April of 2012. The first and last benchmark windows for the school year were not selected purposely so that beginning of the year school data and end of year school data would not be affected in any way by the study. All students in grades two through six took the STAR Enterprise Reading test during their regularly scheduled computer lab time. Eighteen classroom teachers administered the test throughout the entire school year as part of standard district protocol. Each class testing session was 35 minutes from start to finish. The tester, or classroom teacher, had a 40 minute time frame from entrance to exit of the lab each session. Benchmarks were given every six weeks.

Timelines and Procedures Used in This Study

1. Permission to conduct the study was attained from the superintendent.
2. Permission to conduct the study was attained from the elementary school principal (written approval and signature provided).
3. All 18 teachers in grades two through six who administered the Renaissance Learning STAR Enterprise Reading assessment were informed of the study. The researcher personally met with the teachers and explained the extent of participation and secured their consent. Procedures of student engagement observations were explained in detail.

4. Engagement procedures prior, during, and after testing were described to teachers.
5. The researcher shared the tally sheets for marking student engagement distribution, and the procedure was explained to all teachers.
6. The researcher met with the teachers to explain the tally sheets and marking process.

Selection of Participants

The participants of the study were 316 elementary age school children in grades two through six. One hundred and sixteen students were randomly sampled for student engagement data analysis from grades two through six. The researcher selected the random sample by drawing four odd numbers and four even numbers from each classroom population out of a bucket. A total of 24 students for each grade were selected for the random sample of 116 students in all. A total of 60 students were selected from the odd-numbered computer group and 56 students were selected from the even-numbered computer group. Students who were absent during the window for screening for more than one reading comprehension test session were taken out of the random sample population. Student names were scrubbed from the data sets. All data, provided by the Renaissance Learning STAR Enterprise reports, were collected by the researcher. The classroom teachers tallied the student engagement and data was collected on reading comprehension by the researcher.

Procedure for Laboratory Setting

The students in this study were randomly assigned to the computers by their classroom teacher and used the same computer throughout the school year. Classes tested in the computer lab with their self-contained, regular elementary education class. Each teacher submitted a computer laboratory seating chart to the researcher with the computer assignments for the entire 2012-2013 school year. All computers were numbered in sequential order, 1-30. If a computer was out of service during the time of testing, the teacher was instructed to assign the child, if on an odd-numbered computer, to another odd-numbered computer. In essence, the children were placed in either odd-numbered computer groups or even-numbered computer groups. All computers in the rectangular shaped room were facing the outside wall made of white concrete cinderblock. There were two computers on each table facing the wall. The room was cool, comfortable, and brightly lit with fluorescent lighting. There were no windows for natural light. The room was situated on the lower level or basement of the school building. The computer laboratory was directly across from the three, first-grade classrooms. The laboratory was also directly beside two music rooms.

Collection of Student Engagement Data

Teacher observers collected tallies on engagement. The procedures for collecting student engagement were explained to the teachers as follows: The teacher stood behind and to the direct right of the child. The teacher looked down at the carpet for three seconds. Next, the teacher looked up to the child and recorded the behavior or behaviors observed while counting to 10 (posture upright, repeating words on the screen, hand position on mouse, eyes fixed on screen only, finger pointing on screen). Then, the teacher looked down and counted to 10 and then moved to the next child and repeated this procedure. During each sweep of the room, the teacher was allowed to mark one tally for each behavior, but only if observed during the observation. The teacher observed and recorded student engagement for each student. The teacher went around the room to observe students a total of three times for each benchmark session. The teacher used the tally sheet(s) to mark the student engagement behaviors throughout the testing session. Behaviors were marked as observed with a tally mark or left blank if the behavior was not observed.

The researcher and teacher participants circulated, monitored, and recorded through tallies of these five behaviors for the entire 35-minute testing session. The researcher compared the number of positive student engagement behaviors based on black and white background computer displays.

Randomizing the Student Engagement Data

The researcher conducted a stratified random process to select data for analysis. Computers were numbered and students were assigned to computers by their teachers. This assured that students were exposed to both color display background variables throughout the study process. The sample size of 116 students from grades two through six was directly related to the researcher's belief that validity and reliability of findings will be enhanced by the size of the population of 316 students in all. An average of 24 students from each grade, grades two through six, were randomly chosen from the school population. One hundred sixteen students, four odd-numbered and four even-numbered computers were selected from each classroom and 24 from each grade made up the stratified random sample in this study for student engagement.

It is important to note that one fourth-grade teacher placed her students on odd-numbered computers only for the first, third, and fourth trials. On the second testing window, she remained consistent by utilizing even and odd-numbered computers. For purposes of this study, this fourth grade teacher contributed odd-numbered number student engagement results only for the first, third, and fourth trials.

Computer seat numbers randomly chosen for each teacher participant are found in Table A. The researcher highlighted the selected computer numbers on the teacher's computer assignment list. Yellow highlighter was used for the odd-numbered group. Orange highlighter was used for the even numbers selected. The researcher highlighted the selected computer numbers on the teacher's computer assignment list. If students needed to move to a different computer, the teachers were instructed to keep that student in the same odd-numbered or even-numbered group by assigning them to another odd-numbered computer or even-numbered computer in the laboratory.

Prior to the Testing Session

Computer display background contrast was set prior to student testing session. All odd-numbered computers were set to black background displays with white lettering. All even-numbered computers will stay as white background displays with black lettering. Teachers had student engagement behavioral tally sheets ready prior to the testing session along with a stopwatch. The researcher was also present in the room. The tally sheet had computer numbers to the left of the sheet and five engaging behaviors: student posture, repeating words on the screen, hand position on mouse, eyes on screen and finger pointing, across the top of the sheet marked (see Appendix A). Prior to test administration, teachers followed the Renaissance Learning Enterprise STAR Reading Assessment protocol, which was to read test administration directions to students. Students sat at their assigned computers and began testing.

Computer Assignments

Students were randomly assigned to computers in a laboratory setting. All computers were evenly spaced with two computers to a table. Every other computer was black screen/white screen. In the first testing session, all odd-numbered computers had a black background display with white lettering and all even-numbered computers had a white background display with black lettering. A numbered seating arrangement and computer lab map was attached (Appendix B). On successive sessions, the display screen alternated. On the second session, all odd-numbered computers had a white background display with black lettering and all even-numbered computers had a black background display with white lettering. In the third session, all odd-numbered computers had a black background display with white lettering and all even-numbered computers had a white background display with black lettering. In the last session, all odd-numbered computers had a white background display with black lettering. All even-numbered computers had a black background display with white lettering. This was to ensure that students would not experience harmful effects to their results for the purposes of achievement testing.

During Testing

The researcher and teacher participants circulated, monitored, and recorded through tallies of these five behaviors for the entire 35-minute testing session. The researcher compared the number of positive student engagement behaviors based on black and white background computer displays.

The classroom teacher collecting the student engagement data walked around the room three times in all and monitored student testing. Upon recording observations, the teacher followed the written directives which were explained. The researcher was in the room to monitor student testing problem solve technical difficulties during testing, and to answer student questions or needs so that each classroom teacher could focus on the collection of student engagement data without distractions.

Analysis of Data - Student Engagement Data

The researcher calculated the mean level of student engagement on each of the five observed student engagement behaviors as it related to the computer background displays that are white with black lettering. The researcher also calculated the mean level of student engagement on each of the five observed student engagement behaviors as it related to the computer background displays that were black with white lettering. Engagement data were organized according to the two groups of student's tests: students viewing a white background and students viewing a black background. A *z*-test for difference in proportions was applied to data for black and white computer background displays. The *z*-test for difference in proportions compared the student engagement performance of students on black screens versus performance of students on white screens. Once the *z*- test value was computed its significance was judged based on an alpha level of 0.05 to determine whether or not the observe differences were statistically significant.

Procedures for Randomizing the Reading Comprehension Data

All students in grades two through six participated in the administration of four Renaissance STAR Enterprise Reading benchmark tests throughout the entire school year. Students were assigned to computers randomly by their teachers and were assigned either an odd-numbered or even-numbered computer assignment for the entire year. The researcher collected a stratified random sample for each grade two through six. From the stratified random sample, the researcher randomized to a smaller sample size of 20 students for each grade. After students were selected, their reading scaled scores, taking into consideration use of the white and black computer background displays and lettering for each month were placed into a spread sheet, and total averages for black background displays with white lettering and white background displays with black lettering reading scaled scores were calculated for each grade combined.

Analysis of Data-Reading Comprehension

Student achievement scores on the STAR Reading assessments were recorded and compared. The control group, consisting of 116 randomly selected elementary school children in grades two through six, took the STAR using a white computer background display with black lettering. The experimental group, consisting of 116 randomly selected elementary school children in grades two through six, took the same test using a black background with white lettering. The researcher calculated the mean of all the scaled scores of students testing on the white computer background displays and all the scaled scores of students testing on the black computer background displays. A *z*-test for difference in means was applied to the reading comprehension data to compare scores from each group to each other. The *z*-test assessed whether or not the means of two groups were statistically different from each other. Once the *z*-value was computed its significance was judged based on an alpha level at 0.05 to determine significance of the findings.

The researcher conducted a *z*-test for difference in means for each grade level. Later, the researcher combined all grades by adding the monthly reading scaled score totals together for black background displays and for white background and then collected a stratified random sample of combined student reading scaled scores for each background display color. To assure representation for all grade levels the researcher left the students in the list next to their grade when randomizing the overall combined population. From the stratified random sample list of combined grades, the researcher randomized to a smaller sample size of 51 students. Then a z-test for difference in means was applied.

Throughout data collection, the academic well-being of the students was considered. If a teacher felt that a given student's score appeared to be an extreme outlier, the student was retested on the STAR Reading test the following day. Retest data was not a part of the data analysis. This re-testing ensured that student performance was not significantly penalized or harmed academically due to the difference in the computer background screen display administered during the study. In addition, students were tested with different color computer background screen displays every other time they participated. This practice was also meant to ensure that no harm would fall on student performance for an extended period of time throughout the school year. The researcher intended to determine whether the type of background lighting on a computer screen affected student engagement and comprehension as reflected by their scores during the computer-based adaptive test.

Results

Based on the results of the achievement testing the researcher determined if she could reject or not reject the null hypothesis, which stated: There will be no measurable difference in the scores of students who take computer-based tests with the computer screen display set to black lettering on a white screen versus white lettering on a black screen.

Summary

The methodology of this experimental design leads to an investigation of student reading comprehension performance and student engagement when reading on contrasting computer background displays: a black background computer display with white lettering or a white background computer display with black lettering. The researcher approached this study using a quantitative experimental design with careful randomization and procedures that would insure an equal distribution of participants across the selected grade levels of grades two through six. The control data were gathered from participation on the traditional computer color display background. The quantitative results of this experimental study will be presented in Chapter Four

Chapter Four: Results

Introduction

The data collected and analyzed during this study allowed the researcher to explore the relationship of student reading comprehension and engagement to reading on different computer background display contrasts, either black background with white lettering or white background with black lettering. The researcher intended to compare the reading comprehension results of two groups of students, as well as the student engagement of both groups during computer use as they participated in administration of the Renaissance Learning STAR Reading test.

Bonk (2010) stated that technology was increasingly becoming woven into everything we do in today’s society, even in the realm of education. As Race to the Top efforts affected American education, the introduction of high stakes testing forced educators to analyze current practice in the teaching and learning field and also in the area of educational testing (Bonk, 2010). School districts recently, at the time of this writing, opted to introduce students to computer-generated measures that would allow teachers to analyze their current performance in order to adjust instructional strategies and techniques (Bitter & Pierson, 2010). As students take computerized reading tests, several factors may affect elementary students’ reading comprehension scores and student engagement. This study was intended to analyze factors which may help enhance reading comprehension scores and student engagement during the computerized testing of elementary school children enrolled in a low performing turnaround school in a suburban metropolitan area.

Problem Statement

In order to assess growth in reading comprehension, teachers at the study site school administered quarterly summative reading assessments designed by Renaissance Learning called the STAR Reading assessment. Children in grades two through six participated in administration of the test five times per year and children who scored below 80% proficiency could take the test up to 10 times per year, in a prescribed schedule of progress monitoring assessments which utilized the same 34-question test as the benchmark and quarterly assessments (Renaissance , 2011). Several factors may affect the outcomes of these scores. Since children were taking this 34-question test on a computer monitor in a computer lab setting, teachers needed to accommodate students by providing motivation and encouragement, setting controlled language upon administration of the test, and adjusting room or setting conditions such as lighting, temperature, seating space, environmental distractors, and computer monitor display. The purpose of this study was to analyze the effects of computer monitor lighting display on children's reading comprehension scores and their engagement when testing on a computer.

Questions to be answered by the study included: a) If teachers adjusted the computer background display from white lighting with black lettering to black lighting with white lettering, will there be a positive effect on children's reading comprehension scores? And b) If teachers adjust the computer background display from white lighting with black lettering to black lighting with white lettering, will there be a positive affect on children's students' engagement?

Purpose Statement

The purpose of this study was to investigate the effect of background lighting on reading comprehension rates of children in an elementary school setting grades two through six, and examine engagement in the activity between groups using the two different display settings. Students must learn to take tests more regularly on computers in order to prepare for the Missouri MAP Assessment Program, which beginning in 2014 will be taken on the computer. The purpose of this study was to analyze the effect of computer display lighting on students' performance to potentially identify a strategy to help students achieve better reading comprehension scores on the test.

Description of the Sample

The research site for this quantitative experimental study was a Midwest metropolitan elementary school, grades K-6, located in a lower socio economic suburban school district. All students in grades two through six were required to take the Renaissance Enterprise STAR Reading test five times per year as benchmark summative assessments. Teachers could also administer the same assessment as a formative assessment in between benchmark assessments. There were 489, K-6 students enrolled in the school. There were 316 students enrolled in grades two through six. The 2012 Communication Arts results for grades 3-6 were as follows: 19% Below Basic, 54% Basic, 20% Proficient, and 7% Advanced on the yearly MAP assessment (MODESE, 2013).

Quantitative Data Analysis

The researcher investigated the following null hypotheses in this study:

Ho1 - There will be no measurable difference in the scores of students who take computer-based tests with the computer screen display set to black lettering on a white screen versus white lettering on a black screen.

Ho2 - Teacher tallies of student behaviors during the administration of computer-based tests will not verify a measurable difference in student engagement with the computer screen display set to black lettering on a white screen versus white lettering on a black screen.

A *z*-test for difference in proportions was conducted to compare odd-numbered and even-numbered student engagement data generated by the random samples. *Z*-tests were conducted independently for each of the benchmark periods designated as December, February, March, and April. All students in grades two through six were placed in either an odd-numbered group or even-numbered group and data generated by both groups were compared for each benchmark period. In the month of December all odd-numbered computers were black background and all even-numbered computers were white background. In the month of February all odd-numbered computers were white background and all even-numbered computers were black background. In the month of March all odd-numbered computers were black background and all even-numbered computers were white background. In the month of April, all odd-numbered computers were black background and all even-numbered computers were white background. The purpose of alternating the computer background contrasts was to limit the amount of harmful effects on student achievement throughout the year.

Data values for the *z*-test for difference in proportions for December are found in Table 1. Since the level of significance is at 0.05 or 95% confidence level, the critical values are ±1.96. The test value was $z = 0.034$, and since the test value does not fall within the critical region of greater than 1.96, the null hypothesis is not rejected. There is not a difference in means at the 95% confidence level between engagement of students reading on a black versus white display background.

Table 1.

Total December Engagement Data All Grades

	Odd: Black Screen		Even: White Screen	
Grades	Behaviors	Total	Behaviors	Total
n2	88	180	76	180
n3	74	180	78	180
n4	78	180	39	120
n5	95	180	104	180
n6	90	180	97	180
N	425	180	394	180
Sample		60		56
^p1	0.472			
^p2			0.469	
p-bar				0.471
q-bar				0.529
z- test				0.034

Note: Stratified Sample n = 116. Alpha = 0.05. Critical Value = ±1.96.

Data values for the *z*-test for difference in proportions for February are found in Table 2. Since the level of significance is at 0.05 or 95% confidence level, the critical values are ±1.96. The test value was 0.034, and since the test value does not fall within the critical region greater than 1.96, the null hypothesis is not rejected. There is not a difference in proportions at the 95% confidence level between the engagement of students reading on a black versus white display background.

Table 2.

Total February Engagement Data All Grades

	Odd: White Screen		Even: Black Screen	
Grades	Behaviors		Behaviors	Total
n2	91	180	102	180
n3	96	180	93	180
n4	63	180	36	120
n5	101	180	95	180
n6	92	180	103	180
N	443	900	429	840
Sample		60		56
^p1	0.492			
^p2			0.476	
p-bar				0.367
q-bar				0.633
z-test				0.179

Note: Stratified Sample n = 116. Alpha = 0.05. Critical Value = ±1.96.

Data values for the *z*-test for difference in proportions for March are found in Table 3.

Table 3.

Total March Engagement Data All Grades

	Odd: Black Screen		Even: White Screen	
Grades	Behaviors		Behaviors	Total
n2	84	180	86	180
n3	100	180	97	180
n4	79	180	44	120
n5	86	180	81	180
n6	100	180	102	180
N	449	180	410	180
Sample	60		56	116
^p1	0.498			
^p2			0.488	
p-bar				0.751
q-bar				0.249
z-test				0.127

Note: Stratified Sample n = 116. Alpha = 0.05. Critical Value = ±1.96.

Since the level of significance is at 0.05 or 95% confidence level, the critical values are ±1.96. The test value was *z* = 0.127, and since the test value does not fall within the critical region greater than 1.96, the null hypothesis is not rejected. There is not a difference in means at the 95% confidence level between the engagement of students reading on a black versus white display background.

Data values for the *z*-test for difference in proportions for April are found in Table 4. Since the level of significance is at 0.05 or 95% confidence level, the critical values are ±1.96. The test value was *z* = -0.97, and since the test value does not fall within the critical region greater than 1.96, the null hypothesis is not rejected. There is not a difference in means at the 95% confidence level between the engagement of students reading on a black versus white display background.

Table 4.

Total April Engagement Data All Grades

	Odd: White Screen		Even: Black Screen	
Grades	Behaviors		Behaviors	Total
n2	87	180	72	180
n3	85	180	92	180
n4	72	180	48	120
n5	86	180	92	180
n6	85	180	91	180
N	415	900	395	840
Sample	60		56	116
^p1	0.461			
^p2			0.470	
p-bar				0.465
q-bar				0.535
z-test				-0.97

Note: Stratified Sample n = 116. Alpha = 0.05. Critical Value = ±1.96.

A *z*-test for difference in means was conducted to compare reading comprehension data of the random samples generated by students sitting at odd and even-numbered computers. Odd-numbered computers and even-numbered computers always had different color computer background displays. One set would be black, while the other was white. Data from odd-numbered and even-numbered groups were compared for each grade level. The scores for odd-numbered computers were combined for the months of December, February, March, and April for each grade individually. The scores for even-numbered computers were combined for the months of December, February, March, and April for each grade individually. Odd-numbered and even-numbered groups were also utilized for an overall combined grade comparison. The null hypothesis was:

There will be no measurable difference in the scores of students who take computer-based tests with the computer screen display set to black lettering on a white screen versus white lettering on a black screen.

The results of the *z*-test for difference in means for second grade reading comprehension are found in Table 5. Since the level of significance is at 0.05 or 95% confidence level, the critical values are ±1.96. The test value was $z = 0.044$, and since the test value does not fall within the critical region greater than 1.96, the null hypothesis is not rejected. There is not a difference in means at the 95% confidence level between the reading comprehension scores of students reading on a black versus a white display background, in second grade. For second grade there is no significant difference in scores when students were utilizing the different background colors on the computer screen. Observably, the average scores on computers with a black background color were mildly higher than average scores on computers with a white background.

Table 5.

z-Test: Two Sample for Means-Grade 2

	Odd: Black Screen	*Even: White Screen*
Mean	266.05	264.28
Known Variance	14051.46	18020.81
Observations	20	21
Hypothesized Mean Difference	0	
Z	0.044	
P(Z<=z) two-tail	0.964	
z-critical two-tail	1.959	

Note: Stratified Sample n = 116. Alpha = 0.05. Critical Value = ±1.96.

The results of the *z*-test for difference in means for third grade reading comprehension are found in Table 6. Since the level of significance is at 0.05 or 95% confidence level, the critical values are ±1.96. The test value was $z = -0.52$ and since the test value does not fall within the critical region less than -1.96, the null hypothesis is not rejected. There is not a difference in means at the 95% confidence level between the reading comprehension scores of students reading on a black versus a white display background, in third grade. For third grade there is no significant difference in scores when students are utilizing the different background colors on the computer screen. Observably, the average scores on computers with a white background color are higher than average scores on computers with a black background.

Table 6.

z-Test: Two Sample for Means-Grade 3

	Odd: Black Screen	*Even: White Screen*
Mean	383.52	405.10
Known Variance	12110.37	19427.10
Observations	19	19
Hypothesized Mean Difference	0	
Z	-0.529	
P(Z<=z) two-tail	0.596	
z-critical two-tail	1.959	

Note: Stratified Sample n = 116. Alpha = 0.05. Critical Value = ±1.96.

The results of the *z*-test for difference in means for fourth grade reading comprehension are found in Table 7. Since the level of significance is at 0.05 or 95% confidence level, the critical values are ±1.96. The test value was z = -0.10 and since the test value does not fall within the critical region less than -1.96, the null hypothesis is not rejected. There is not a difference in means at the 95% confidence level between the reading comprehension scores of students reading on a black versus a white display background, in fourth grade. For fourth grade there is no significant difference in scores when students are utilizing the different background colors on the computer screen. Observably, the average scores on computers with a white background color are mildly higher than average scores on computers with a black background.

Table 7.

z-Test: Two Sample for Means-Grade 4

	Odd: Black Screen	*Even: White Screen*
Mean	448.19	456.33
Known Variance	11058.66	110553.43
Observations	21	21
Hypothesized Mean Difference	0	
Z	-0.107	
P(*Z*<=z) two-tail	0.914	
z-critical two-tail	1.959	

Note: Stratified Sample n = 116. Alpha = 0.05. Critical Value = ±1.96.

The results of the *z*-test for difference in means for fifth grade reading comprehension are found in Table 8. Since the level of significance is at 0.05 or 95% confidence level, the critical values are ±1.96. The test value was z = -1.00 and since the test value does not fall within the critical region less than -1.96, the null hypothesis is not rejected. There is not a difference in means at the 95% confidence level between the reading comprehension scores of students reading on a black versus a white display background, in fifth grade. For fifth grade there is no significant difference in scores when students are utilizing the different background colors on the computer screen. Observably, the average scores on computers with a white background color are higher than average scores on computers with a black background.

Table 8.

z-Test: Two Sample for Means-Grade 5

	Odd: Black Screen	*Even: White Screen*
Mean	506.25	555.60
Known Variance	21055.57	26738.46
Observations	20	20
Hypothesized Mean Difference	0	
Z	-1.009	
P(Z<=z) two-tail	0.312	
z-critical two-tail	1.959	

Note: Stratified Sample n = 116. Alpha = 0.05. Critical Value = ±1.96.

The results of the *z*-test for difference in means for sixth grade reading comprehension are found in Table 9. Since the level of significance is at 0.05 or 95% confidence level, the critical values are ±1.96. The test value was $z = 0.22$ and since the test value does not fall within the critical region greater than 1.96, the null hypothesis is not rejected. There is not a difference in means at the 95% confidence level between the reading comprehension scores of students reading on a black versus a white display background, in sixth grade. For sixth grade there is no significant difference in scores when students are utilizing the different background colors on the computer screen. Observably, the average scores on computers with a black background color were higher than average scores on computers with a white background.

Table 9.

z-Test: Two Sample for Means-Grade 6

	Odd: Black Screen	*Even: White Screen*
Mean	785.63	767.77
Known Variance	69730.72	70864.37
Observations	22	22
Hypothesized Mean Difference	0	
z	0.223	
P(Z<=z) two-tail	0.823	
z-critical two-tail	1.959	

Note: Stratified Sample n = 116. Alpha = 0.05. Critical Value = ±1.96.

The researcher combined reading comprehension scores for all four months together to obtain a combined sample for those using a black display background and for those using a white display background. The results of the *z*-test for difference in means for combined grades are found in Table 10. Since the level of significance is at 0.05 or 95% confidence level, the critical values are ±1.96. The test value was $z = -0.45$ and since the test value does not fall within the critical region less than -1.96, the null hypothesis is not rejected. There is not a difference in means at the 95% confidence level between reading comprehension scores of students reading on a black versus a white display background, for all grades combined. For the combined sample represented by all grades, there is no significant difference in scores when students are utilizing different contrasts in background computer background screens. Observably, the average scores on computers with black background color are very close to average scores on computers with a white background.

Table 10.

z-Test: Two Sample for Means- Combined

	Odd: Black Screen	Even: White Screen
Mean	432.68	434.80
Known Variance	53518.90	55308.48
Observations	51	51
Hypothesized Mean Difference	0	
Z	-0.045	
P(Z<=z) two-tail	0.963	
z-critical two-tail	1.959	

Note: Stratified Sample n = 116. Alpha = 0.05. Critical Value = ±1.96.

Summary

The purpose of this study was to investigate whether or not student reading comprehension and student engagement while taking a test on a computer would be affected by the differences in background lighting on a computer display screen. A summary of the hypotheses and results are shown in Table 11.

According to the results of the *z*-tests for difference in proportions of student engagement and *z*-tests for difference in means for reading comprehension, the data analysis failed to reject the null hypothesis for each disaggregated category, which stated: There will be no measurable difference in the scores of students who take computer-based tests with the computer screen display set to black lettering on a white screen versus white lettering on a black screen.

According to the results of the *z*-tests for difference in proportions of student engagement and *z*-tests for difference in means for reading comprehension, the data analysis failed to reject the null hypothesis for each disaggregated category, which stated: There will be no measurable difference in the scores of students who take computer-based tests with the computer screen display set to black lettering on a white screen versus white lettering on a black screen.

Table 11.

Summary Results: Testing of Null Hypotheses

Ho1- Reading comprehension: There will be no measurable difference in the scores of students who take computer-based tests with the computer screen display set to black lettering on a white screen versus white lettering on a black screen.

	Result	Critical Value	Test Value
Grade 2	Failed to reject	+1.96, (-1.96)	0.044
Grade 3	Failed to reject	+1.96, (-1.96)	-0.052
Grade 4	Failed to reject	+1.96, (-1.96)	-0.100
Grade 5	Failed to reject	+1.96, (-1.96)	-1.000
Grade 6	Failed to reject	+1.96, (-1.96)	0.220

Ho2- Student Engagement: Teacher tallies of student behaviors during the administration of computer-based tests will not verify a measurable difference in student engagement with the computer screen display set to black lettering on a white screen versus white lettering on a black screen.

Grades Combined	Result	Critical Value	Test Value
December	Failed to reject	+1.96, (-1.96)	0.034
February	Failed to reject	+1.96, (-1.96)	0.179
March	Failed to reject	+1.96, (-1.96)	0.127
April	Failed to reject	+1.96, (-1.96)	-0.97

Note: Stratified Sample n = 116. Alpha = 0.05. Critical Value = ±1.96.

The quantitative data analysis also failed to reject the null hypothesis for each disaggregated category, which stated: Teacher tallies of student behaviors during the administration of computer-based tests will not verify a measurable difference in student engagement with the computer screen display set to black lettering on a white screen versus white lettering on a black screen.

Further discussion of results, recommendations for further research, and conclusions will be discussed in Chapter Five.

Chapter Five: Discussion of Results and Conclusion

This quantitative study investigated whether or not using different background colors on computer display screens during the administration of Renaissance's STAR Enterprise assessment would make a significant difference in the reading comprehension scores and student engagement of two randomly selected elementary student populations, enrolled in grades two through six. The student participants were randomly assigned to computers, utilized for reading assessment, with either a white display screen with black lettering or a black display screen with white lettering. The study compared data from teacher-observed student engagement scores and reading comprehension scores of 116 randomly selected elementary school children from a Midwestern suburban school district during four benchmark periods in the 2012-2013 school year.

Summary of Results

Analysis of the student engagement data used in the application of the *z*-test for difference in proportions failed to reject the null hypothesis, which stated: Teacher tallies of student behaviors during the administration of computer-based tests will not verify a measurable difference in student engagement with the computer screen display set to black lettering on a white screen versus white lettering on a black screen. Furthermore, data representing the reading comprehension results of participants used in the application of the *z*-test for difference in means failed to reject the null hypothesis, which stated: There will be no measurable difference in the scores of students who take computer-based tests with the computer screen display set to black lettering on a white screen versus white lettering on a black screen.

Each analysis was applied to individual grade levels and to the combination of all grade levels while comparing averages generated by students using the black display screen to averages generated by students using the while display screen. To minimize potential harmful academic results in varying the display colors, students were tested with one of the two different color computer background screen displays every other time the reading comprehension test was administered. In addition, teachers watched for unusual scores from students during each administration, with a retest administered when necessary.

Methodology

Students in grades two through six were assigned to an odd-numbered or even-numbered computer for an entire year. The background computer display screens were switched, so that students alternated every other benchmark period between having a black or white background. Reading comprehension data for black and white computer background displays were compared using a *z*-test for difference in means. All student random samples were compared within each grade level, and a combined *z*-test for difference in means for combined grades was also calculated for black and white screen comparison. In addition, teachers collected data using student engagement tally sheets, and recorded the five observable student engagement behaviors. A *z*-test for difference in proportions of the black versus white screen samples was calculated, and failed to reject the null hypothesis in each case.

Research Questions and Hypotheses

This study was guided by the following research question: How is student reading engagement and comprehension during computer-based testing affected by the colors of the contrasting display screen background and letters on the display?

Contrary to the researcher's initial belief that black screen displays would be associated with a difference in student engagement and comprehension when answering test questions on a computer, the reading engagement of elementary students in this study was not significantly different between the two groups using black display screens versus white display screens. There was a small observational difference in the means of the two groups presenting the white screens as slightly more favorable. The fifth grade group in particular showed the greatest test-value of $z = -1.01$, but was not within the critical region with a critical region less than the value of $z = -1.96$. Thus, rejection of the null was possible. This especially intrigued the researcher. To explore further, a *t*-test for difference in means for dependent samples was applied to the fifth grade sample to compare results generated on a black screen versus a white screen. Testing the null hypothesis that there would be no difference, the result of this *t*-test yielded a test value of $z = -0.40$. The critical value was $z = \pm 2.0$. So, once again there was not enough of a difference to reject the null hypothesis. This simple test confirmed the previous results and affirmed that there is not a significant difference in reading comprehension when the computer displays are presented on black or white displays to elementary school children. Despite the statistically supported results of this study, as an educational leader, and even though there was an observational difference with a more favorable result for the white screen, the researcher would still not recommend that students change the computer display background screen from white to black.

Hypothesis # 1. There will be a measurable difference in the scores of students who take computer-based tests with the computer screen display set to black lettering on a white screen versus white lettering on a black screen.

Data in this study did not support Hypothesis # 1. Based on the results of this study, the researcher believes that elementary school children do not experience a favorable increase in reading comprehension performance when the computer background display is changed to black with white lettering. Possibly, this result may be due to the age of the children. For children's young eyes, the luminance of the computer screen may not be as sensitive to the light of the white screen as compared to adults. Kretzschmar et al. (2013) described the results of a study in which older adults read from an iPad versus paper. The researchers found there was evidence to conclude that older readers were affected by contrast changes of the computer background display when reading. Kretzschmar et al. (2013) found older adults had fewer fixations when reading on an iPad versus paper, based on the number measurement of eye fixations using a device designed for that purpose. The researchers concluded that lower luminance contrast decreased the number of mistakes made by readers (Kretzschmar et al.). This may not be the case for elementary school children due to the age of their eyes, and further study would be necessary to make a determination.

Hypothesis # 2. Teacher tallies of student behaviors during the administration of computer-based tests will verify a measurable difference in student engagement with the computer screen display set to black lettering on a white screen versus white lettering on a black screen.

Data in this study did not support Hypothesis # 2. Based on the results of this study, the researcher believes that elementary school children did not experience a favorable increase in student engagement when changing the computer background display to black with white lettering, even if the white-on-black display was preferred. The researcher believes that further research related to student engagement should be analyzed.

Limitations

The results of the student engagement data had several limitations. First, the researcher observed lack of teacher buy-in. Even though the teachers consented to participate in the study, teachers were not always consistent and prepared to test. The teachers did not have the tally sheets ready to go. They often had to ask the researcher for a fresh sheet even though they had been given materials, or the teacher had to send a child back to the room to get the tally sheet. This indicated that teachers had many tasks and often appeared distracted and unprepared. One teacher did not fill out the tally sheet correctly, even though the teacher had been instructed several times. Another teacher lost the tally sheets and gave the researcher the tally sheets several weeks after testing. The teacher asked for a new tally sheet prior to turning it in. The researcher was suspicious of the results turned in, even though the tally marks were consistent with other benchmark observational sheets.

Another challenge with the data collection process was a number of interruptions during the testing of students. A few times, office personnel called the computer lab looking for students to go home early. In one incident, there was a power outage and students had to restart testing. During another administration of the test, there was a tornado drill. These interruptions, associated with the elementary school computer laboratory setting were factors that could have limited the engagement of students, as well as affected the reading comprehension results.

Implications

For the study site school, these results showed that even though children may prefer the black background display screen, children should be discouraged from changing the screen away from the traditional white background with black lettering to the black background with white lettering. The researcher recommends that teachers at the site and other teachers within the district should discourage students from changing the background screen during testing. On state tests, especially the computerized Smarter Balance assessment, teachers should discourage students from changing the background computer screen display. Based on the results of this study for elementary school children, changing the background color of the computer screen from white to black computer background display may not significantly help regular education elementary school children in grades two through six when taking a reading comprehension test on a computer.

Studies by Geske and Bellur (2008) and Kretzschmar et al. (2013) compared the luminance contrasts of the computer screen versus paper mediums. These previous studies compared the luminance of the screen (computer light shining in the reader's eyes) versus absence of luminance (no light from a computer shining in the reader's eyes). In the present study, the students were compared on computer display screens with differences in luminance indirectly: more luminance with white screens and less luminance with black screens. Both previous studies were also with adult readers. The study here presented was a study of elementary school children only, and age may have been a contributing factor to the difference in the results when compared with the studies aforementioned.

Kragness (2007) compared the reading comprehension differences of background computer screen display of white background versus yellow background. The participants in Kragness' study were young adults. The results of Kragness' study are congruent to the results of this study, which resulted in no significant difference in reading comprehension. Like Kragness, the researcher recommends future studies to explore different colors of the spectrum for computer screen background display. This researcher recommends the participants should be a comparison of elementary school children readers versus adult readers.

Recommendations for Further Study

For future study, the researcher would recommend a comparison of more schools across districts or schools with differences in socioeconomic status and less homogeneity of racial ethnicity. It is important to note that the children in this study were grouped by grade level alone. Upon reflection, the researcher would recommend a comparison of children with learning disabilities as compared to children with no learning disabilities. In addition, a comparison could be made between children with corrective lenses and children without corrective lenses, or between children diagnosed with attention deficit-hyperactivity disorder (ADHD) and children without this diagnosis. Other future studies might investigate potential gender differences. Future studies could explore reading comprehension and student engagement differences of black computer screen displays versus white computer screen displays for these population subgroups of students in this study or in future studies.

Another recommendation for similar studies in the future is that another individual, other than the classroom teacher, should tally the results for all groups of children throughout the testing window. The reliability and validity of results in the present study may have varied due to the different ways in which the various observers tallied student engagement behaviors. There was no incentive in place to motivate the adults to conduct the observational student engagement data accurately. The researcher was somewhat skeptical of the results due to the fact that there were dips in the reading comprehension scores of individual students. The tally sheets were not studied to see if there was a difference in the individual student engagement scores that correlated with these dips. This could be further explored using the data collected. In addition, there were not enough observations within the testing window. For a future study, the researcher would tighten up the procedures of the student engagement tally sheets by requiring more observations of students per session. Another way to implement this would be to videotape and record each child as the test was presented. More observational data could be collected if this were part of the procedures in future studies.

As a researcher, the procedures for the computer lab and the expectation for goal setting should be addressed in future studies and in daily practice as well. The spike in fifth grade scores may be attributable to the observational difference for that particular grade. The researcher noted that in fifth grade, the teachers had discussed goal setting and provided incentives for students to do their very best on the Renaissance Learning STAR Enterprise assessment as part of their yearly curriculum requirement. Students in grade 5 would receive more Accelerated Reader reading opportunities and more interesting books if their scores improved each time on the STAR Enterprise Reading test. The researcher believes this incentive motivated students to pay attention and perform their best. The researcher believes that all teachers should implement this incentive in the classroom to help students improve their reading comprehension and positively impact their student reading engagement. Internal motivation is another possible avenue to explore, and adding a qualitative measure in addition to the quantitative measures could possibly give some insight into student motivation and increases or decreases in reading comprehension scores and student reading engagement on a computerized benchmark assessment.

Discussion

This researcher, a reading specialist, believed that there would be a difference in reading comprehension and student engagement when changing the computer background display from the traditional background of white with black lettering to black with white lettering. The researcher believed that the findings of aforementioned studies by Chen and Wang (2003), Geske and Bellur (2008), Kragness (2007), and Kretzchmar et al. (2013) demonstrated that contrast differences affected student reading performance. Although each of these studies measured the contrast differences on a computer screen versus a paper medium, these studies also measured luminance differences ranging from low luminance (black screen) to luminance measurements within contrasting color variations. All of the studies measured reading performance, and the researcher believed these studies showed promise of a difference between the largest contrasting difference, black versus white screen.

The researcher was motivated to pursue this study in part by her interest in Irelen’s (1991) Scoptic Sensitivity Syndrome. The researcher, a reading specialist, had observed that children with reading difficulties often have difficulty reading in bright light. The researcher also had personally witnessed more successful reading performance when adding different colored lenses to the printed page for struggling readers. The researcher had hoped that this study would possibly help students who experience reading difficulty and recommendations could be made to change the computer background screen display from white to black to help children to read and comprehend text on a computer screen more successfully. The upcoming computerized state MAP test was also a concern for the researcher, who was looking for ways to help student performance on state tests as well.

As a result of this study, the researcher is recommending that children not change the background color of the computer screen from black to white when testing, even if it is preferred. The researcher believes that future studies on children with reading disabilities and attention deficit disorder may narrow the target population for future benefit of reading performance. The new research questions could possibly be as follows: a) How is a reading disabled student's reading engagement and comprehension during computer-based testing affected by the contrast of the display screen background and letters on the display? And b) How is attention deficit disorder student reading engagement and comprehension of students during computer-based testing affected by the contrast of the display screen background and letters on the display?

As a researcher, it is important to constantly reflect and analyze the different variables associated with testing students using technology, especially young children in an elementary school setting. It is imperative to get the most accurate information, as quantitative data is used to analyze the effectiveness of teaching, learning, and planning the school curriculum. In an era of high-stakes testing, teachers, administrators and school district administrations are making financial decisions, curriculum decisions, and many other crucial decisions based on the computerized results of reading, writing, and mathematics assessments. Technology is playing a vital role in transforming the educational system in the United States and the world as a whole. Educational leaders should understand the role of technology, the variables associated with testing instruments, and the uses of technology to enhance student performance in order to make informed decisions about teaching and learning in individual schools and school districts, as well as more broadly in the high-stakes testing environment of the 21st century.

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Appendix A

Computer	Posture upright	Repeating words on screen	Hand positioned on mouse	Eyes fixed on screen only	Finger pointing on screen
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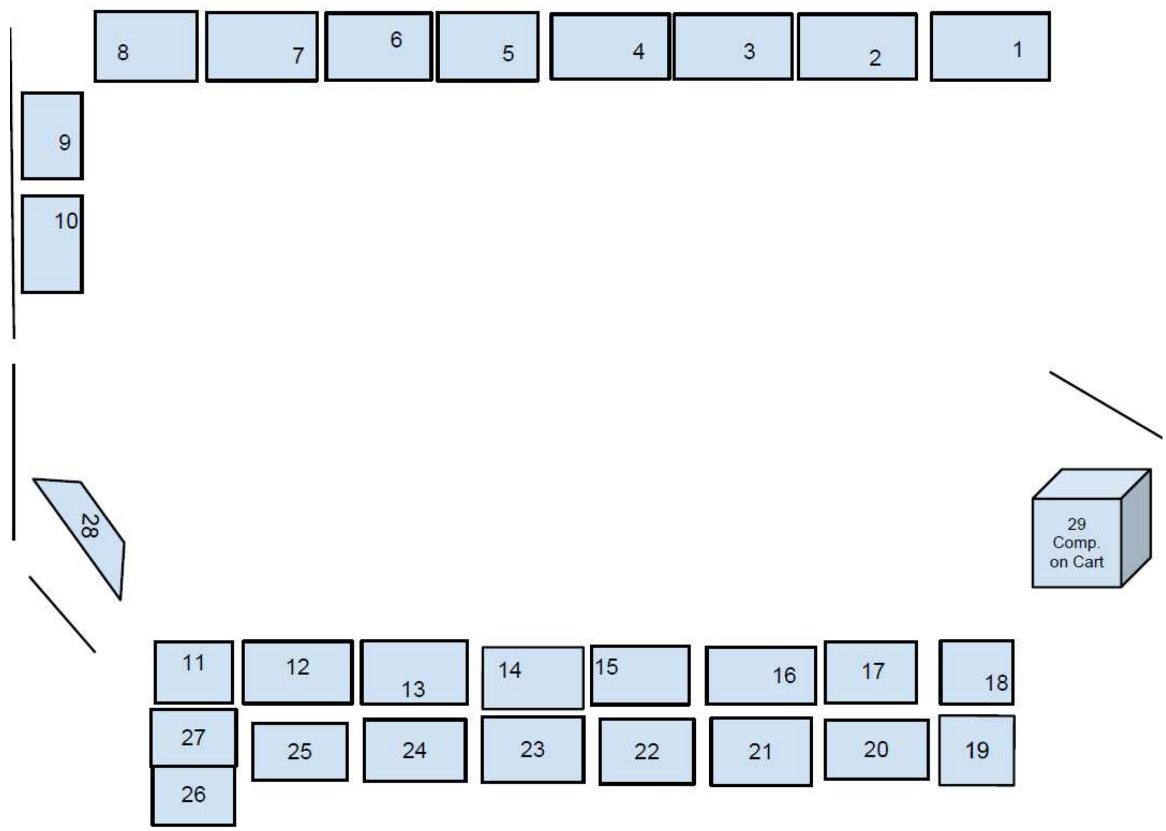
Appendix B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Vitae

Jennifer Ann Botello is a 1991 alumnus of Southern Illinois University-Edwardsville with a Bachelor of Science in Elementary Education. She also earned a Master of Science in Reading Education from Southern Illinois University-Edwardsville, a Master of Science in School Administration from Lindenwood University, and began doctoral studies in 2011 at Lindenwood University. Upon graduation, she will earn a Doctorate in Education with a major in Educational Leadership.

Currently, Jennifer is employed as an Elementary Instructional Coach in Florissant, Missouri. Previously, she served as an elementary classroom teacher, a Title 1 reading specialist, and a Reading Recovery teacher. Her professional affiliations include membership in the Association for Supervision and Curriculum Development (ASCD), the Missouri Association of Elementary and Secondary Principals (MAESP), the International Reading Association, and Reading Recovery Council of North America.

As a life-long learner, it is Jennifer's desire to support students, parents, and teachers by educating them with best practices and providing them with sound instructional strategies. One day, she would love to train new teachers at the college or university level in the areas of literacy and leadership. Jennifer believes as we educate our teachers and students, we are touching the lives of future generations. Investing in the development of future leaders is her greatest passion and helping others learn and grow brings her great joy.