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The Impact of Adaptive Computer Assisted Instruction on Reading Comprehension: Identifying the Main Idea

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The Impact of Adaptive Computer Assisted Instruction on Reading Comprehension: Identifying the Main Idea

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Dedicated

In Loving Memory

To My Mother

Carole Anne Toonder

1945 - 2009

May She Forever

Rest In Peace

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Abstract

This study examined the impact of an adaptive computer assisted instructional program, Digital Comprehension, on struggling upper-elementary school readers' reading comprehension skills. Digital Comprehension is a researcher-developed instructional program that focuses on explicitly teaching students to identify the main idea of texts, a critical comprehension strategy. Research has shown that adaptive computer assisted instruction can have a significant impact on students' decoding, vocabulary, and fluency skills. However, there has been insufficient research into whether such technologies can be used to improve students' specific comprehension skills, such as the ability to identify the main idea. This study employed a small-scale randomized trial to determine whether the 24 students who used the Digital Comprehension program demonstrated significantly greater improvement in comprehension skills, as measured by a researcher-developed main idea assessment and a standardized general comprehension measure, than the 23 students who did not use the program. Additionally, students in the treatment condition completed a survey to gage their perceptions of the intervention. Results showed that students who received the adaptive CAI intervention demonstrated statistically significant growth in their ability to identify the main idea skills (proximal measure) than students who did not use the program, but failed to demonstrate significantly greater growth in their general reading comprehension levels (distal measure). The results of a participant perceptions survey yielded positive results with most of the students reporting positive effects on their reading and academics, as well as their general attitudes toward the program. Overall, the results of the study indicate that adaptive computer assisted instruction may be an effective means for remediating struggling readers' comprehension skills.

CHAPTER 1: INTRODUCTION

Strong literacy skills are crucial to academic success (Klien & Knitzer, 2007; Watson, Gable, Gear, & Hughes 2012). In fact, the ability to read is a strong predictor of scholastic achievement regardless of gender, race, or socioeconomic status (Aspen Institute Education & Society Program, 2012; Wijekumar, Meyer, & Lei, 2017). Reading skills affect student performance across the curriculum and throughout every level of schooling, with an impact that grows greater as children progress from grade to grade (Chall, Jacobs, & Baldwin, 2009).

Of course, the impact of reading achievement can be felt well outside the confines of the classroom. Proficient reading skills are indicative of future economic independence, constructive civil engagement, and lifelong learning (Wijekumar et al., 2017). While the inability to read well is, conversely, associated with a wide range of social problems, including delinquency, high dropout rates, and chronic underemployment (Moats & Tolman, 2009). Students who fail to acquire proficient reading skills find themselves at a severe disadvantage (Biancarosa & Snow, 2004). They are far less likely to succeed in college courses (American College Testing Program, 2005). They often struggle to participate effectively in civil matters, and they are more likely to face challenges when competing in the workforce (Biancarosa & Snow, 2004; Wijekumar et al., 2017).

Despite the educational community's awareness of reading's importance and the large amount of instructional time that educators dedicate to literacy as a result (Heafner & Fitchett, 2015), our students are struggling to achieve. Only 35% of U.S. fourth grade students are reading at or above grade-level (National Assessment of Education Progress [NAEP], 2019), and these statistics have been fairly stable over time. The number of students who struggle with literacy has not changed noticeably in the last decade and has actually fallen in recent years. Despite

modest 1% gains in 2015 and 2017, fourth-grade proficiency levels have receded to 2013 levels. Eighth-grade proficiency levels have fluctuated between 34% and 36% since 2011, and fell 3% since 2017 (NAEP, 2019). The situation is particularly dire for students from economically disadvantaged homes, where only 21% of fourth-grade students eligible for free or reduced lunch are reading on grade-level (NAEP, 2019).

Children in poverty face a host of environmental inequities (Evans, 2004). They experience more trauma and fewer social supports than their middle- and upper-class peers (Evans, 2004). They live in neighborhoods that are more dangerous, offer poorer municipal services, and suffer greater physical deterioration (Evans, 2004; Garo, Allen-Handy, & Lewis, 2018). Their schools and day-cares are often overcrowded and are, on average, inferior to the institutions of their more well-off peers (Evans, 2004; Gagnon & Mattingly, 2015). Given that parents are experiencing significant environmental stressors, it is not surprising that they may not be able to invest the same amount of resources into their children's education as parents who do not experience these same challenges. For instance, children in poverty are read to less often, watch TV more, and spend less time visiting libraries and other learning centers than children who live in economically stable homes (Coley, 2002; Evans, 2004; Korat & Haglili, 2007). They also have limited exposure to computers, stimulating toys, books, and language-rich parental interactions (Bradley, Corwyn, McAdoo, & Garcia Coll, 2001; Evans, 2004; Orr, 2003; Pribesh, Gavigan, & Dickinson, 2011; Weilgel, 2006).

These factors have a cumulative effect on children of poverty, and the effects of the inequities they face can be traced through their academic lives. By age three, these children have vocabularies half the size of their middle- and upper-class peers (Hart & Risley, 2003). By five years old, the cognitive scores of children from the poorest homes are 60% lower than the most

affluent children (Lee & Burkam, 2002), and by third grade, children from low-income homes with less educated parents have vocabularies that are 4,000 words behind children from high-income homes with more educated parents (Snow, 2005). By the time they enter high school, students from economically disadvantaged homes have literacy skills that are an average of five years behind their middle-class and upper-class peers (Reardon, Valentino, Kalogrides, Shores, & Greenberg, 2013).

The low achievement scores of our students in general, and of our underprivileged populations in particular, have led educators and national organizations to identify our population's low reading achievement as a national crisis (Chall et al., 2009; Sweet, 2004). These concerns are heightened by the recognition that the demands for proficient literacy skills are accelerating at a rapid rate and by the knowledge that people with low levels of literacy will be at an increasing disadvantage in the years to come (Moats & Tolman, 2009; Torgesen, 2002). As Biancarosa and Snow (2004) noted, between the mid-1990s and mid-2000s alone, the average literacy level required for all jobs increased by 14%, and far fewer employment opportunities now exist for those with weak reading skills. This trend has and is predicted to continue, so that students who leave school with poor literacy skills in the 21st century will be at an incredible disadvantage (Biancarosa & Snow, 2004; Moats & Tolman, 2009), and as many as 20% will be considered functionally illiterate (Hasselbring & Goin, 2004; National Joint Committee on Learning Disabilities, 2008).

Fueled by such alarming statistics, there is a growing sense of urgency to improve our country's literacy outcomes (Torgesen, 2002). Research tells us that the devastating effects of reading failure can be prevented (Foorman, 2003; Moats & Tolman, 2009). Yet, the rising literacy demands of our modern society can only be met by adapting our reading instruction so

that we produce better literacy outcomes for a higher percentage of our population (Torgesen, 2002). We must work to develop and implement instructional programs and interventions that are capable of providing more intensive, explicit, and supportive literacy instruction to the students who require it (Torgesen, 2002; Vaughn, Solis, Miciak, Taylor, & Fletcher, 2016).

Upper-elementary grades are a particularly important time to focus on reading instruction because students who have fallen behind by this time often have great difficulty catching up with their more proficient peers. These years, generally identified as third through fifth grades, are also viewed as a particularly vital time in a student's schooling because they mark a transition when the texts encountered in schools become an increasingly significant source of knowledge (Ilter, 2017). They are often the last years in which formal, in-depth reading instruction occurs and are the first years in which the understanding of complicated texts is apparent (Vaughn et al., 2016).

The upper-elementary years, therefore, may be a particularly good target for the implementation of research-based reading intervention (Vaughn et al., 2016). Yet, our interventions often fail to demonstrate sufficient effects on these struggling students (Wanzek & Vaughn, 2009; Vaughn et al., 2016). In fact, more than two thirds of students that are identified as reading-disabled in third grade will, despite attempts at remediation, continue to exhibit reading problems through the end of their high school experience (Shaywitz, 2003). Without the literacy skills to keep up with an increasingly complex curriculum, these students will continue to struggle and will, as a result, be much more likely to drop out (Hernandez, 2012; Kamil, 2003; Snow & Biancarosa, 2003).

In order to achieve and maintain reading proficiency, students need strong foundational literacy skills. They need proficient phonological and phonemic awareness, effective decoding

and word identification skills, a robust vocabulary, fluent reading rates and expression, and the skills necessary to accurately comprehend what they read. It is also important to acknowledge that the reading demands placed upon our students and the resulting deficiencies they demonstrate shift with age (Ilter, 2017). As students progress through school, the numbers of struggling readers that need help deciphering the words on a page decline, while the numbers of readers who demonstrate the inability to comprehend what they read increase dramatically (Biancarosa & Snow, 2004).

Therefore, in order to handle the more difficult kinds of reading they must perform as they advance through school, our struggling readers need ongoing support that moves beyond that of basic literacy skills, such as decoding, and progressively shifts toward a focus on adept and robust comprehension (Gallagher, 2009). To comprehend texts at a high level, students need to be taught to combine the more natural ability to understand oral language with accurate, fluent reading, and one of the best ways to ensure that this interaction takes place at a high level is through the use of effective and active reading comprehension strategies (National Research Council, 1998; Torgesen, 2002). Instructing students in reading comprehension strategies, the specific cognitive techniques that readers use to extract meaning from texts, is a highly effective way to improve the amount of information they can glean from texts (Ness, 2016). In fact, Sulak and Günes (2017) stated that improving our students' reading comprehension is only possible with the use of various comprehension strategies, and that when teachers demonstrate these strategies, it enables their students to learn and apply them at a high level. This claim is supported by the research, in which numerous studies conducted over the last decades have demonstrated that students who experience reading comprehension difficulties benefit from

specific and explicit reading comprehension instruction (see Bulut, 2017; Edmonds, Vaughn, Wexler, Reutebuch, Cable, Tackett, & Schnakenberg, 2009; Hall, 2004).

These comprehension strategies can be conceptualized as distinct, yet interrelated metacognitive processes that enable students to actively gain knowledge from print (Hagaman & Reid, 2008; Ilter, 2017). These strategies cover a wide range of sub-skills, such as comparing and contrasting details or ideas, analyzing elements of setting, character, and plot, and understanding the relationships between problems and solutions. Some, like the ability to conceptualize the sequence of events within a narrative or set of directions, can be viewed as more or less important depending on the type of text with which one is engaged, while others, like the ability to make inferences, are seen as critical for the understanding of almost any written work (Potocki, Ecalle, & Magnan, 2015).

Among the list of more crucial comprehension sub-skills, the ability to identify the main idea is considered particularly vital (Potocki et al., 2015; Watson, Gable, Gear & Hughes 2012; Van Den Broek, Lynch, Naslund, Ievers-Landis, & Verduin, 2003). Identifying the main idea is an essential foundational skill that serves as a prerequisite for many other higher-level strategies (Watson et al., 2012). Readers with strong main idea skills are able to better summarize passages, integrate information across texts, understand story structure, and more accurately recall ideas presented to them in print (Lord, 2015; Van Den Broek et al., 2003), while students who struggle with this strategy are often unable to chunk concepts and are thereby unable to form a coherent understanding of the ideas presented to them (Gallagher, 2009; Rapp et al., 2007).

To improve student performance on such a critical comprehension skill, our struggling readers need carefully organized, explicit, and active instruction on the use of the strategy

(Biancarosa & Snow, 2004; Gallagher, 2009; Watson et al., 2012). It should be more intensive than our general reading curriculum, and its content and activities should be tailored to the strengths and weaknesses of each learner (Roy, Guay, & Vaolis, 2013; Torgesen, 2002). Many schools attempt to provide more intensive instruction to the students who require it by engaging in the Multi-Tiered System of Support (MTSS) process. Through MTSS, students are divided into three tiers based on their ability level. "Tier 1" students are those who are functioning at or above grade-level and generally receive regular classroom instruction. "Tier 2" students are those functioning below grade-level and receive added instruction and support. "Tier 3" students are those functioning far below grade-level and receive daily, intensive support. Though the MTSS process provides educators with a framework for attempting to provide individualized instruction to those in need, it often proves problematic to target every student's skills at the exact ability level where it would be most beneficial.

Computer assisted instruction (CAI), remediation or instruction delivered and monitored by a computer program, presents educators with a potentially powerful way to reach those struggling Tier 2 and Tier 3 readers. CAI has been shown to successfully adapt and tailor its content to the learner (Hasselbring, 2015; Taylor, Hasselbring, & Williams, 2001). Such adaptive CAI has been shown to be an effective intervention for achieving reading gains in struggling elementary students' fluency levels, as well as emergent literacy skills such as phonemic awareness, phonics, and vocabulary development (Council, Cartledge, Green, Barber, & Gardner, 2016; Shamir, Feehan, & Yoder, 2017). Some studies have also shown that adaptive CAI can improve readers' listening and reading comprehension (Schechter, Macaruso, Kazakoff, & Brooke, 2015; Shamir, Feehan, & Yoder, 2017; Shamir, Yoder, Pocklington, & Feehan, 2018); however, these studies have been limited to primary school students and addressed only

general levels of comprehension. Thus, little is known about the effects of adaptive CAI on specific reading comprehension skills, such as the ability to identify the main idea. Since the ability to identify the main idea is such a critical skill for successful reading comprehension, examining whether students' ability to identify the main idea can be improved with the use of adaptive CAI is crucial for determining the usefulness of such instructional technology.

Statement of Purpose

The purpose of the study was to build upon the literature about the use of adaptive CAI in reading interventions by exploring the effectiveness of an adaptive CAI program to improve the reading comprehension skills of struggling upper-elementary readers. The study had three aims. The primary aim of the study was to determine if struggling readers' use of the adaptive CAI program, Digital Comprehension, would lead to significant improvements in students' ability to identify the main idea. The study's secondary aim was to determine if struggling readers' use of the Digital Comprehension program would lead to significant improvements in students' general reading comprehension levels. The study's third aim was to gather information about the students' perceptions of the Digital Comprehension program.

Research Questions

This study employed a quasi-experimental design whereby struggling (i.e., Tier 2 and 3) readers were assigned to a treatment or control condition. The study's control group engaged in only business-as-usual regular classroom instruction and reading support. The regular classroom instruction consisted of phonics, fluency, grammar, vocabulary, and comprehension instruction within a well-established anthology series, and included whole group, small group, online, and independent components. Further reading support was provided through the school's MTSS process to those students who demonstrated the need for added help and consisted of small-

group, teacher-led instruction in various phonics and fluency skills. The materials and activities for this supplemental instruction were also provided by the school's adopted anthology series. The study's treatment group used the Digital Comprehension program, which provided participants with systematic main idea instruction, practice, and assessment, in addition to regular classroom and supplemental instruction.

The study investigated the potential impact of the Digital Comprehension program by addressing the following research questions:

1. Did struggling upper-elementary readers' use of the computer assisted instructional program, Digital Comprehension, lead to significantly greater gains in their ability to identify the main idea than students who did not use the program?
2. Did struggling upper-elementary readers' use of the computer assisted instructional program, Digital Comprehension, lead to significantly greater gains in their general reading comprehension levels than students who did not use the program?
3. To what degree did the participants perceive the intervention to be beneficial and engaging?

It was hypothesized that the participants who engaged in the Digital Comprehension program would show significantly greater growth in their ability to identify the main idea than the participants who did not use the program. It was also hypothesized that the participants who engaged in the Digital Comprehension program would show significantly greater growth in their general reading comprehension than the participants who did not use the program. Ascertaining the students' perceptions of the intervention was exploratory in nature; however, based on the results of a previous study involving an earlier rendition of the intervention, it was hypothesized that the participants would likely report positive perceptions.

Significance of the Study

Our nation's low and static reading achievement has been identified as a national crisis, and the need to find effective intervention methods for our struggling readers is a major educational priority (Chall et al., 2009; Sweet, 2004; Torgesen, 2002). The development of strong reading comprehension is critical to literacy development (Vaughn & Fletcher, 2012), and the use of adaptive CAI may be a powerful mechanism to improve reading comprehension in our struggling students. Yet, the effectiveness of adaptive computer assisted instruction to improve specific reading comprehension skills is unclear. This study helped fill this gap in the existing research literature by providing empirical evidence for the use of adaptive computer assisted instructional programs in supplemental reading comprehension instruction. Specifically, the study examined the potential impact of an adaptive computer assisted instructional program on struggling readers' comprehension sub-skills, specifically the ability to identify the main idea in expository texts. The study also sought to determine whether the use of the adaptive computer assisted instruction program would lead to significant gains in students' general reading comprehension.

Since the study demonstrated that the Digital Comprehension program, which was developed for and administered in this study, positively impacted students' comprehension skills, it provided a rationale for the further development, expansion, and eventual dissemination of the program to the larger educational community. Such a dissemination could provide teachers with an easily accessible intervention to help meet the needs of the struggling readers they serve.

By examining the potential of an adaptive computer assisted instructional program students' ability to identify the main idea, the positive results of this study could also impact the development, assessment, and dissemination of other adaptive CAI programs. These programs

could be designed to address a wide range of comprehension skills, thereby providing educators with a practical way to provide struggling learners with the wide range of interventions required to meet their individual needs (Biancarosa & Snow, 2004).

CHAPTER 2: LITERATURE REVIEW

In this chapter, a review of the literature is presented. This includes an overview of reading and reading comprehension, a discussion on the importance of main idea skills, and an overview on how research suggests main idea instruction should be approached. This chapter also includes a description of differentiated instruction as it relates to reading and how computer assisted instruction, specifically adaptive computer assisted instruction, could be a promising way to teach comprehension strategies. This is followed by the summary of an exploratory study which was previously conducted using the Digital Comprehension program. The chapter concludes with a final thought on how that study's results, when combined with the current body of literature, lead to the conclusion that the proposed study was worthy of pursuit.

Reading and Reading Comprehension

The act of reading is a complex mental activity requiring multiple networks of the brain to work in concert to process speech-sounds, recognize symbols, associate symbols with sounds, perceive context, apply background knowledge, and construct meaning (Kusdemir & Bulut, 2018; Moats & Tolman, 2009; Watson et al., 2012). In order to make this complicated process more comprehensible, educators often adopt a more simplified view of literacy where it is broken into distinct, yet interrelated, skills. The Simple View of Reading model (Gough & Tunmer, 1986; Hoover & Gough, 1990), for instance, takes a somewhat reductionary view and describes the process of reading as the product of word recognition and listening comprehension, often discussing the underlying processes as some iteration of phonological and phonemic awareness, vocabulary knowledge, phonics, fluency, and comprehension. Other models, like Scarborough's Rope Model of Reading Development (Scarborough, 2001), break the reading

process down further and also include aspects of fact and concept recall, knowledge of language structures, concepts of print, and verbal reasoning skills.

Regardless of which model one adopts, reading comprehension is the ultimate goal of any reading endeavor (Torgesen, 2002). Reading comprehension is defined as the process by which the reader extracts and creates meaning while interacting with written language (Shanahan et al., 2010; Watson et al., 2012). It plays a key role in cognitive development (Bulut, 2017) and is so central to the reading process that it has been referred to as the essence of reading (Durkin, 1993).

The skills involved in comprehension need to take place in conjunction with purposeful, strategic reading (Ilter, 2017). For some students, this ability may not develop naturally alongside other literacy skills (Watson et al., 2012). Research has shown that deficits in comprehension can sometimes be linked to underlying weaknesses in receptive vocabulary, semantic processing, decoding, word recognition, grammatical understanding, and fluency (Catts, Adlof, & Weismer, 2006). These skills allow readers to translate print into language and are necessary components of successful reading comprehension, but it is important to understand that they are not, by themselves, sufficient for high levels of comprehension (Spencer, Wagner, & Petscher, 2019; Savage & Wolforth, 2007). Many children struggle to comprehend texts at a high level despite demonstrating normal or near-normal levels of proficiency in component literacy skills (Catts et al., 2006; Watson et al., 2012), and as such are said to possess specific reading comprehension deficiencies (Watson et al., 2012).

Reading comprehension can be conceptualized as a set of interdependent skills and strategies, including the ability to make inferences, summarize, compare and contrast details, analyze characters, settings, and plot, recognize the sequence of events, determine cause and

effect relationships, understand problems and solutions, and identify the main idea (Beers, 2003; Potocki et al., 2015). These higher-order reading skills, which allow readers to intentionally monitor and adjust their thinking processes as they encounter texts, are essential to successful comprehension (Klingner, Vaughn, & Boardman, 2007; Rapp et al., 2007) and differences in students' ability to understand the things they read may very well hinge on their knowledge and use of such strategies (Muijselaar & de Jong, 2015; Potocki et al., 2015; Sulak & Günes, 2017).

Students with high levels of comprehension use this set of complex skills and strategies to control their attempts to understand and remember the things they read (Afflerbach, Pearson, & Paris, 2008; Edmonds, Vaughn, Wexler, Reutebuch, Cable, Tackett, & Schnakenberg, 2009). They monitor their understanding regularly while reading, creating mental models and incorporating new information with previous knowledge (Edmonds et al., 2009; Klingner et al., 2007). Poorer comprehenders are, on the other hand, significantly less strategic (Muijselaar & de Jong, 2015; Sulak & Günes, 2017) and struggle to perform many crucial learning tasks at high levels as a direct result (Mason, 2004; Pape, 2004; Watson et al., 2012). Without the ability to use comprehension strategies effectively, they often fail to construct meaning and learn subject matter (Klingner et al., 2007). They have trouble processing both inferential and literal information (Cain, Oakhill, Barnes, & Bryant, 2001). They are often overwhelmed by the text density and complexity they encounter in content areas (Hall, 2004; Mastropieri, Scruggs, & Graetz, 2003). They struggle on high-stakes tests, demonstrate low self-efficacy, frequently exhibit behavior problems, and are less likely to have positive experiences with the texts they encounter at school (Hall, 2004).

In order to increase the reading comprehension for struggling students, it is necessary to intervene on the processes by which they form meaning by providing systematic and explicit

comprehension instruction (Bulut, 2017; Hagaman, Casey, & Reid, 2012; Muijselaar & de Jong, 2015; Rapp et al., 2007). Systematic training in comprehension strategies, where students are taught specifically how to access and effectively process the information found in texts, can lead to improved comprehension for struggling readers (Hall, 2004; Ilter, 2017; Klingner et al., 2007; Vaughn & Fletcher, 2012). Indeed, the relationship between reading strategies and reading comprehension has been examined through multiple intervention studies, and this research has shown that interventions focused on reading strategies can positively impact comprehension (Hagaman, Casey, & Reid, 2012; Hall 2004; Mastropieri et al., 2003; Muijselaar, Swart, Steenbeek-Planting, Droop, Verhoeven, & de Jong, 2017). For instance, in their work examining the way fourth-grade readers form and update their mental models while reading, Muijselaar and de Jong (2015) found that knowledge of reading strategies and their application was directly related to higher levels of reading comprehension. Manset-Williamson and Nelson (2005) had related findings. Their study concluded that struggling upper-elementary and middle school readers who received explicit strategy instruction made greater gains in reading comprehension than those who received more traditional guided reading instruction.

Such research demonstrates that the way comprehension strategies are approached by educators is crucial for eliciting significant growth from struggling readers. The instruction should incorporate research-based practices, including elements such as extensive teacher modeling and appropriate practice opportunities (Afflerbach et al., 2008; Klingner et al., 2007). Instruction must be systematic, explicit, and intense (Catts et al., 2006; Swanson & Deshler, 2003; Swanson et al., 2007; Watson et al., 2012; Williams et al., 2005), and because some strategies have a greater impact on overall comprehension than other comprehension skills,

instruction should focus first on the strategies that have the most powerful impact on comprehension (Klingner et al., 2007).

Among the set of comprehension sub-skills, such as making inferences or understanding cause and effects, the ability to identify the main idea is seen as particularly critical for successful reading comprehension (Ilter, 2017; Potocki et al., 2015; Watson et al., 2012). It serves as a prerequisite for many other comprehension processes, such as recalling details and summarizing, and is necessary in order to accurately understand story structure and integrate information across texts (Van Den Broek et al., 2003; Watson et al., 2012). Yet, the ability to find the main idea is a skill that the vast majority of poor readers struggle with and one that many teachers are not adequately equipped to teach (Lord, 2015).

Identifying the Main Idea

Though educators have long recognized how central the ability to identify the main idea is to successful reading comprehension, forming an accurate and instructionally applicable definition proved no simple matter (Pearson, 1981; Wang, 2009; Williams, 1986). Even in the research literature, there was no clear consensus as to the definition of the term (Pearson, 1981; Williams, 1986). As Wang (2009) noted, the phrase "main idea" has been used, even in relatively recent years, in a variety of contexts that morph the concept's meaning from one study to another. The term has been used synonymously with concepts as diverse as the theme of a narrative story, an expository text's central idea, and an explicitly written topic sentence (Wang, 2009). This unfocused operational definition led to predictable difficulties. It precipitated a research base that was often confusing to discern, making it difficult to accurately compare different studies' results, and making it challenging to use research findings to guide and improve instruction (Pearson, 1981; Wang, 2009).

Ultimately, the lack of clarity led to the broad implementation of ineffective instructional designs (Williams, 1986), which linger in the educational field to this day. Students are regularly taught that the process of identifying the main idea is limited to locating explicitly written statements or that using graphic organizers in a top-down, main-idea-first manner is an adequate way to decipher a passage's main message (Lord, 2015; Stoeger, Sontag, & Ziegler, 2014). Such approaches are based on the often-false presumption that the main idea of a text can be found written out within it, and incorrectly imply that identifying the main idea is a passive process where the reader simply receives and recognizes knowledge (Jacobowitz, 1990). Identifying the main idea is, however, rarely so simple, and these traditional forms of instruction, though often viable for proficient readers, regularly fail to help struggling students (Stoeger et al., 2014; Van Den Broek et al., 2003).

The impact of such non-optimal instructional strategies is amplified by the pivotal role the ability to identify the main idea plays in the comprehension process (O'Connor, Beach, Sanchez, Bocian, Roberts, & Chan, 2017; Van Den Broek et al., 2003). The ability to determine the main idea is one of the key factors that separates a proficient reader from a struggling one (Gallagher, 2009; Wang, 2009). Without proficient main ideas skills, it is harder for a reader to form accurate mental representations of the concepts they encounter (Klingner et al., 2007; Van Den Broek et al., 2003), it is more challenging for them to distinguish between important and unimportant information (Naidu, Briewin, & Embi, 2013), and it is more difficult for them to organize and synthesize those ideas (Klingner et al., 2007; Naidu et al., 2013). As a result, students who struggle to form accurate main ideas are left with the impossible task of trying to absorb all the information they encounter and are much more likely to become confused (Naidu et al., 2013). As noted above, the ability to identify the main idea also serves as a foundational

skill for other comprehension strategies (Ilter, 2017; Watson et al., 2012), and readers who struggle with it will often, by extension, struggle to draw appropriate inferences, understand story structure, summarize passages, and integrate information across texts (Boudah, 2014; Van Den Broek et al., 2003; Williams, 1986).

Though the awareness of the skill's importance has made it central to nearly every school's reading curriculum (Heafner & Fitchett, 2015), the vast majority of below grade-level readers continue to struggle to accurately identify the main idea in passages (Lord, 2015; Wang, 2009). In fact, many students fail to identify the main idea of simple texts and a significant portion struggle to provide even the general topic of single paragraphs (Baumann, 1983; Williams, 1986).

In the hopes of clarifying the functional definition of this crucial skill, and thereby improving instructional pedagogy and outcomes, researchers turned to the Kintsch and van Dijk (1978) model of text-processing. This model describes text as a set of propositions, or ideas, organized into a hierarchy that reflects their relative importance within a text. A key aspect of this model, that of macrostructure–the broader semantic and conceptual structures that smaller, more local, topics of written and spoken discourse are organized into (van Dijk, 1980), is particularly relevant to the concept of main idea (Kintsch & van Dijk, 1978). According to the Kintsch and van Dijk model, as a reader works their way through a text, converting sentences and paragraphs into propositions, they engage in a process by which the converted propositions are deleted, generalized, and integrated into a "macrostructure" of concepts that accurately and succinctly summarize the text (Kintsch & van Dijk, 1978; Williams, 1986).

Van Dijk (1980) later expanded upon this model and proposed that topics of spoken and written discourse consist of both a global (or general and overarching) topic and its specific topic

(the synthesized sum of its local, or component, parts). It is from this conceptual basis that educators are able to derive a clear, and instructionally applicable, definition of main idea. All collections of texts, the theory postulates, have a general topic which they address. The general topic is relative, dependent upon what piece of text one is examining, so that it could refer to the synthesized ideas of the words that form a sentence, the sentences that form a paragraph, the paragraphs that form a passage or chapter, or the chapters that form an entire book. This general topic is a crucial component of the main idea, but it is usually too broad to be considered complete. It is rarely sufficient to say that a paragraph, passage, or book is simply about a certain general topic (e.g., robots) so the reader must almost always delve deeper and identify what the text is saying about that topic (e.g., robots are helpful). The main idea, then, lies in the specific topic of a text, when the local propositions are synthesized in order to determine exactly what that piece of writing is conveying about its general topic.

The act of identifying the main idea can, therefore, be seen as a complex and active process whereby the reader constructs meaning by recognizing and inferring the connections between the individual pieces and the larger whole of a text (Jacobowitz, 1990; O'Connor et al., 2017; Van Den Broek et al., 2003). Thus, researchers suggest that an effective instructional approach may be to teach students to recognize the link between overarching general topics, individual propositions within the text, and the commonalities between those ideas (Boudah, 2014; Lord, 2015; O'Connor et al., 2017; Williams, 1986). Because the concept of main idea within narrative literature is often confused or supplanted with elements of theme and plot, it is recommended that this instruction should begin using expository texts that increase in complexity in time with reader's competence (Lord, 2015; Williams, 1986).

Williams, Taylor, Jarin, and Milligan, (1983) operationalized this procedure, developing a method for teaching the main idea which focuses on teaching students to move from the "general" to "specific" topics within expository texts. To evaluate the approach, Williams and her colleagues conducted a small-scale quasi-experimental study with eleven-year-old children with learning disabilities who were reading an average of two years below grade-level. Their results indicated that the students who were explicitly taught to synthesize details into main idea statements about the general topic made significantly more improvement than students in the control group. Their positive results have been supported by other researchers, indicating that this method of instruction supports readers' ability to use inferential thinking to identify the main idea whether or not the main idea is explicitly stated and whether or not the students have diagnosed reading disabilities (Boudah, 2014; Jitendra, Kay Hoppes, & Xin, 2000; O'Connor et al., 2017; Sulak & Günes, 2017; Van Den Broek et al., 2003; Williams, 1986). Jitendra, Kay Hoppes, and Xin (2000), for example, conducted a small-scale randomized control trial with 33 middle school students with diagnosed reading disabilities. They found that students in the treatment group who were taught this strategy were able to formulate the main idea better than students who received only regular classroom instruction, with a large effect size of 2.23. Sulak and Günes (2017) found similar results in a quasi-experimental study they conducted with 62 fourth grade students. They reported that the students in the study's experimental group, who were taught to make connections between the important ideas presented to them in texts, were better able to organize the text's supporting ideas and, as a result, could more easily and systematically identify the main idea than students in the control group.

Though this formula for systematic main idea instruction has been shown to be empirically effective, it has yet to be widely adopted by educators. Few teaching resources move

beyond traditional, and often ineffective, approaches to main idea instruction such as locating explicit topic statements or using graphic organizers in a top-down manner (Lord, 2015; Stoeger et al., 2014), and few teachers have a sufficient understanding of the processes that go into identifying the main idea to effectively supplement the resources they are given (Lord, 2015). Since the use of evidence-based approaches to reading instruction is so central to the successful implementation of interventions (Vaughn & Fletcher, 2012), it is important that this strategy be put into wider practice. Yet to be highly-effective, the strategy must be disseminated to students within an instructional model that is also research-based and in a manner that follows supported best-practices, such as the gradual release of responsibility model. Like any comprehension strategy, identifying the main idea needs to be modeled explicitly and then practiced extensively (Echevarria, Richards-Tutor, Chinn, & Ratleff, 2011). The instruction should also be tailored to each student's individual performance level, and it should be scaffolded so that supports allow students to move from their current proficiency to increasingly higher levels of achievement (Echevarria et al., 2011).

Differentiated Instruction

Traditional one-size-fits-all instruction, where every student receives the same content, is rarely the most effective instructional model (Dixon, Yssel, McConnell, & Hardin, 2014; Firmender, Reis, & Sweeny, 2013). Students come to school with ability levels and background knowledge that are simply too varied to assume that uniform lessons will adequately address all their needs (Dixon et al., 2014). Educators, therefore, must endeavor to adjust their curriculum and instruction so that they match the unique set of students they serve (Dixon et al., 2014). This instructional approach, where student differences are systematically taken into account and

targeted when designing learning opportunities, is commonly referred to as differentiated instruction (Tomlinson & Jarvis, 2009; Vaughn, Solis, Miciak, Taylor, & Fletcher, 2016).

The theoretical framework behind differentiated instruction stems, in large part, from the work of renowned developmental psychologist Lev Vygostky (Tobin & McInnes; 2008; Vygotsky, 1980). As he formulated his social cognitive theory, Vygotsky examined the interplay of previously gained knowledge on new learning (Vygotsky, 1980). He postulated that in order for learning to be optimized, learning should take place beyond what the learner can do independently, but not beyond what they can successfully do with guidance. He referred to this ideal learning range as the *zone of proximal development*. The zone of proximal development emphasizes the importance of having learning experiences balanced between students' independent and frustrational levels, as well as the significance of providing students the learning support they need to grow (Yancsurak, 2013). Jerome Bruner's theory of scaffolding on learning supported and built upon this concept, suggesting that scaffolds, or instructional supports, enable a learner to succeed beyond that which they would be able to accomplish on their own (Wood, Bruner, & Ross, 1976). Since the zone of proximal development is unique to each student, the scaffolds each student needs are also unique, and the importance of individualizing, or differentiating, instruction so that each learning experience is adapted to and optimized for each learner is apparent.

By differentiating instruction, teachers are able to effectively respond to variances in students' developing ability levels and are able to effectively match students with the correct content, activities, and assessments (Tomlinson & Jarvis, 2009). Differentiated instruction allows teachers to provide struggling students with the increasingly intensive instruction that they require (Torgesen, 2002; Vaughn et al., 2016). It also creates the framework where group size

and instructional time can likewise be tailored specifically to the content and needs of the student (Vaughn et al., 2016; Wanzek & Vaughn; 2009).

Research has shown that differentiated instruction can positively impact learning outcomes, and that it can do so regardless of a student's cultural, ethnic, or socio-economic background (Reis et al., 2011; Roy, Guay, & Vaolis, 2013; Valiandes, 2015). Differentiated instruction has been shown to be effective across the education spectrum, from kindergarten children learning the alphabet (Piasta, 2014) to college students learning complex concepts (Lightweis, 2013), and it is considered to be a particularly effective tool for increasing reading achievement (Reis et al., 2011; Roy et al., 2013; Valiandes, 2015).

Differentiated instruction has a positive effect on a wide range of literacy skills, including fluency development (Firmender, Reis, & Sweeny, 2013; Morris & Gaffney, 2011; Reis et al., 2011) and comprehension (Niño Santisteban, 2014). In their experimental study involving students from an urban elementary school with high rates of poverty, Reis, McCoach, Little, Muller, and Burcu Kaniskan (2011) found that those students who received differentiated reading instruction in specific reading comprehension and decoding strategies achieved significantly higher on comprehension and fluency measures than students who only received regular classroom instruction. Firmender, Reis, and Sweeny (2013) had findings which support these conclusions, noting a positive relationship between differentiation, reading comprehension levels, and oral fluency levels for students with a variety of ability levels, from gifted students to struggling readers.

While the benefits of differentiated instruction are empirically supported, the literature suggests that the majority of teachers struggle to differentiate effectively or sufficiently (Dixon et al., 2014; Goddard, Goddard, & Kim, 2015; Schumm & Vaughn, 1998). Though most teachers

are well aware of the large spectrum of needs in their classrooms, they are daunted by the complexity of trying to address those needs and by the breadth of tasks that addressing them would demand (Dixon et al., 2014; Tobin & McInnes; 2008). This, compounded with the difficulties inherent with large class sizes, lack of time, insufficient resources, and lack of administrative support, lead to low teacher efficacy in the differentiation process and contribute to the fact that teachers regularly fail to differentiate appropriately (Dixon et al., 2014; Suprayogi, Valcke, & Godwin, 2017; Tobin, 2008).

The result is a disparity between research-based best practices and teachers' everyday realities. There is a need, therefore, to find ways to address differences in academic achievement and cognitive skills through scaffolded, adaptable, and individualized instruction that is more practical to implement (Shamir, Yoder, Pocklington, & Feehan, 2018; Wang, Kinzie, McGuire, & Pan, 2010). Computer assisted instruction could offer educators an effective solution to this problem, for it possesses many characteristics that make it uniquely suited for the task of differentiated instruction.

Computer Assisted Instruction

Computer assisted instruction, remediation or instruction delivered and monitored by a computer program, presents educators with a potentially powerful instructional tool (Jethro, Grace, & Thomas, 2012). In fact, Bruning, Schraw, and Norby (2011) professed the hope that such technology could improve, and even revolutionize, the way that students learn and the way that teachers teach.

CAI programs offer instructional designers, teachers, and students a host of potentially powerful, and often unique, set of advantages. CAI can be designed to combine instructional best practices with our growing understanding of the intricacies of learning and memory

(Hasselbring, 2015). CAI allows instructional designers to develop learning experiences with enhanced control over the standardization of the content, learning sequences, instructional pace, and learner accountability (Jethro, Grace, & Thomas, 2012), and it allows them the unique flexibility to continuously update materials (Jethro et al., 2012). CAI programs give teachers the ability to systematically target instructional content that is less familiar to them (Schechter, Macaruso, Kazakoff, & Brooke, 2015), and it enables teachers to better leverage their time by helping them to collect, manage, and analyze student data more efficiently so they can better focus instruction (Roy et al., 2013; Schechter et al., 2015). CAI improves students' access to learning (Jethro et al., 2012). It provides them with the opportunity to learn independently and at their own pace, while giving them appropriate feedback (Mioduser, Tur-Kaspa, & Leitner, 2000; Potocki et al., 2015). It also gives them the chance to practice skills in a judgement-free environment (Hasselbring, 2015; Stetter & Hughes, 2010), and can enhance readers' motivation and engagement (Beechler & Williams, 2012; Flewitt, Messer, & Kucirkova, 2015; Shamir et al., 2018).

CAI programs can be subdivided based on the types of learning experiences they provide learners. Standard, or non-adaptive, CAI presents each learner with the same experience. Feedback may be provided based on things like correct and incorrect responses, but the content remains the same regardless of the learner's actions. Adaptive CAI programs, while they share the fundamental characteristics of any CAI program, differ in the fact that they actively adjust the user experience to the learner.

Standard, Non-Adaptive, Computer Assisted Instruction. Research suggests that standard CAI, referred to here as simply CAI, can produce deep learning outcomes in students of all ages, and it has been shown to be particularly impactful for students with learning disabilities

and students with limited English proficiency (Beechler & Williams, 2012; Bruning, Schraw, & Norby, 2011; Mioduser, Tur-Kaspa, & Leitner, 2000; Stetter & Hughes, 2010). Beechler and Williams (2012), for example, conducted a study to discern if CAI could positively impact the word recognition automaticity of 26 elementary school English language learners in kindergarten, first grade, and second grade. Participants engaged in an online tutorial program that rehearsed the Dolch Basic Sight Words through a series of flashcards and games. Though their results are tempered by the lack of a control group, their analysis of students' pre- and posttest readings of their grade's corresponding sight word list showed that students made significant progress, with average word accuracy scores rising from 66% to 95%. Mioduser, Tur-Kaspa, and Leitner (2000) found a similar positive correlation between the use of CAI and literacy growth in 46 kindergarten students in a special education program. The participants were given a pretest on phonological awareness, word recognition, and letter recognition skills and then divided into three groups: one that received a specialized teacher-led instructional support program, one that received CAI training and a specialized teacher-led instructional support program, and a control group that received only business-as-usual classroom instruction. They found that the students who received CAI training demonstrated significantly more growth in all three areas than either the other treatment group or the control group.

CAI has been found to aid the acquisition of a wide variety of reading skills. It can enhance students' critical early literacy skills, such as phonological awareness, letter naming, and letter-sound correspondence (Saine, Lerkkanen, Ahonen, Tolvanen, & Lyytine, 2010). It can improve fundamental literacy abilities such as sight-word recognition, fluency, and writing (Beechler & Williams, 2012; Fidaoui, Bahous, & Bacha, 2010; Saine et al., 2010), and, though research in this area is limited, has the potential to significantly impact comprehension skills

(MacArthur, Ferretti, Okolo, & Cavalier, 2001; Potocki et al., 2015). Potocki, Ecalle, and Magnan (2015), for example, conducted a study to determine the impact of a computer-based comprehension training program on the literal, text to text, and inferential comprehension skills of 39 second graders who were reading below grade-level. Using a within group pre- and posttest study design, they found that engagement in the CAI program, LoCoTex, led to significant gains in all three categories of comprehension.

While such results are encouraging, the research base surrounding CAI's use in comprehension instruction is not extensive enough, or indeed focused enough, to form definitive conclusions. Many of the studies do not include control groups, which can make interpreting their results difficult. Also, as MacArthur and colleagues (2001) noted in their review of CAI's impact on literacy skills, the bulk of studies which analyze CAI and comprehension do not focus on the instruction of comprehension skills. Rather they tend to examine the effect of component skills (i.e. word identification and vocabulary knowledge) or in-text supports (i.e., speech synthesis and other audio-visual features) on reading comprehension.

Further research into CAI's application toward reading comprehension is certainly needed, and one of its more promising uses may be in the field of differentiated instruction. CAI has the ability to provide learners with many of the features that research has shown to be key factors in highly successful differentiated instruction. It facilitates one-on-one instruction that can be individually paced and automatically tracked (Jethro et al., 2012; Shamir et al., 2018; Wanzek & Vaughn; 2009). It provides students the opportunity to work independently, while simultaneously providing them with explicit instruction (Tobin & McInnes, 2008). It allows a large number of students to engage in different learning activities and pathways simultaneously, helping teachers more easily meet the needs of diverse learners (Beechler & Williams, 2012;

Schechter, Macaruso, Kazakoff, & Brooke, 2015), and perhaps most importantly, it has the ability to adapt and tailor its content to those learners (Hasselbring, 2015; Taylor, Hasselbring & Williams, 2001).

Adaptive Computer Assisted Instruction. Adaptive computer assisted instruction, CAI programs that adjust their lessons, activities, or assessments to the user, provide educators with a potentially powerful tool for differentiating instruction (Caverly & Fitzgibbons, 2007). Adaptive CAI allows teachers to address areas of deficiency from a data-driven approach and in a manner that is manageable within the constraints of a typical classroom (Schechter et al., 2015). In fact, adaptive CAI can be designed to individualize student learning in ways educators often cannot, providing immediate corrective feedback and adjusting instruction according to each student's responses and constantly changing ability levels (Collins, Carnine, & Gersten, 1987; Howard-Jones, Ott, Van Leeuwen, & De Smedt, 2015; Perry & Klopfer, 2014).

By employing such individualization, researchers have demonstrated the effectiveness of adaptive CAI to significantly improve literacy outcomes in a wide variety of areas (Bruning et al., 2011; Hasselbring, 2015; Shamir et al., 2018; Taylor et al., 2001). There is emerging evidence that adaptive CAI is an effective mechanism to improve elementary students' proficiency in phonological and phonemic awareness (Segers & Verhoeven, 2005; Shamir et al., 2018), phonics (Shamir et al., 2018), vocabulary and language development (Shamir, Feehan, & Yoder, 2017; Wang, 2016), word recognition (Shamir et al., 2017), and fluency (Council et al., 2016; Shamir et al., 2017). The question remains, however, whether or not adaptive CAI can be applied to the higher cognitive demands of reading comprehension with equal effect.

Schechter, Macaruso, Kazakoff, and Brooke (2015) conducted a randomized control study using adaptive CAI as part of a blended learning model (i.e., teacher-led and software

components). Forty-seven first and second grade students were placed in a treatment group, where they received teacher-led instruction along with the adaptive CAI program, *Core5*, while 41 students were placed in a control group, where they received only teacher-led instruction. They found that although both groups achieved statistically significant growth in reading comprehension and vocabulary over the course of the study, the students who participated in the treatment group showed significantly more growth, particularly in the area of reading comprehension. These results are encouraging, but it is important to note that the study focused on students only in first and second grade, and it only reported comprehension gains in terms of overall growth rather than specific comprehension skills development.

Shamir, Feehan, and Yoder (2017), also found that adaptive CAI helped improve readers' comprehension. The study used an experimental design to examine the effectiveness of the Waterford Early Reading program to teach kindergarten and first grade students' various early reading concepts. They found that the treatment group's exposure to the adaptive CAI program led to significantly greater reading gains in a number of different literacy skills, including phonemic awareness, phonics, fluency, vocabulary, and, notably comprehension. While promising, the study's findings related to comprehension are somewhat difficult to interpret since they listed growth of reading comprehension only in terms of "sentence-level" and "paragraph-level" comprehension, and focused only on very young primary-grade readers.

In a subsequent study, Shamir and colleagues (2018) found similar promising results with a sample of over 1,600 kindergarten students. Specifically, they found that using the Waterford Early Reading Program led to significant progress in a number of different reading skills, including comprehension. Yet, like the previously listed work, which addressed comprehension only at the sentence and paragraph level, the study's scope was somewhat narrow in the way in

which it approached reading comprehension. It addressed comprehension only in terms of listening comprehension and, also like the previously discussed studies, focused only on young, primary readers.

Therefore, while research in adaptive CAI has been promising, it is still unclear if the positive findings on adaptive CAI could be applied to specific comprehension sub-skills instruction, where individual comprehension strategies such as making inferences or identifying the main idea are approached and measured separately. It is also unclear if the positive effects of adaptive CAI would translate and be able to have such a positive impact on the reading comprehension of older students. There is reason to hypothesize that the promise of adaptive CAI may promote reading comprehension in struggling upper-elementary readers by systematically targeting individual weaknesses in specific comprehension skills. Yet, to date little research has been done in this area (Schechter et al., 2015). The majority of research on CAI in elementary grades, especially those employing the type of adaptive content and feedback shown to be so effective, have tended to focus on simpler cognitive tasks such as word recognition, decoding, and the memorization of word meanings, and few researchers have investigated such programs' effects on reading comprehension (Council et al., 2016; Schechter et al., 2015; Segers & Verhoeven, 2005).

In an effort to begin to fill this gap in the literature, the author of this proposed study developed an adaptive CAI program, Digital Comprehension, that targeted main idea skills and conducted an exploratory study of the effectiveness of the intervention. The results of this study were promising, but, as discussed below, necessitated the need for improvement and further lines of inquiry.

Preliminary Research Involving the Digital Comprehension Program

The Digital Comprehension is an adaptive CAI program that the researcher developed in order to provide struggling readers with differentiated instruction in the ability to identify the main idea. Prior to conducting the current research project, an earlier rendition of the Digital Comprehension was the subject of an exploratory study. A more complete description of the intervention program is offered in Chapter 3 (see Description of the Intervention). A brief summation of the program is offered here, however, in order to help ensure that the reader can better interpret the results and implications discussed below.

The Digital Comprehension program was based on the findings and recommendations found in the literature and designed to serve as a supplement to regular classroom instruction. The program consists of 11 modules that guide students to actively formulate the main idea by recognizing the overarching general topic, identifying what the individual pieces of text are saying about that topic, and synthesizing those commonalities into a main idea statement. After each of the program's main lesson strands, the students were assessed on newly covered skills and those students who failed to show proficiency (delineated as < 80%) were directed to added instruction, practice, and assessment.

Results. In the fall of 2018, an exploratory study was conducted in order to evaluate the promise of using the adaptive CAI program, Digital Comprehension, to improve the comprehension skills of struggling upper-elementary readers. The study measured changes in the participants' general and main-idea-specific comprehension skills using a within group pre- and posttest design. Information about the participants' perceptions of the intervention were also collected.

The study was conducted in an urban public school in eastern Pennsylvania where more than 90% of the population received free and reduced lunch. A convenience sample of 20

participants was drawn from fourth-grade and fifth-grade struggling readers as delineated by a school-wide standardized reading comprehension assessment, the Reading Inventory. In order to qualify for the study students had to score below grade-level on the assessment (< 739 Lexile level for fourth graders, and < 829 Lexile level for fifth graders). The results of this initial Reading Inventory were also used as the study's pretest measure for general reading comprehension, while a researcher-designed assessment was utilized to gather baseline data on the participants' ability to identify the main idea.

The participants completed the Digital Comprehension program during an after-school tutoring program, which students attended twice a week for a period of four to eight weeks, depending on the learning pathway each participant followed. The Digital Comprehension software monitored and recorded student scores as the students completed the program. These scores showed that participants made noteworthy improvements as they worked their way through the programs various modules, with average scores on the software's internal assessments climbing 27% following both of the program's differentiated instruction modules.

After completing the Digital Comprehension program, the participants were administered the posttest researcher-designed main idea assessment, and a paired samples *t*-test was conducted to compare the participants' posttest scores with their pretest data. The results indicated that participants made statistically significant growth in their ability to identify the main idea between pretest (M = 47.3%, SD = 10.2%) and posttest (M = 85%, SD = 8.9%); $t(19) = -16.69$, $p < .001$, with average scores rising nearly 38% and a large effect size (Cohen's $d = 3.73$).

At the conclusion of the intervention, the participants were also administered the posttest Reading Inventory, and a paired samples *t*-test was conducted to determine whether the intervention led to significant participant gains in general comprehension. The results indicated

that the participants made statistically significant growth in their general comprehension levels between pretest (M = 502.90, SD = 151.72) and posttest (M = 523.05, SD = 147.92); $t(19) = -2.25$, $p < .05$, with average scores rising more than 20 Lexile points and a medium effect size (Cohen's $d = 0.50$).

The results of the student perceptions survey, which was given at the conclusion of the study, were encouraging as well. The majority of students thought the intervention program had a positive effect on their reading and academics. Ninety-five percent of the participants reported that the intervention improved their ability to identify the main idea, 80% reported that it made them better readers, 80% reported that they would be able to apply the things they learned when reading other materials, and 95% reported that taking part in the intervention would help them perform better in other subject areas. Student responses were also positive regarding their general attitudes toward the program. Ninety-five percent of the students reported that they enjoyed using a computer for the intervention, 75% reported that the program helped them to enjoy reading more, and 85% said that the program was fun.

Implications. The results of this exploratory study were positive, indicating that the adaptive computer assisted instructional program, Digital Comprehension, was a promising mechanism to help improve the comprehension skills of struggling upper-elementary readers. While the study showed promise, it was not without its limitations, and analysis revealed several areas where improvements to the research design and intervention could be made and applied to the currently proposed study.

The results of the analysis conducted at the conclusion of the study showed that the participants made statistically significant growth on both identifying the main idea and general reading comprehension. However, since the study had no control group, it was impossible to

determine whether that growth occurred due to the participants' exposure to the Digital Comprehension, the co-occurring business-as-usual classroom reading instruction that took place during the study, or some combination of the two forms of instruction.

Furthermore, a reliability analysis revealed low Cronbach's alpha levels for the researcher-designed main idea pretest ($\alpha = .377$) and posttest ($\alpha = .352$), and as such the resulting findings should be interpreted with caution. This low reliability could be due to a myriad of factors, including the low number of assessment items at each time period (5), the small sample size ($n = 20$), and the construct-irrelevant writing skills needed to perform well on the assessment. To address these concerns and more accurately determine whether the Digital Comprehension program does directly improve students' main idea skills, the main idea measure was slightly modified and piloted with a larger sample prior to its use in the present study, and the results indicated strong reliability (see Measures).

Assuming that the Digital Comprehension program did have a positive effect on students' reading comprehension growth, it was postulated that the careful design of the intervention was a key factor. Thus, while the prototype proved effective, it was theorized that any improvements to the program based on the participants' feedback and researcher observation should positively affect future student performance. Revisions were made to the intervention after the pilot study's conclusion and included improvements to the program's interface, adjusting the user experience in order to increase students' time-on-task, and fixing various glitches and typos within the software's animation.

Closing

Reading comprehension, the ultimate goal of reading, is made possible by a complex set of prerequisite skills and cognitive strategies. The ability to identify the main idea is among the

more critical strategic comprehension skills and tends to be a process which a great number of below grade-level readers struggle to master. Though a research-based pedagogy for helping students to achieve main idea proficiency has been well established and the benefits of differentiating such instruction to address the individual needs of struggling students are clear, neither have yet to be fully adopted by the majority of the educational community.

An adaptive computer assisted instructional program that employs research-based instructional practices may present a powerful way to differentiate main idea instruction. The current body of research literature suggests that adaptive CAI programs could be an effective tool for increasing the comprehension skills of struggling upper-elementary school readers. These programs have the capability of putting research-based instructional best-practices into a consistently applicable format. They have demonstrated the ability to provide students with differentiated instruction, and have the unique capacity to continuously adjust instruction and remediation to students' changing ability levels. Yet, research regarding the use of CAI with upper-elementary readers is incomplete and the potential of adaptive CAI to address weaknesses in specific comprehension sub-skills is, as of yet, unclear.

CHAPTER 3: METHODS

In this chapter, the research methods employed in this study are discussed. This includes an overview of the research design, a restating of the research questions, a description of the setting and participants, and a description of the intervention. It also includes an overview of the treatment and control conditions, a description of the measures, a discussion of the procedures, and a description of the data analysis plan.

Research Design

This study employed a small-scale randomized control trial to determine if the use of an adaptive computer assisted instructional program would lead to gains for upper-elementary school struggling readers in their ability to identify the main idea and in the area of general reading comprehension. A treatment group received supplemental main idea instruction through the researcher-developed adaptive CAI program, Digital Comprehension, while a control group received only business-as-usual reading instruction and supports. In order to measure the study's primary aims, the participants from both the treatment and control groups were administered two measures pre- and post-test: (a) a researcher-developed main idea assessment and (b) a standardized general comprehension assessment, the Reading Inventory. Inferential analyses, namely analysis of covariance, were conducted to determine whether participants in the treatment group outperformed participants in the control group, controlling for initial performance. Participants in the treatment group also received a survey regarding their perceptions of the intervention and descriptive statistics were gathered to analyze the results.

Research Questions

This study investigated the potential impact of the Digital Comprehension program on upper-elementary students' reading comprehension. It investigated these aims by addressing the following research questions:

1. Did struggling upper-elementary readers' use of the computer assisted instructional program, Digital Comprehension, lead to significantly greater gains in their ability to identify the main idea than students who did not use the program?
2. Did struggling upper-elementary readers' use of the computer assisted instructional program, Digital Comprehension, lead to significantly greater gains in their general reading comprehension levels than students who did not use the program?
3. To what degree did the participants perceive the intervention to be beneficial and engaging?

Setting and Participants

This study employed a convenience sample, which was drawn from the site school's third, fourth, and fifth grade struggling readers. Forty-eight students consented to participate and began the study; however, one student in the control group left the study when the student relocated to a different school. The original sample size of 48 was chosen to ensure sufficient power to detect a large effect size (N = 34) while allowing for possible attrition. Participants were selected from an urban public school in eastern Pennsylvania where more than 90% of the population was below the poverty line (National Center for Education Statistics, 2019).

Table 1 provides the demographic information on the 47 third, fourth and fifth grade students who completed the study. Almost all participants were students of color, with the majority identifying as Latinx. The vast majority were identified as being economically disadvantaged. Approximately one-fifth of the students received special education services and

only a small percentage received English language services. No statistically significant differences were found for any of the demographic variables between the treatment and control groups.

Table 1.

Participant Demographics.

Subgroups	Total Sample (N = 47)	Control Group (N = 23)	Treatment Group (N = 24)	Group Differences	
				χ^2	*p*
Gender					
Female	25	10	15	1.707	.191
Male	22	13	9		
Grade					
Grade 3	17	8	9	.038	.981
Grade 4	20	10	10		
Grade 5	10	5	5		
Race/Ethnicity					
LatinX	38	19	19	2.78	.249
Black	5	1	4		
White	4	3	1		
Reading Proficiency					
Below Basic	24	11	13	.189	.664
Basic	23	12	11		
Special Education					
Special Education	10	4	6	.406	.524
Regular Education	37	19	18		
SES					
Low	45	22	23	.001	.975
Working/middle	2	1	1		
Language Services					
ESL services	2	1	1	.001	.975
No ESL services	45	22	23		

Study Conditions

This study employed matched random sampling to assign students to treatment and control conditions. Participants were first matched based on grade level (3rd, 4th, or 5th grade). Then, participants were matched based on the grade-level proficiency (Basic or Below Basic) and Lexile level (numerical Lexile number) as determined by the standardized Reading Inventory comprehension assessment. Finally, participants were matched based on whether or not they received additional services in special education and whether or not they were identified as English Language Learners. After participants were matched as closely as possible based on these variables, they were randomly assigned to treatment and control conditions using *Research Randomizer*, a closed-source, web-based randomization service.

Control Condition

The participants in the control condition were administered a pre- and posttest researcher-developed main idea assessment and a pre- and posttest general reading comprehension assessment, the Reading Inventory. The participants in the control condition received business-as-usual classroom instruction and supports, which consisted of phonics, fluency, grammar, vocabulary, and comprehension instruction within an anthology series, as well as business-as-usual reading supports provided through the school's MTSS process.

Treatment Condition

Participants in the treatment condition were administered the pre- and posttest main idea assessment and Reading Inventory. In addition to business-as-usual classroom instruction and support, the participants in the treatment condition received supplemental comprehension instruction, practice, and assessments through the Digital Comprehension program. They were also administered a post-study survey regarding their perceptions of the intervention.

Description of the Intervention

Digital Comprehension, the intervention employed in this study, is a researcher-developed adaptive CAI program. The program was designed to serve as a supplement to regular classroom instruction.

Instructional Content

The Digital Comprehension program guides students through a series of five to 11 modules, with the number of modules being dependent on the student's performance (see Figure 5). The modules provide students with direct instruction, guided practice, and assessments that utilize evidence-based practices to heighten the students' ability to identify the main idea in expository passages.

Throughout the program's instructional, guided practice, and assessment modules, the students encounter as many as 60 expository passages. These passages were authored by the researcher and written to represent varying Lexile scores, a numerical indicator of text difficulty that is calculated by the analysis of text's semantic difficulty and its syntactic complexity (Houghton Mifflin Harcourt, 2015). The passages range in difficulty from 500 to 1100 Lexiles, with an average Lexile score of 840 Lexiles. This range of text difficulty represents the on- and below-grade-level proficiency range for third, fourth, fifth grade readers. The passages cover a wide variety of high-interest topics, from science to sports to history, and were written to limit extraneous information that could distract students from synthesizing the details into main idea statements. They were also written to ensure that participants could derive the main idea regardless of personal background knowledge and experience. Throughout the program, the passages are read aloud to the students by the program's narrator and highlighting is utilized as a tracking mechanism. This method was chosen to ensure that the struggling readers involved in

the program could more easily access the information in the texts (Morris & Gaffney, 2011). It was also chosen so that decoding and fluency skills would not impact the acquisition of the comprehension skill being instructed upon, and because of the strong link between listening and reading comprehension processes (Watson et al., 2012).

The Digital Comprehension program approaches the identification of main ideas as a constructive process where the reader actively formulates the main idea by identifying the overarching topic, recognizing what the individual pieces of text are saying about that topic, and synthesizing those commonalities into main idea statements (Boudah, 2014; Williams, 1986). As such, students are taught to move systematically from identifying the general topic of a passage (e.g., whales) to the specific main idea of the passage (e.g., whales are very large). This process allows the reader to draw connections between the units of a text–be they groups of sentences, groups of paragraphs, or groups of sections–in order to form accurate mental representations of the content (Van Den Broek et al., 2003).

The Digital Comprehension program uses a gradual release of responsibility model (Pearson & Gallagher, 1983), whereby the concept of identifying the main idea is first explicitly taught, then students are given opportunities to practice the skill with immediate feedback (i.e., guided practice), and finally they are provided opportunities to independently practice the skill (i.e., assessment sessions). Students' skills are scaffolded such that early lessons focus on identifying the general topic and main idea of single paragraphs (see Figure 1), while later lessons ask students to apply these skills to longer and more complex passages (see Figure 2).

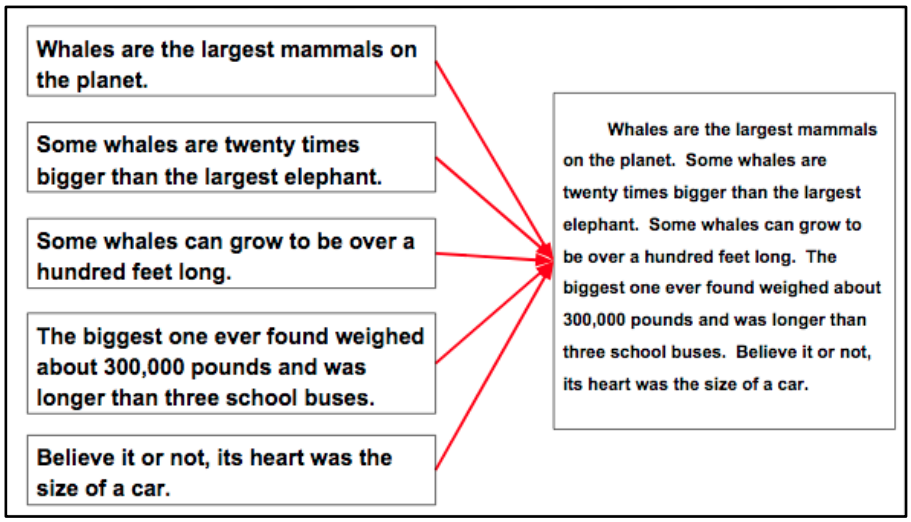

Figure 1. *Example of single paragraph direct instruction.*

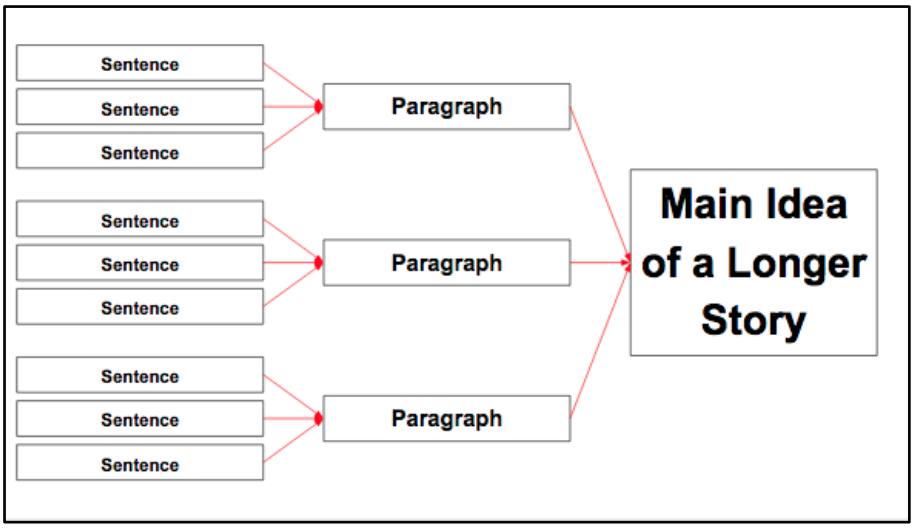

Figure 2. *Representation of multiple paragraph direct instruction.*

The Digital Comprehension program provides students with real-time corrective and elaborative feedback to their responses, which has been shown to increase student acquisition and retention rates of learned skills (Collins, Carnine, & Gersten,1987; Hasselbring, 2015). For each practice item, the students are told whether their answer is correct (see Figure 3), as well as why the correct choice is the best answer (see Figure 4).

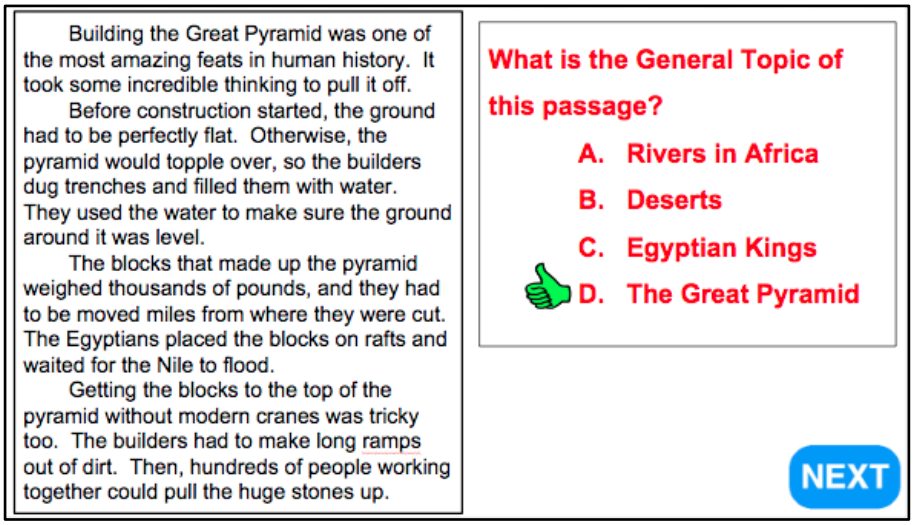

Figure 3. *Example of immediate positive feedback.*

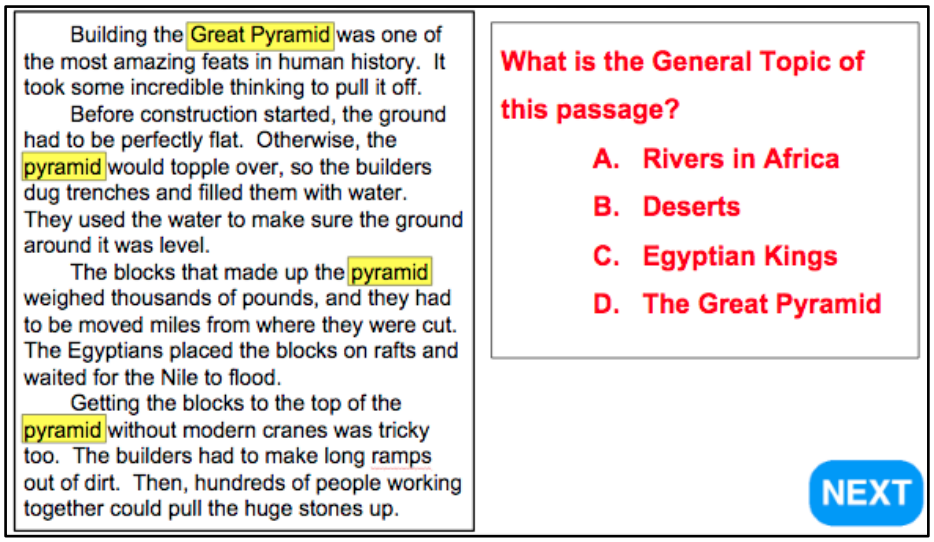

Figure 4. *Example of elaborative feedback to correct responses.*
As the software highlights the topic identified in each paragraph, the narrator explains that since the subject of the Great Pyramid is shared by every paragraph, this is the general topic of the entire passage.

The learning pathway for each student is differentiated based on the student's performance on the previous modules' assessment (Figure 3). Students who demonstrate proficiency of covered skills (defined as ≥ 80%) are moved to the next module, while students who demonstrate weaknesses within a given topic (< 80%) are provided a series of supplemental

instructional lessons and assessments. The supplemental lessons review previously covered concepts and strategies in greater detail and at a slower pace. They also offer students additional practice opportunities using repeated passages, which is designed to allow students to shift a greater amount of their attention from text content to skill development. The supplemental assessments are used to gage student attainment. However, it is important to note that on these supplemental assessments the students progress to future modules regardless of whether or not their scores met the previous 80% benchmark.

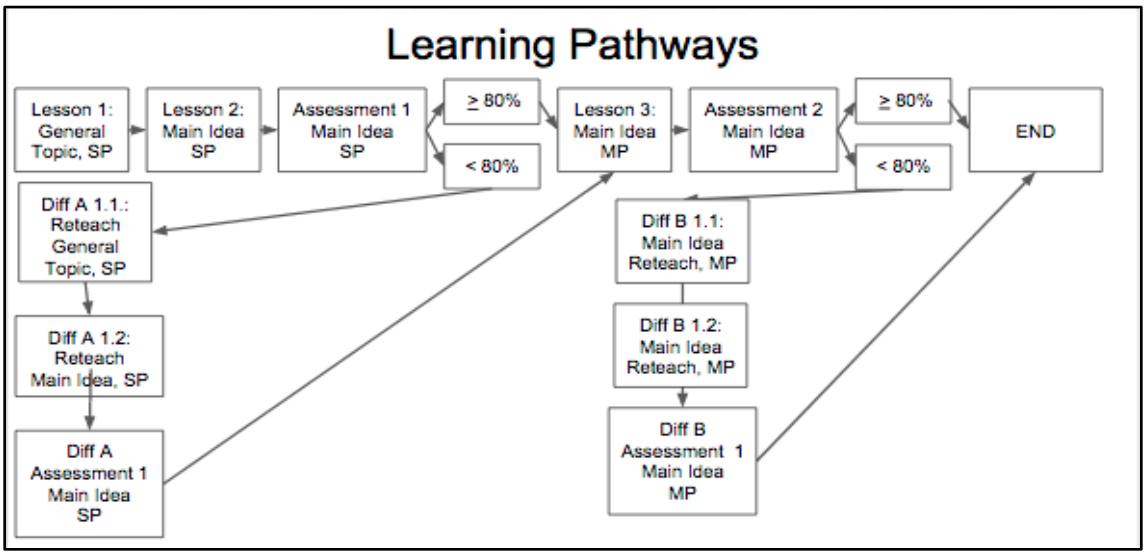

Figure 5. *Learning pathway structure.*
SP= Lesson/Assessment for Single Paragraph; MP= Lesson/Assessment for Multiple Paragraph

The limited breadth of the Digital Comprehension program is based on the literature. Research suggests spending a relatively small number of instructional sessions on explicit comprehension skills instruction, noting that after the initial benefit of explicit teaching further instruction has limited impact (Hirsch, 2003). In fact, Rosenshine and Meister (1994) found that there was no significant difference in spending six instructional sessions or 25 instructional sessions on a skill, for once the skill is understood and applicable the students will have constructed a situational model that will allow them to refine the skill over time (Hirsch, 2003).

Software Design Details

The Digital Comprehension program's server was built utilizing the *Node.js* platform. *Express.js* was used as the web application framework and the template engine *EJS* was used to create dynamic web pages. A Postgres database provided the backend for the application, while the *Google OAuth2* protocol was utilized to allow sign-in with the students' existing Google accounts. The application was hosted on the cloud platform *Heroku*.

Procedures

This study took place over an eight-week period, from January 6th, 2020 to February 28th, 2020. Prior to beginning the study, the approval of the IRB and the building principal (see Appendix A) was attained. Once those permissions were received, a school-wide general comprehension measure, the Reading Inventory, was administered to all students in third, fourth, and fifth grades. Based on those results, students whose proficiency fell below grade level on the assessment (< 520 Lexile for third graders, < 740 Lexile for fourth graders, and < 830 Lexile for fifth graders) were invited to participate in the study. Students who scored a 0 Lexile on the assessment, designated as Beginning Readers by the Reading Inventory's data analysis system, were excluded from participating because their language proficiency was deemed insufficient for successful completion of the software and study's assessment requirements. Participation also required a signed assent form from the participant and a signed consent form from the participant's legal guardian (see Appendices B & C).

Upon receipt of student assent and parental consent, 48 students were assigned to treatment and control conditions using matched random sampling. Participants were matched according to grade level, proficiency level as determined by the Reading Inventory comprehension assessment (i.e., Basic Proficiency Level/Below-Basic Proficiency Level),

numerical Lexile score, and whether they receive additional services in special education (i.e., Special Education Student/Non-Special Education Student) or English language services (i.e., English Language Learner/Non-English Language Learner). Participants in each sub-group were then randomly assigned to treatment (n = 24) and control conditions (n = 24) using *Research Randomizer,* a web-based randomization service that has shown to be effective for random sampling, random assignment, and matched randomization (Saghaei, 2011). However, one control student left the study due to changing schools. The student had pre-test scores on the Reading Inventory and main idea assessment but left the study prior to post-testing. As such, the student was not included in the analysis.

Once students were assigned to treatment and control groups, both groups were administered the pretest main idea assessment. The assessment included ten open-response items and was graded using a researcher-developed rubric (see measures for more specific details).

Students in the treatment group used the Digital Comprehension program two to three times a week (approximately 20 minutes per session) for a period of three to six weeks. The possible variations in time and frequency of sessions were due to the individual learning pathways offered by the software, which required more or less sessions to complete based on the number of modules the student was required to progress through. If the students required no differentiation as they progressed through the main modules, they encountered three instructional and practice sessions and two assessments. Students who required differentiation, on the other hand, engaged in as many as 11 different modules. On average, students in the treatment group completed 8.6 modules.

The intervention occurred during each grade's multi-tiered intervention time when students were separated into groups based on levels of needed support. Since all participating

students were below or far-below grade-level readers, and as such considered *Tier 2* and *Tier 3* students, all of the students received added instructional support in addition to their normal classroom instruction. This support may have included special education services, English as second language services, small group instruction with a classroom teacher, and/or small group instruction with a designated reading specialist. The participants in the treatment group used the software in place of the school's adopted anthology's online program. When not engaged in the Digital Comprehension program, the treatment group took part in all business-as-usual teacher-led, online, and independent educational activities.

When all the students in the treatment group completed the intervention, students in both the treatment and control conditions were administered a posttest main idea assessment and a posttest Reading Inventory. The participants in the treatment group were also administered a survey regarding their perceptions of the intervention.

Measures

This study employed three measures for the purposes of participant selection, the assessment of reading skills, and the gathering of student perceptions. These measures included a main idea assessment, a standardized comprehension assessment, the Reading Inventory, and a survey about the students' perceptions of the intervention.

In addition to these measures, the Digital Comprehension software monitored and recorded student scores as the students completed the program. This included information on students' average scores on the program's internal assessments, as well as data on the impact of the differentiated learning pathways that the program offered. Therefore, in addition to analyzing the results of the study's pre- and post-test assessments and the perceptions survey discussed

below, an examination of the descriptive results of the students' instructional software experience was conducted.

Main Idea Assessment

In order to gage students' proficiency at identifying the main idea pre- and post-study, students were administered a researcher-developed main idea measure (see Appendix D). The students were read a series of ten expository passages that were gathered from the Read 180 program's Topic Software passages (Scholastic, 2012) and were leveled within a 601-900 Lexile range. This range of text difficulty represents the on- and below-grade-level proficiency range for third, fourth, fifth grade and matches the average difficulty of the passages in the instructional software (approximately 840L). After following along as each passage was read aloud to them, the students were asked to provide an open-ended written response about the main idea after being provided the sentence starter, "This story was about _____."

The short-answer, open-ended response format was chosen in lieu of a multiple-choice format for a number of reasons. First, the written response format was selected to reduce the possibility of students guessing the correct answer, thereby helping to ensure that any observed growth will be a true reflection of increased skill rather than chance. Second, the ability to formulate main ideas into one's own words is viewed as one of the best indications that the skill is being successfully learned applied (Stoeger, Sontag, & Ziegler, 2014), so measuring this ability in this way could be viewed as a solid indication of skill acquisition. Finally, because struggling readers often fail to generalize the strategies they have learned and apply them beyond the format in which they were instructed (Biancarosa & Snow, 2004), it was theorized that moving beyond the multiple-choice assessments found within the intervention would be advantageous in seeing whether the skills were truly attained.

The results of the assessment were evaluated using a four-point main idea rubric, where the students' responses were rated according to whether they contained complete, partial, or inaccurate general topic and main idea statements (1 = incorrect general topic & main idea, 2 = correct general topic, but incorrect main idea, 3 = correct general topic & partially correct main idea, 4 = correct general topic and correct main idea). In order to ensure scoring accuracy and help control for any potential researcher bias, a reading specialist at the school where the study took place was used as a secondary scorer. Any discrepancies between the researcher and secondary scorer's results were discussed and those scores were reevaluated. Each students' results were then summed to achieve a total score between ten and 40 and converted to a percentage score.

In order to ensure adequate reliability, pilot tests of the main idea pretest and posttest were conducted and evaluated prior to the start of the study. The pilot tests were conducted with 20 below grade-level readers from third, fourth, and fifth grade. After the assessments were administered, internal reliability was evaluated by calculating Cronbach's alpha using SPSS software. Results revealed acceptable to good reliability levels on both the main idea pretest (α = .683) and main idea posttest (α = .860) (De Vellis, 2012).

A secondary rater, a certified reading specialist with more than 20 years experience, was also utilized to help ensure reliability of scoring. The secondary rater scored the pilot test as well as the study's official pre- and posttest main idea assessments. The secondary rater scored 100% of the pilot tests (20 out of 20) and 32% of the study's official pretest assessment (15 out of 47) and posttest assessment (15 out of 47). The reporting inter-rater agreement was 94% on the pilot test, 91% on the study's pretest, and 87% on the study's posttest assessment.

When used with the current study sample (N = 47), the internal reliability of the main idea pretest and posttest assessments were evaluated by calculating Cronbach's alpha using SPSS software. Results revealed good reliability levels on both the main idea pretest (α = .891) and main idea posttest (α = .875) (DeVellis, 2012; Field, 2013).

Reading Inventory

The Reading Inventory is a standardized computerized, adaptive, research-based reading assessment designed to measure general reading comprehension and growth in elementary, middle, and high school students (Houghton Mifflin Harcourt, 2015). The assessment results are reported in terms of a numerical Lexile score, ranging from 0 to above 1725. These numerical scores are then related to grade-level proficiency ranges and reported in terms of Below Basic, Basic, Proficient, and Advanced proficiency.

The Reading Inventory was designed to be administered three to five times per school year in order to measure baseline reading comprehension and monitor growth throughout the academic year. To maintain validity and reliablity, it is recommended that a minimum of 30 days are alloted between assessments. During each administration, students are presented approximately 25 items, which are randomly assigned based upon ongoing student performance. Repetitive exposure threats are controlled by drawing test items from a bank of over 5,000 questions of varying reading difficulty. Each question is targeted to the individual student's reading level, adjusting to correct and incorrect responses by raising and lowering the difficulty of the test on an ongoing basis.

Reliability and validity levels have been established for the Reading Inventory. Because each student takes a unique test, the standard error of measurement varies. At the initial administration, the average standard error of measurement for the assessment ranges from 84 to

104 Lexile points. Once the reading level for each student is established, however, the standard error of measurement for subsequent administrations decreases to a range of 54 to 58 Lexile points. The Reading Inventory has a reported marginal, or model, reliability estimate of .94, based on a Winsteps item analysis, and a reader consistency correlation of .89 between two administrations over a four-month period (Scholastic, 2014). The assessment also reports high levels of criterion-related validity (Scholastic, 2014), demonstrating a high correlation to other norm-referenced and criterion-referenced comprehension measures such as the Stanford Achievement Test (.93), the Iowa Tests (.88), and the Metropolitan Achievement Test (.93).

Perceptions Survey

In order to explore the students' perceptions about the intervention, students in the treatment condition were administered a researcher-developed survey (see Appendix E). The survey consisted of eight questions, covering topics such as the level of student enjoyment during the intervention, the perceived impact of the intervention on their reading and academics, and whether or not they felt the intervention would prove helpful to other students. The students responded to each item using a five-point Likert scale that utilized emojis to delineate how strongly they agreed or disagreed with a given statement.

In order to ensure adequate internal reliability, a Cronbach's alpha was conducted on the perceptions survey using SPSS software. The results of the analysis revealed acceptable reliability levels ($\alpha = .746$) (DeVellis, 2012; Field, 2013).

Data Analysis Plan

The aims of the study were to identify the impact of CAI of students' comprehension skills by addressing the following research questions: (a) did struggling upper-elementary readers' use of the computer assisted instructional program, Digital Comprehension, lead to

significantly greater gains in their ability to identify the main idea than students who did not use the program? (b) did struggling upper-elementary readers' use of the computer assisted instructional program, Digital Comprehension, lead to significantly greater gains in their general reading comprehension levels than students who did not use the program? The study also sought to explore the students' perceptions about the Digital Comprehension program by addressing the following research question: (c) to what degree did the Digital Comprehension participants perceive the intervention to be beneficial and engaging? In addition to these primary aims, the study monitored students' progress through the software's internal practice items, assessments, and learning pathways.

Analysis of covariance (ANCOVA) tests were utilized to address research questions one and two. Descriptive analysis was utilized to address research question three as well as to analyze students' performance within the software's internal practice and assessment modules. The Statistical Package for the Social Sciences (SPSS) software (version 25) was used to run all statistical analyses.

Analysis of Covariance

When the main focus of a study is to compare means, as between different experimental groups, the predictors can be referred to as covariates, and an analysis of covariance is often recommended (Field, 2013). This form of linear model, known as ANCOVA, allows researchers to determine the influence that measured variables, or covariates, have on the observed outcomes (Field, 2013). This statistical process entails entering the covariate into a linear model, and then entering the experimental manipulation in order to see what effect the predictor outcome has after adjusting for the effect of the covariates (Field, 2013).

ANCOVA has two main benefits. First, it reduces within-group variance and thus allows researchers to accurately determine the cause of the difference between control group and experimental group means (Field, 2013). Second, by taking into account the initial states of both control and experimental groups, the effect of any confounding variables can be reduced as a cause of any observed effect that the treatment or intervention may have (Field, 2013).

Research Question 1: Did struggling upper-elementary readers' use of the computer assisted instructional program, Digital Comprehension, lead to significantly greater gains in their ability to identify the main idea than students who did not use the program?

In order to address this research question, quantitative data were collected using the researcher-developed main idea measure. First assumptions of normality, linearity, and the equality of variance were examined for this measure. Then, after running descriptive statistics on this measure and checking the dataset for normality, an analysis of covariance (ANCOVA) was conducted. This analysis helped determine if, when controlling for previous ability at pretest, the students in the treatment group made significantly greater gains in identifying the main idea than students in the control group.

Research Question 2: Did struggling upper-elementary readers' use of the computer assisted instructional program, Digital Comprehension, lead to significantly greater gains in their general reading comprehension levels than students who did not use the program?

In order to address this research question, quantitative data were collected using the standardized reading comprehension assessment, the Reading Inventory. First assumptions of normality, linearity, and the equality of variance were examined for this measure. Then, after running descriptive statistics on this measure and checking the dataset for normality, an analysis of covariance (ANCOVA) was conducted. This analysis helped determine if, when controlling

for previous ability at pretest, the students in the treatment group made significantly greater gains on the general comprehension measure than students in the control.

Research Question 3: To what degree did the participants perceive the intervention to be beneficial and engaging?

In order to address this research question, descriptive statistics were run on the students' survey responses. This included the students' perceptions about the intervention's effect on their ability to identify the main idea, how it may have affected their general reading skills, if they thought they'll be able to apply the things they learned when reading other materials, and if taking part in the intervention helped them perform better in other subject areas. It also included information about the students' general attitudes toward the program, including whether or not they enjoyed using a computer for the intervention, if they felt the program helped them enjoy reading more, and if they thought the program was fun.

CHAPTER 4: RESULTS

The purpose of this study was to evaluate the possible impact of adaptive computer assisted instruction of struggling readers comprehension skills. A small-scale randomized control trial was used to determine if students who used the adaptive CAI program, Digital Comprehension, would demonstrate higher post-test scores, when controlling for pretest scores, in the area of identifying the main idea and general comprehension than students who did not use the program. Information was also collected about the participants' experience within the software's modules and regarding the participants' perceptions of the intervention.

Prior to presenting results related to the intervention, this chapter begins by discussing the learning pathways and assessment results that the students experienced as they completed the Digital Comprehension program. Then, the results of the pre- and posttest main idea and standardized comprehension measures analysis are presented. The chapter concludes with a description of the study's student perceptions survey and a summary of the study's overall findings.

Digital Comprehension Software Data

The Digital Comprehension software monitored and recorded student scores as the students completed the program. These data were gathered by the software's internal processing system and then the descriptive results of the students' progress and pathways were run and analyzed.

After completing the instruction and practice portions of the first two modules, students were presented with an assessment of ten single-paragraph passages in the third module. There, students were asked to select the correct main idea from a set of four statements. The average score on the assessment was 58%, and 15 of the study's 24 treatment group participants (who

scored below the 80% benchmark, averaging 43%) were directed to complete the first branch of differentiated instruction, extended guided practice, and re-assessment. The average score on the following single-paragraph assessment was 73%, an increase of 30% compared to the students' average scores on the first assessment.

Next, all 24 participants were presented with instruction, guided practice, and assessment on identifying the main idea in multi-paragraph passages. The average score on this assessment was 66%, and 14 of the study's 24 treatment group participants (who scored below the 80% benchmark, averaging 52%) were directed to complete the program's second branch of differentiated instruction, extended guided practice, and re-assessment. The average score on the following multi-paragraph assessment was 79%, an increase of 27% compared to the students' average scores on the first multi-paragraph assessment.

Of the students who received the intervention, six students needed no differentiation. Of the remaining 18 students, seven students completed a single series of differentiation modules, while 11 students required remediation during both of the offered differentiation series.

Research Question 1

The first research question asked if struggling upper-elementary readers' use of the computer assisted instructional program, Digital Comprehension, lead to significantly greater gains in their ability to identify the main idea than students who did not use the program. It was hypothesized that students who engaged in the Digital Comprehension would demonstrate statistically significant higher scores at post-test, when controlling for pretest scores, on the main idea assessment than the students who received only business-as-usual reading instruction.

Participants in both the control and treatment groups were administered a researcher-designed pretest and posttest main idea assessment. Each assessment consisted of ten written

response items. Student responses to these items were evaluated using a four-point rubric and then the total sum-score, ranging from ten to 40, was converted into a percentage score. Table 2 provides pretest and posttest scores for both treatment and control groups.

Table 2.

Comparison of Main Idea Pretest and Posttest Scores (N = 47)

Measure	Main Idea Pretest Mean (SD)	Main Idea Posttest Mean (SD)
Control (n = 23)	46% (12%)	50% (12%)
Treatment (n = 24)	46% (12%)	77% (11%)

Prior to conducting the ANCOVA to address the research question, the assumption of normally distributed difference scores was examined. This assumption was satisfied, as the skew level was estimated at .058 and the kurtosis level was estimated at -.715., both of which are within the recommended allowable levels for an ANCOVA (Field, 2013). The data sample was also analyzed to check for outliers and none were noted.

With these assumptions satisfied, an independent samples t-test was then conducted to ensure that there was no statistically significant difference between the control and treatment group means at pretest. Results revealed that there was no statistically significant difference on the main idea assessment at pretest between the control (M = 46%, SD = 12%) and the treatment group (M = 46%, SD = 13%); $t(45) = .049$, $p = .961$.

Following this analysis, mean differences between the control and treatment groups' posttest main idea scores were investigated with an ANCOVA analysis using pretest scores as the covariate and study condition as the independent variable. The results of the ANCOVA

indicated that students who received the adaptive CAI intervention demonstrated statistically significant higher posttest scores on the main idea measure when controlling for pretest scores than students in the control group, $F(1,45) = 92.835$, $p < .001$, with a moderate effect size ($\eta_p^2 = .678$). Students' pretest scores were statistically significant related to their post-test scores, $F(1,45) = 18.445$, $p < .001$.

As a post hoc analysis, the researcher examined students' gains in main idea skills by the amount of differentiation they experienced within the Digital Comprehension software. As a first step, a one-way ANOVA was conducted to determine whether there were differences in students' pretest scores as related to the number of differentiated modules they completed (i.e., none, one series, both series). No significant differences were found, $F(2, 20) = 1.94$, $p = .170$. Difference scores were then calculated for all intervention students to determine how much growth they demonstrated in main idea skills between pretest and posttest. A one-way ANOVA was run to determine whether there were significant differences between students in the three differentiation groups on their main idea difference scores. No significant differences were found, $F(2, 20) = .32$, $p = .731$.

Table 3.

Comparison of Pretest and Difference Scores Based on Intervention Pathways

Number of Differentiation Modules Completed	Main Idea Pretest Mean (SD)	Main Idea Difference Score Mean (SD)
No Differentiation	52% (16%)	29% (15%)
1 Differentiation Module	51% (18%)	28% (15%)
2 Differentiation Modules	40% (9%)	33% (12%)

Research Question 2

The second research question asked if struggling upper-elementary readers' use of the computer assisted instructional program, Digital Comprehension, lead to significantly greater gains in their general reading comprehension levels than students who did not use the program. At the onset of the study, it was hypothesized that students who engaged in the Digital Comprehension would demonstrate statistically significant higher scores at posttest, when controlling for pretest scores, on the Reading Inventory than the students who received only business-as-usual reading instruction.

Participants in both the control and treatment groups were administered the Reading Inventory at the beginning and conclusion of the study. The reading inventory is a computer-based standardized general comprehension assessment that was designed to measure and monitor reading comprehension ability in elementary, middle, and high school students (Houghton Mifflin Harcourt, 2015). The assessment results are reported in terms of a numerical Lexile score, ranging from 0 to above 1725, which are then related to grade-level proficiency ranges (3rd grade on-level proficiency range = 520-820L, 4th grade on-level proficiency range = 740-940L, 5th grade on-level proficiency range = 830-1010L).

Table 4.

Comparison of Reading Inventory Pretest and Posttest Scores (N = 47)

Measure	Reading Inventory Pretest Mean (SD)	Reading Inventory Posttest Mean (SD)
Control (n = 23)	453.00 (161.60)	460.00 (141.04)
Treatment (n = 24)	438.67 (181.45)	455.79 (184.75)

Prior to conducting the ANCOVA to address the research question, the assumption of normally distributed difference scores was examined. This assumption was satisfied, as the skew level was estimated at .313 and the kurtosis level was estimated at -.666., both of which are within the recommended allowable levels for an ANCOVA (Field, 2013). The data sample was also analyzed to check for outliers and none were noted.

With these assumptions satisfied, an independent samples *t*-test was conducted to ensure that there was no statistically significant difference between the control and treatment groups at pretest. Results revealed that there was no significantly significant difference on the Reading Inventory on the pretest between the control (M = 453.00, SD = 161.60) and the treatment group (M = 438.67, SD = 181.45); $t(45) = .286$, $p = .78$.

The results of the ANCOVA indicated that students who received the adaptive CAI intervention did not demonstrate statistically significant higher posttest scores on the general comprehension measure when controlling for pretest scores than students in the control group, $F(1,45) = .080$, $p = .78$, with an effect size close to zero ($\eta_p^2 = .002$). However, treatment group students did show statistically significant increases in their performance between pretest and posttest $F(1,45) = 108.65$, $p < .001$.

Research Question 3

The third research question asked to what degree did the participants perceive the intervention to be beneficial and engaging. At the conclusion of the study, participants were administered a researcher designed survey to gage their perceptions of the intervention and descriptive statistics were used to analyze the results. Responses indicated that the majority of students thought the intervention program had a positive effect on their reading and academics (see Table 5). The majority of students reported that the intervention improved their ability to

identify the main idea, made them better readers, would help them to apply the things they learned when reading other materials, and would help them perform better in other subject areas. Student responses were also positive regarding their general attitudes toward the program (see Table 5). The majority of students reported that they enjoyed using a computer for the intervention, that the program helped them to enjoy reading more, that they believed the program would help their classmates, and that the program was fun.

Table 5.

Student Perceptions Survey Results.

Item	Percent Strongly Disagreed	Percent Disagreed	Percent Not Sure	Percent Agreed	Percent Strongly Agreed
1. I think that this reading program made me better at identifying the main idea.	0%	0%	0%	17%	83%
2. I think this program made me a better reader.	0%	0%	17%	38%	44%
3. I think I will be able to use the things I learned in this program when I read other things.	0%	8%	17%	25%	50%
4. I liked using the computer for this reading program.	0%	0%	0%	21%	79%
5. I think that this program would help my other classmates and friends.	0%	0%	0%	17%	83%
6. I think that completing this program will help me do well in other school subjects.	0%	0%	21%	17%	63%

Item	Percent Strongly Disagreed	Percent Disagreed	Percent Not Sure	Percent Agreed	Percent Strongly Agreed
7. I thought this program was fun.	0%	4%	0%	25%	71%
8. This program helped me like reading more.	4%	0%	4%	17%	75%

Summary of Findings

The participants who engaged in the researcher developed adaptive CAI program, Digital Comprehension, demonstrated statistically significantly higher skills in identifying the main idea than the participants who were not exposed to the program. The participants who engaged in the Digital Comprehension program did not demonstrate significantly higher posttest general comprehension scores than the study's control group. The study's treatment group demonstrated notable improvement on the software's internal assessments as they progressed through the program, and reported favorable perceptions to the software's effect on their reading skills as well as their general attitudes toward the program.

CHAPTER 5: DISCUSSION

The importance of proficient reading skills and their impact on academic, civic, and economic success make it essential that educators find more effective ways of remediating the literacy skills of struggling readers. Reading comprehension, the ultimate goal of any reading endeavor, can be conceptualized as a set of interrelated-subskills, and among these the ability to find the main idea is seen as particularly crucial (Klingner et al., 2007; Ilter, 2017; Potocki et al., 2015; Van Den Broek et al., 2003; Watson et al., 2012). It is also a skill that many struggling readers find difficult (Baumann, 1983; Lord, 2015; Wang, 2009; Williams, 1986). Research has demonstrated that differentiated instruction can be an effective means of boasting specific comprehension skills in struggling readers, and that instructional technology, particularly adaptive CAI, has a positive impact on a diverse range of literacy skills. Adaptive CAI, therefore, may be a powerful way to bolster main idea skills. Yet, there has been insufficient research into whether or not adaptive CAI has a similar positive impact on specific comprehension skills.

In order to help fill this gap in the literature, this study investigated the impact of using an adaptive computer assisted instructional program to provide supplemental reading comprehension instruction. A small-scale random control trial was utilized to see whether students who engaged in the Digital Comprehension program exhibited statistically significant higher scores at posttest, when controlling for pretest scores, in main idea identification skills and general comprehension abilities than students who did not use the program. The study also investigated the participants' perceptions of the program.

Three main findings emerged. First, the use of the Digital Comprehension program by the study's treatment group led to significantly higher scores on the main idea assessment, when

controlling for pretest scores, than the study's control condition. Second, the use of the Digital Comprehension program by the study's treatment group did not lead to significantly higher scores on the general comprehension measure, when controlling for pretest scores, than the study's control condition. Third, the participants reported that, overall, the Digital Comprehension program had a positive effect on their reading and that they had positive perceptions regarding the program's use.

Adaptive Computer Assisted Instruction and Identifying the Main Idea

Consistent with the study's hypothesis, students who engaged in the adaptive CAI program, Digital Comprehension, demonstrated statistically significant higher posttest scores on the main idea assessment than students who took part in only business-as-usual reading instruction. Students who used the Digital Comprehension program saw their scores rise from 46% at pretest to 77% at posttest, an increase of more than 30 percentage points. These results strike a sharp contrast to the control group's pretest and posttest scores, which remained relatively stagnant, rising only from 46% at pretest to 50% at posttest. This finding was expected given that the Digital Comprehension program was grounded in a research-based approach to main idea instruction (Boudah, 2014; Jitendra et al., 2000, O'Connor et al., 2017; Sulak & Gunes, 2017; Williams, 1986) and given the potential benefit of using adaptive computer assisted instruction to address specific comprehension skills (MacArthur et al., 2001; Potocki et al., 2015).

The Digital Comprehension program approached the identification of main ideas based on the instructional method developed by Williams and her colleagues (1983), whereby students are taught to move from the "general" to "specific" topics within expository texts by recognizing the commonalities between details and synthesizing those ideas into main idea statements

(Williams, 1986; Williams et al., 1983). This pedagogical approach allows the reader to draw connections between the units of a text and has been shown to lead to significant results in multiple studies (Boudah, 2014; Jitendra et al., 2000; O'Connor et al., 2017; Sulak & Günes, 2017; Van Den Broek et al., 2003; Williams, 1986).

The Digital Comprehension program sought to merge this research-based methodology with the potential that adaptive CAI holds for differentiated literacy instruction. Adaptive CAI allows educators to adjust their lessons, activities, or assessments to the user (Caverly & Fitzgibbons, 2007), providing them with a unique way to address areas of deficiency from a data-driven approach (Schechter et al., 2015). Indeed, research has shown that adaptive CAI programs can significantly improve a wide variety of literacy skills, including phonological and phonemic awareness (Segers & Verhoeven, 2005; Shamir et al., 2018), phonics (Shamir et al., 2018), vocabulary and language development (Shamir et al., 2017; Wang, 2016), word recognition (Shamir et al., 2017), fluency (Council et al., 2016; Shamir et al., 2017), and, though research in this area is limited, reading comprehension (Schechter et al., 2015; Shamir et al., 2017; Shamir et al., 2018).

This study's findings support the premise that adaptive CAI may be an effective tool for increasing the main idea skills of struggling upper-elementary readers and gain added importance when the unique role main idea skills play in literacy and our documented struggles in teaching it effectively are taken into account. The ability to identify the main idea is critical for successful reading comprehension (Ilter, 2017; Potocki et al., 2015; O'Connor et al., 2017; Watson et al., 2012). It serves as the foundation for many other comprehension processes (Van Den Broek et al., 2003; Watson et al., 2012) and is, therefore, one of the key factors that separates proficient and struggling readers (Gallagher, 2009; Wang, 2009). Unfortunately, and despite the large

amount of instructional time devoted to it (Heafner & Fitchett, 2015), the vast majority of below grade-level readers continue to struggle with this skill (Baumann, 1983; Lord, 2015; Wang, 2009). Efforts to provide effective main idea instruction and remediation, often due to a lack of in-depth understanding about the processes the skill entails, have seen limited success (Stoeger et al., 2014; Van Den Broek et al., 2003). There is even confusion within the research base as to what the term "identify the main idea" actually refers, making it challenging to compare different studies' results and, thereby, making it difficult to use refine and improve instruction (Pearson, 1981; Wang, 2009) (Pearson, 1981; Wang, 2009).

Therefore, finding more effective means of delivering instruction and remediation in main idea identification skills is critical for helping our struggling readers to close the achievement gap. The Digital Comprehension program, by providing a research-based method to consistently deliver high quality main idea skills instruction and remediation, suggests that adaptive CAI might be an effective means to improve the skills of the readers who are in most need of main idea intervention.

Adaptive Computer Assisted Instruction and General Comprehension Levels

Contrary to the study's hypothesis, the students who engaged in the Digital Comprehension program did not demonstrate statistically significant higher posttest scores on the Reading Inventory assessment than students who did not use the program when controlling for pretest scores. This hypothesis, though contradicted by the findings, was based on the research literature, which suggested a strong connection between proficiency in specific comprehension strategies and overall comprehension ability (Hall, 2004; Ilter, 2017; Klingner et al., 2007; Vaughn & Fletcher, 2012).

The relationship between comprehension sub-skills, such as the ability to identify the main idea, and overall comprehension levels has been examined through multiple intervention studies, and the research has shown that interventions which focus on specific comprehension skills often have a significant and positive impact on general comprehension levels (Hagaman et al., 2012; Hall 2004; Mastropieri et al., 2003; Muijselaar et al., 2017). In fact, it has been hypothesized that the differences in students' ability to comprehend may actually hinge on their knowledge and use of such reading skills and strategies (Muijselaar & de Jong, 2015; Potocki et al., 2015; Sulak & Günes, 2017). Since the ability to identify the main idea is noted as being particularly impactful on successful reading comprehension (Boudah, 2014; Ilter, 2017; Potocki et al., 2015; Van Den Broek et al., 2003; Watson et al., 2012), the presumption that systematic instruction and guided practice in main idea skills would lead overall comprehension skills was logical and well-founded. Yet, this study's results failed to find such a relation.

The mean scores of both the students in the treatment and the control group increased from pretest to posttest on the standardized comprehension measure. In fact, the treatment group showed more average gain increases than the students in the control group. The treatment group mean scores rose from 439L at pretest to 456L at posttest, an increase in 17 Lexile points, while the students in the control group mean scores rose from 453L to 460L, an increase of only seven Lexile points. However, this may be accounted for by the treatment groups larger standard deviations, and, when controlling for pretest scores, the students in the treatment group did not demonstrate statistically significant higher posttest scores on the Reading Inventory than students in the control group.

When juxtaposed against the much larger gains the treatment group demonstrated on the main idea measure, these results may appear surprising. Based on much of the literature, one

would expect large gains in main idea ability to naturally correlate to significant gains in general comprehension. However, there is also literature suggesting that a students overall comprehension skills are highly dependent on the students' background knowledge and vocabulary knowledge (Wexler, 2018), and therefore it would be unlikely that an improvement in one specific comprehension skill, even a critical one, would be enough to overcome the cumulative effect of weaknesses in these areas, particularly on a standard test (Meadows & Karr-Kidwell, 2001). The duration of the study could have further exacerbated these issues; for while the study may have been long enough to provide adequate initial instruction in a specific comprehension skill areas such as main idea, it certainly may not be long enough or have a high enough dosage to move the broader measure of general reading comprehension (Hirsch, 2003).

Other factors that may have contributed to these results include sample size and uncontrolled testing variables. One possible explanation for the study's insignificant general comprehension findings is the effect the study's relatively small sample size may have had on the statistical analysis. The 47-participant sample required a large effect size to demonstrate significance. Even a modest increase in the sample size would allow greater sensitivity in detecting effects. Increasing the sample size by seven students, for example, would lower the needed effect size to medium, while a dramatically larger sample (N = 416) would lower the threshold for significance to a low effect size (Cohen's d = .2).

Another factor that could have influenced the general comprehension findings is the effect of uncontrolled testing variables. The Reading Inventory has reported high levels of validity and reliability (Scholastic, 2014). However, like all standardized assessments, it is subject to mitigating factors that can affect outcomes (Meadows & Karr-Kidwell, 2001), and analysis of differences in individual student's pre- and post-test performance suggest some

discrepancies. Many of the students in both the treatment and control conditions showed dramatic Lexile fluctuations that fell well outside the established average standard error of measure for the assessment, and these may point to the influence of such variables. The average standard of measure on a students' initial Reading Inventory ranges from 84 to 104 Lexile points, and falls to a range of 54 to 58 Lexile points with subsequent administrations. Yet, 20 students saw point swings in excess of 65 Lexile points at the second administration (15 positive: 7 treatment, 8 control; 5 negative: 2 treatment, 3 control), and ten of the students saw point swings in excess of 100 Lexile points at the second administration (6 positive: 2 treatment, 4 control; 4 negative: 2 treatment, 2 control), including Lexile drops of 113, 120, 198, and 272 points.

The fact that a student might make a large amount of progress is not unprecedented over an eight-week period, especially with intensive research-based instruction (Houghton Mifflin Harcourt, 2016). Yet, such dramatic decreases in performance over a relatively short time period suggest the possibility that uncontrolled variables may have influenced students' scores at pretest, at posttest, or both. For instance, the high levels of poverty present within the participant sample makes it likely that some of the students are dealing with stressful, even traumatic, issues (Evans, 2004). Adverse physical, social, and psychological conditions, such as violence, family disruption, and family separation, occur far more often to children of poverty (Evans, 2004) and have been shown to have detrimental effects on academic results (Frieze, 2015; Paiva, 2019). Another factor that could have impacted the Reading Inventory measure's results is motivation. Intrinsic motivation levels always have some influence on testing results; however, students' extrinsic motivation may have been negatively affected by the fact that students knew that their results did not count toward their academic grades (Emmett, 2013). This could have led to higher

attention to task during one test versus the other and may at least partially account for the seemingly erratic differences in pretest and posttest scores.

Student Perceptions of the Adaptive CAI Program

Consistent with the study's hypothesis, the students who engaged in the Digital Comprehension program reported positive perceptions of the intervention. Though ascertaining these perceptions was exploratory in nature, the results of a previous study involving an earlier rendition of the intervention made the hypothesis of positive student perceptions likely.

The majority of the students reported that the intervention program had a positive effect on their reading and academics, including skill development, application, and perceived effects on overall reading abilities. The students reported perceptions of the intervention were also positive regarding their general attitudes toward the program, indicating that the program was enjoyable, that it positively affected the enjoyment they get from reading, and that they felt the program would help their classmates.

These findings were consistent with the research, which suggested that the use of adaptive CAI would likely have a positive impact on the students (Schechter et al., 2015; Shamir et al., 2017; Shamirer et al., 2018) and that students tend to report favorably to the use of instructional technology (Flewitt et al., 2015; Jethro et al., 2012; Shamirer et al., 2018). It was also consistent with the researched-based notion that there is a positive correlation between children's attitudes towards reading activities and reading attainment (Clark, 2014; McGeown et al., 2015).

Limitations

The results of this study were promising. It demonstrated the potential impact that adaptive computer assisted instruction could have on students' specific comprehension skills,

specifically the ability to identify the main idea. The students' reported perceptions of the intervention were positive, and although the results of the general comprehension measure were not statistically significant, the students did show measurable gains in overall comprehension levels. Yet, the study did have several limiting factors.

One of the study's limitations was the use of a convenience sample rather than representative sample. While the use of a convenience sample always has a negative impact on the generalizability of findings, the make-up of this particular sample, namely the lack of diversity within its population, presented added challenges. The population was drawn from a single elementary school and was relatively small (N = 47), both of which limit the generalizability of its findings. Furthermore, the participant population was, despite containing a high number of ethnic and racial minorities, fairly homogeneous. Ninety-six percent of the participants came from economically disadvantaged homes, and 81% were Latinx (n = 39). Only 10% of the students were Black (n = 5), only 8% of the students were White (n = 4), and there were no students of Asian or Middle Eastern descent. This lack of heterogeneity makes it difficult to predict how samples of other demographics, such as middle- and upper-class students or largely Asian, Black, and White populations, might respond to the intervention and makes it hard to generalize this study's findings to the larger population.

A second limitation of this study was its failure to directly account for novelty effect. Novelty effect, an increase in student attention and motivation due to exposure to unfamiliar instructional activities, has been shown to have a positive, but temporary impact on student achievement (Jeno, Vandvik, Eliassen, & Grytnes, 2019; Keller & Suzuki, 2004). This effect is common to educational technologies and could have worked to inflate this study's observed results. Its impact may have been partially mitigated by the structure of the Digital

Comprehension program, which mimicked typical reading instruction rather than teaching main idea through game-based instruction, as well as the common presence of electronics in student's personal and academic lives (Hochberg, Kuhn, & Müller, 2018; Miller, Krockover, & Doughty, 2013).

Another possible limitation was the skill transference required for the participants to complete the main idea assessment pretest and posttest. The pretest and posttest assessments consisted of an open-ended, short-answer format, while the practice and assessment items the participants encountered during the intervention were all multiple-choice questions. While this was an intentional part of the study's design, based on the premise that the ability to formulate main ideas into one's own words is a better indicator that the skill is being successfully learned (Stoeger, Sontag, & Ziegler, 2014), it did have possible adverse consequences. The use of the short-answer format brought into play the students' writing ability and other prerequisite skills that may have affected their performance on the assessments. Students may have performed better on either the pretest or posttest had the assessments been in the same multiple-choice format found in the program's modules.

A related limitation was the use of a researcher-designed main idea assessment rather than a standardized assessment. Though a standardized main assessment was sought during the research and planning phase of the study, an appropriate and well-established standardized main idea assessment could not be identified. Cronbach's alpha values indicated good reliability at pre- and post-test. Additionally, the use of a secondary scorer was used to ensure reliability of scoring. However, the results from the assessment should still be viewed with caution.

Finally, while the intervention was designed and implemented according to research-based best practices, resource restrictions led to limitations in the intervention software that may

have improved the program. For example, the original design called for the addition of a feature that would allow students to have answer choices read to them, thereby limiting the possible effects of word recognition and decoding on performance and learning. Similarly, the original software design called for the user to be able to have every story reread by the narrator on demand, which could have impacted the readers' ability, especially those with weaker language skills, to re-attack passages when needed. Perhaps the most important example of these limitations in the software's design was the inability to imbed features to help alleviate gaps in background and vocabulary knowledge. Research has shown that reading comprehension is largely dependent on a reader's prior knowledge and vocabulary levels (Wexler, 2018), so the software's original design called for several supports in these areas, including videos to scaffold each passage's content and a feature that would allow students to hear definitions, translations, and examples of unfamiliar vocabulary. The lack of these supports in the final intervention could have dramatically affected students' ability to understand the passages they encountered in the software and, therefore, may have had a large impact on the amount of subsequent growth they experienced.

Future Directions

Implications for Future Research

The results and limitations of this study hold several implications for future research. These include the expansion of the present study into wider populations, the incorporation of independent reading tasks with the program's practice items and assessments, research into whether the gains demonstrated through the intervention are retained over time, and the development and assessment of adaptive CAI programs that address the wide variety of specific comprehension skills.

As noted above, the small sample size that this study employed limits the generalizability of these findings to the wider population and is further exacerbated by the relatively homogenous nature of the participant population. Future research should, therefore, include efforts to examine the effects that the Digital Comprehension has when the population sample is expanded to include greater numbers and students from more varied economic, ethnic, and racial backgrounds.

Another possible line of future inquiry would be to examine the retention rates of the main idea skills observed during the study. It is currently unclear if the students who used the Digital Comprehension program would maintain their demonstrated skill-gains over time. Therefore, it would be interesting to investigate retention rates by including later rounds of assessment that take place after extended periods of time to determine if learning gains are maintained.

This study utilized read-alouds and audio narration during instruction, practice, and assessment in order to alleviate any cognitive strain that would cause phonics and fluency levels to negatively impact skill attainment. The research showed that this instructional method was ideal for initial skill acquisition. However, the goal of any reading instruction is for the students to be able to apply the skills independently without the reliance on teacher or narrator assistance. Therefore, future studies involving this intervention could include the addition of independent reading tasks in order to see if the observed student gains are maintained when the audio supports are removed and students are required to undertake main idea tasks using their own decoding and fluency skills.

Research could also be conducted to explore how the program's effectiveness might be bolstered by combining it with teacher-led instruction and supplemental support. In this study,

the intervention was intentionally isolated in order to gauge its effects, but the effective application of instructional technology often hinges on the summative effect of the software's instruction, the role of the teacher in guiding and/or supplementing the instruction, and the methods of its use (Cheung & Slavin, 2013; Macarthur et al., 2001). Therefore, it is hypothesized that developing and implementing a curriculum that includes teacher-led remediation alongside the adaptive CAI program would lead to even greater comprehension gains.

A similar line of inquiry would be to examine how the study's outcomes would be affected by the addition of various improvements to the program's interface and supports. The options for possible adaptations are nearly limitless, but chief among them would be to test the program's influence when language supports, such as background knowledge videos, language translation, and content vocabulary supports are added. These improvements could be evaluated in a myriad of ways, such as examining their effect on students with language and special education needs, investigating the impact such improvements would have on the individual learning pathways students take, and analyzing how the improvements affect overall skill development.

Finally, the observed effects of the Digital Comprehension program on main idea skills support the development of similar programs that could address the broad range of other specific comprehension skills. Adaptive CAI programs could be designed to bolster students' ability to make inferences, compare and contrast details, analyze problems and solutions, identify sequence of events, and summarize. Such programs could be assessed in a similar fashion and the ideal use of adaptive CAI for comprehension skills instruction could be explored.

Application of the Intervention

This study established the Digital Comprehension program as a potentially powerful tool for providing valuable remediation to struggling readers. In the future it could be disseminated to the education community and used, either as a stand-alone intervention or as part of a more comprehension curriculum to improve the comprehension skills of struggling readers. However, the study's findings should be confirmed through further extensive testing involving wider populations and in other settings before the Digital Comprehension program is put into wider implementation.

Future research needs to determine the optimal format for such remediation, such as whether it should be administered as part of a teacher-led curriculum or remain as a stand-alone intervention. Future research should also investigate improvements to the program and how it may be paired with other adaptive CAI programs that address other specific comprehension skills.

Closing

The task of providing our struggling readers with effective, research-based instruction is a daunting one. Students' skill levels vary greatly and the challenge of addressing each students' unique needs requires the flexible application of differentiated instructional practices. The use of adaptive computer assisted instruction may provide teachers with an effective tool for differentiating literacy skills instruction. Such use of instructional technology has been shown to lead to significant improvement in a myriad of areas, but research into this technology ability to address specific comprehension skills has been limited.

This dissertation project evaluated the use of an adaptive computer assisted program on struggling upper-elementary readers' comprehension skills, specifically their ability to identify the main idea. The study's positive findings, especially as they relate to main idea skill

development, show the unique role adaptive CAI could play in our efforts to close the literacy gap and provide more of our students with the effective instruction they require.

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Appendix A

Principal Consent Letter

To whom it may concern,

I am writing this letter in support of Scott Toonder's research study "The Impact of Adaptive Instructional Software on Reading Comprehension: Identifying the Main Idea" that is being conducted in conjunction with Lehigh University under the supervision of Dr. Brook Sawyer.

I consent to him recruiting approximately 40 students from our school's third, fourth, and fifth grade classes in order to conduct his research on how instructional software can impact students' ability to identify the main idea. I understand that half of these students will be assigned to take part in his researcher-designed instructional software intervention for a period of approximately seven weeks during our school's small-group reading intervention time, in addition to receiving business as usual reading instruction. The other group will only receive business as usual instruction.

I have been assured that all participation on the part of students will be voluntary and that all parents will provide written informed consent. I have also been assured that all student identities and data will be kept anonymous and confidential at all times.

Sincerely,

Eric Fontanez
Principal of Marvine Elementary School
1425 Livingston Street
Bethlehem, PA 18017

Appendix B

Student Consent Letter

Dear _____,

I created a new computer program to help students with reading. I am asking for your help to see if it works.

If you agree to help, you will first be asked to answer some questions about reading. Then, you will be placed in one of two groups. One of the groups will use the computer program that I created, and the other will not. When the program is finished, everyone will answer some more questions about reading. Then, I'll look to see if the computer program helps students with their reading.

It is okay to say no to trying the reading program. If you decide to try the reading program, you will be allowed to stop using the program whenever you want. Saying no or stopping the program won't hurt your grades.

If you would like to try out the program, please sign your name below.

Signature: _____ Date: _____

Appendix C

Parental Consent Form

LEHIGH UNIVERSITY®

PARENTAL CONSENT FORM

The Impact of Adaptive Instructional Software on Reading Comprehension: Identifying the Main Idea

Your child has been invited to take part in a research study to determine whether a reading software program can help elementary students improve their reading comprehension. They were selected as a possible participant because they have been identified by the school as needing reading support. We ask that you read this form and ask any questions you may have before agreeing to allow your child to participate in the study.

This study is being conducted by:
Scott Toonder, a doctoral student in the Teaching, Learning, and Technology program at Lehigh University. The supervising professor and principal investigator is Dr. Brook Sawyer.

Scott Toonder is a contracted reading specialist at the school. However, his role as the school's reading specialist is independent from his role as a researcher for this study.

Background Information

The purpose of this study is:
To determine if the educational reading software improves the reading skills of elementary school students that need additional reading support.

Procedures

If you agree for your child to be in this study, you are providing permission for the following things:

- Take two reading ability tests which take approximately 30 minutes each at the beginning and end of the study. These will not count as grades for school.
- Allow your child to be assigned to one of two groups: (a) students use the reading software as part of their small group reading instruction along with continuing to receive their regular reading instruction in school and (b) students will continue to receive their regular reading instruction but will not use the educational reading software.
    - If your child is assigned to the group that uses the educational reading software, each session on the software will take approximately 20-30 minutes for your child to complete.
    - If your child is assigned to the group that does not use the reading software, they will be given the opportunity to use the software after the study has ended.

Risks and Benefits of Being in the Study

The risks to participants are:
There are no more than minimal risks for participating in this study. In order to mitigate any risks that do exist or arise, you or your child may choose to withdraw from the study at any time. In the event that any unexpected adverse effects are noted by the researcher, the study will be discontinued until those risks can be eliminated.

The benefits to participation are:
Your child's reading skills may improve if they participate. Your participation will benefit other students by helping us determine whether the educational reading software is a way to help students improve their reading skills.

Compensation

There will be no compensation for participating in this study.

Confidentiality

The records of this study will be kept confidential and any information collected through this research project that personally identifies your child will not be voluntarily released or disclosed without your separate consent, except as specifically required by law. In any sort of report that might be published, we will not include any information that will make it possible to identify your child. Research records will be stored securely, and only the researcher will have access to the records.

Voluntary Nature of the Study

Participation in this study is voluntary:
Your decision whether or not to allow your child to participate will not affect your current or future relations with Lehigh University,Marvine Elementary School, or Bethlehem Area School District. If you decide for your child to participate, you and/or your child are free to not answer any question or withdraw at any time without affecting those relationships.

Contacts and Questions

The researchers conducting this study is:
Scott Toonder. You may ask any questions you have before consenting. If you have any questions, **you are encouraged** to contact Lehigh University, email Scott at stoonder@basdschools.org, or email Dr. Sawyer at lbs211@lehigh.edu.

Questions or Concerns:
If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher or his supervising professor, **you are encouraged** to contact Lehigh University's Office of Research Integrity at (610) 758-2871 or inirb@lehigh.edu. All reports or correspondence will be kept confidential.

You will be given a copy of this information to keep for your records.

Statement of Consent

I have read the above information. I have had the opportunity to ask questions and have my questions answered. I consent to participate in the study.

Signature of parent or guardian:_____ Date: _____

Signature of Investigator:_____ Date: _____

Consent to Access Student Records

In research, it is also important to understand the characteristics of students who participated in the project. This allows us to know who the intervention may work for in the future. We are also asking your permission to access your child's school records to document your child's demographic information and the services they receive. This will consist of your child's grade, gender, race/ethnicity, English language learner status, and whether or not your

child receives special education services. We will not review your child's records for any other information or purpose.

- Your child's demographic information and education records will be kept anonymous at all times. They will be assigned an identification number at the beginning of the study and all records and data will only refer to them by using that identification number.

Please check here to indicate if you give permission to access the specific information we listed above.

____ Yes, you may access my child's records to determine their demographic information and the services that they receive.

____ No, you may not access my child's records to determine their demographic information and the services that they receive.

Signature of parent or guardian:_____ Date: _____

Appendix D

Main Idea Assessment, Sample Passage and Rubric

Sample Passage:

Titanic's *Forgotten Sister*

You probably know the story of the *Titanic*. However, you might not know the story of her sister ship, the *Britannic*. When the *Titanic* sank in 1912, the *Britannic* was half-built and its builders were wary of sending her out to sea. They took extra precautions to protect it from a tragic fate.

The ship's owners were sure the *Britannic* was unsinkable, but their confidence was premature. During World War I, the *Britannic* was used to transport wounded British soldiers. That's when the ship was hit by a German torpedo or mine. It sank to the murky depths of the Aegean Sea.

Dr. Robert Ballard, an explorer, had questions about the *Britannic*. First, why did the Germans attack a hospital ship which they should have ignored? Secondly, why did the ship sink in only 57 minutes when it had safety features that should have kept it afloat?

After an in-depth investigation, even Dr. Ballard and his team don't have the answers. They remain buried with the *Britannic* in its watery grave.

Students follow the writing prompt: "This story was about..."

Main Idea Assessment Rubric:

	The student presented an accurate and complete general topic and main idea statement.	The student presented an accurate general topic, but the main idea statement was only partially accurate or complete.	The student presented an accurate general topic, but failed to present an accurate main idea statement.	The student failed to present an accurate general topic or main idea statement.
Passage 1	3	2	1	0
Passage 2	3	2	1	0
Passage 3	3	2	1	0
Passage 4	3	2	1	0
Passage 5	3	2	1	0
Passage 6	3	2	1	0
Passage 7	3	2	1	0
Passage 8	3	2	1	0
Passage 9	3	2	1	0
Passage 10	3	2	1	0

Appendix E

Student Perceptions Survey

	Strongly Disagree  **1**	**Disagree**  **2**	**Not Sure**  **3**	**Agree**  **4**	**Strongly Agree**  **5**
1. I think that this reading program made me better at identifying the main idea.					
2. I think this program made me a better reader.					
3. I think I will be able to use the things I learned in this program when I read other things					
4. I liked using the computer for this reading program.					
5. I think that this program would help my other classmates and friends.					
6. I think that completing this program will help me do well in other school subjects.					
7. I thought this program was fun.					
8. This program helped me like reading more.					

Scott Toonder

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Research Interests

Adaptive Educational Technology, Visualization in Reading, Phonological and Phonemic Awareness, Reading Comprehension, Impacts of Poverty on Education

Education

Lehigh University — Bethlehem, Pennsylvania
Doctor of Philosophy in Teaching, Learning, and Technology — 2020

Moravian College — Bethlehem, Pennsylvania
Master of Education in Curriculum and Instruction — 2012

Kutztown University — Kutztown, Pennsylvania
Bachelor of Science in Education — 2006

Work Experience

Literacy Specialist, Bethlehem Area School District — 2007 – Present
READ 180 Stage A Blogger, Scholastic Education — 2011 – 2018
Educational Consultant, Scholastic Education — 2010 – 2014

Honors and Awards

Nominated for the Elizabeth V. Stout Dissertation Award — 2020
Student honored with Scholastic's national System 44 All-Star Award — 2014
Nominated for Moravian College's Master of Education Thesis Award — 2012
Recipient of Scholastic's national System 44 Outstanding Educator Award — 2010
Student honored with Scholastic's national System 44 All-Star Award — 2009
Recipient of Bethlehem Area School District's Certificate of Excellence — 2008
Nominated for Scholastic's national READ 180 Outstanding Educator Award — 2008
Recipient of Bethlehem Area School District's Award of Commendation — 2008

Publishing History

"The Traveler's Companion," *Dreaming Robot Press*	2017
"The Seven Squares," *Scholastic Inc.*	2013
"Quynh and the Golden Gate," *Spider*	2013
"The Five Snakes," *Scholastic Inc.*	2011
"The Fading Star," *Silver Blade's "Screams and Dreams" Anthology*	2010

Presentations and Advisory Boards

Boston Literacy Summit- Boston, Massachusetts	2014
Read 180 National Summer Institute- Orlando, Florida	2014
Digital Learning Day- Washington D. C.	2014
Scholastic's Outstanding Educator Advisory Board- New York, New York	2013
Bill and Melinda Gates Foundation Round Table Discussion- New York, NY	2013
Scholastic's Outstanding Educator Advisory Board- New York, New York	2011
Read 180 National Summer Institute- Orlando, Florida	2010
Read 180 National Summer Institute- Nashville, Tennessee	2009