EFFECTS OF CONTENT ACQUISITION PODCASTS ON VOCABULARY PERFORMANCE OF SECONDARY STUDENTS WITH AND WITHOUT LEARNING DISABILITIES

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ABSTRACT

The purpose of this experimental research study was to investigate effects of using Content Acquisition Podcasts (CAPs) to provide vocabulary instruction to adolescents with and without learning disabilities (LD). A total of 279 urban high school students, including 30 with LD in an area related to reading, were randomly assigned to one of four experimental conditions with instruction occurring at individual computer terminals over a three-week period. The four experimental conditions contained various combinations of multimedia-instruction and evidence-based practices for vocabulary instruction including: (a) CAPs designed using validated instructional design principles and a combination of explicit instruction and the keyword mnemonic strategy (Group 1); (b) CAPs with validated design principles and only explicit instruction (Group 2); (c) CAPs with validated design principles and only the keyword mnemonic strategy (Group 3); and (d) multimedia instruction without adherence to validated design principles and explicit instruction (Group 4). Results indicated that students with LD who received vocabulary instruction using CAPs with explicit instruction and the keyword mnemonic strategy (Group 1) significantly outperformed all other students with LD on measures of vocabulary knowledge on a posttest of 30 history-specific vocabulary terms, and again on a maintenance probe three weeks later for 10 history terms. In addition, students with LD in Group 1 significantly outperformed students without disabilities who received multimedia instruction that did not adhere to validated design principles at posttest and maintenance (Group 4), and had higher mean scores than students without LD in Groups 2 and 3. Students without disabilities in Group 1 significantly outperformed all other students at both posttest and maintenance. A student satisfaction survey indicated a strong student preference for learning vocabulary using the CAPs.

DEDICATION

This dissertation is dedicated to the memory of Mrs. Mary Brieck—a treasured colleague and great friend. After putting her infinite wisdom and patience on full display when mentoring me while writing my first grant proposal, she presided, smiling, as I clicked the submit button for the first time. Every time I repeat this process in the future, I will remember that crazy week when she and I skipped the first two days of the NCAA tournament, and became friends. She will be missed, and remembered, always.

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CHAPTER I

INTRODUCTION

The No Child Left Behind (NCLB) Act of 2001 provided a directive that students with disabilities be included in school accountability measures (McKenzie, 2009). Coupled with stipulations set forth in the Individuals with Disabilities Education Act (IDEA 2004), the prevailing paradigm for students with disabilities shifted from having a right to *access* education to having a right to access *accountable* education. The question remains, however, whether *accountable* education translates to *effective* education.

Unfortunately, many students emerge from American high schools without the requisite skills to succeed in the 21st-century global environment (Carnegie Council on Advancing Adolescent Literacy [CCAAL], 2010); this includes students with and without disabilities (National Joint Committee on Learning Disabilities [NJCLD], 2007). Indeed, for students with learning disabilities (LD), limited academic skills and poor academic performance during formal schooling frequently manifests as lifelong struggles (Cortiella, 2009). To illustrate, approximately 61% of students with LD graduate from high school with a regular diploma, as opposed to 87.6% of students in the general population (U. S. Department of Education, National Center for Education Studies [NCES], 2007). The National Longitudinal Transition Study II [NLTS II]; (Wagner et al., 2005) found (a) 21% of students with LD were five or more grade levels below in reading; (b) 31% of students with LD dropped out of school compared to 9.4% of peers without disabilities; and (c) only 11% of students with LD had attended postsecondary institutions. Further, according to data from states with mandatory exit examinations, a disproportionate percentage of students with disabilities underperform compared to their peers without disabilities in four tested areas: English, algebra, biology, and physical science (Zhang, Katsiyannis, & Kortering, 2007). These statistics are alarming. Yet, considering the demands of accountability and related pressure to cover vast amounts of curriculum (Frase-Blunt, 2000), there is little reason to expect significant improvements to these outcomes will be forthcoming without explicit action on the part of researchers and practitioners (Wise, 2010).

Given pervasive, negative outcomes for an unacceptably large number of students with and without LD, it is incumbent upon researchers and practitioners to develop, test, and disseminate interventions that support the cognitive and academic learning needs of adolescents with LD who are required to successfully respond to rigorous curricular and post-school demands. Specifically, interventions should be grounded in theory and empirical findings related to cognitive processing structures and functioning for adolescents with LD. In addition, those who design new interventions must take careful note of the demands of specific content areas and break those demands into the component skills that underlie higher-order learning tasks. Designing instruction that meets both specific cognitive and academic demands is complex. However, emerging developments in the use of multimedia learning to support cognition and deliver effective instruction provide a logical starting point for this critical work (Kennedy & Deshler, 2010).

Significant scholarship regarding the structure and function of cognitive processing for students with LD provides a roadmap for the design of effective instructional practices (Daneman & Carpenter, 1980; Johnson et al., 2010; Swanson, 2001, 2009; Swanson, Cooney, & McNamara, 2004; Swanson & Deshler, 2005; Swanson & Hoskyn, 2003; Swanson & Saez, 2005; Swanson, Zheng, & Jerman, 2009). For example, several studies have found that students with LD in the area of reading also have trouble with tasks that require short-term retention of ordered information (McDougall, Hulme, Ellis, & Monk, 1994; Swanson, Cooney, &

O'Shaughnessy, 1998; Swanson et al., 2009), which is an indicator of inefficient phonological rehearsal processing (Henry & Millar, 1993; cited in Swanson et al., 2009, p. 261). In addition, seminal work by Daneman and Carpenter (1980) has demonstrated high correlations (.66) between working memory (WM) and various measures of achievement (e.g., reading comprehension, language comprehension; Swanson et al., 2009). Based partially on Daneman and Carpenter's work, a recent meta-analysis by Swanson and colleagues (2009) demonstrated that many students with LD in areas related to reading also have separate processing challenges within WM and short-term memory (STM) that impact learning.

The functional impact of challenges within WM and STM for adolescents with LD include limited capacity to comprehend various types of texts (e.g., narrative, expository; Berkeley et al., 2011; Faggella-Luby & Deshler, 2008; Roberts et al., 2008); communicate through writing (Graham, 2008); use higher-order thinking skills to solve problems (Swanson, 2009; Swanson & Deshler, 2005); and retain essential information (e.g., vocabulary definitions, important facts/dates, procedures for various tasks; Bulgren et al., 2007; Scruggs et al., 2010; Swanson, 2001). Therefore, to be effective, interventions should be tailored to first support, and then augment the WM and STM capacity of students.

To address processing issues within WM, STM, and long-term memory (LTM), it is critical to understand the structure and purpose of each. Baddeley's (1986) influential model of WM provides a useful framework. It consists of (a) a phonological loop for processing auditory information; (b) a visuospatial sketchpad for processing visual and spatial information; (c) a central executive, which functions as the control for all other cognitive systems; and (d) an episodic buffer that coordinates metacognition for stimuli being relayed between LTM and WM and STM. Each of the structures within Baddeley's model is limited with respect to its capacity to interpret incoming information and then rapidly makes connections within LTM that result in learning (Sweller, 2005). Thus, Baddeley's model helps designers of instructional materials recognize the distinct processing challenges associated with processing incoming stimuli given extremely limited capacity within WM to retain information. An applied example of Baddeley's model is Mayer's cognitive theory of multimedia learning [CTML], (2001, 2005, 2009). Mayer (2009) refers to the CTML as a student-centered learning theory. This is a critical distinction from other technology-centered interventions, which lack Mayer's specific attention to issues related to cognitive processing. The theory posits:

> Meaningful learning occurs when learners are able to pay attention to relevant portions of the words and graphics as they are registered in sensory memory, mentally organize them into coherent cognitive structures in working memory, and connect the verbal and pictorial representations with each other and with relevant knowledge retrieved from long-term memory. (Mayer & Johnson, 2008, p. 380).

Mayer's CTML is also built on Paivio's (1986) dual processing theory, which holds that humans access stimuli through visual and auditory channels, as well as cognitive load theory (Chandler & Sweller, 1991), which holds that cognitive processes are limited and can quickly be overwhelmed by environmental stimuli. Thus, Mayer (2009) leveraged Baddeley's model by incorporating the dual processing and cognitive load theories to provide a roadmap for the design of multimedia instruction that limits cognitive load while maximizing human capacity to learn through both input channels (DeLeuuw & Mayer, 2008). Indeed, Mayer's model includes a set of validated steps for the design of multimedia instruction that constitute a roadmap for creating instructional materials that limit extraneous cognitive processing, manage essential processing, and foster active processing (DeLeeuw & Mayer).

In summary, the use of multimedia instruction, if designed according to solid theoretical principles, can be considered in the design and delivery of instruction for adolescents with LD. However, multimedia instruction alone without careful consideration for the subject-matter content to be delivered is not sufficient to result in learning. Therefore, evidence-based interventions for specific subject-matter content demands should be evaluated to determine the extent to which they can be combined with multimedia instruction to support the cognition and learning of adolescents with LD (Kennedy & Deshler, 2010).

As noted, a critical element of effective instruction in content areas for adolescents with LD is the need to break academic demands into their component skill elements. For those designing instructional materials, component skills with high payoffs with respect to supporting advanced thinking and performance tasks should be identified and prioritized. In secondary-level content-area classrooms, vocabulary knowledge is an example of a high-leverage academic skill (Ebbers & Denton, 2008).

Thus, vocabulary knowledge is essential for success during many tasks common within academic learning, including comprehension and fluency (National Reading Panel, 2000; Rand Reading Study Group, 2002); higher-order thinking (Conley, 2008; Lee & Spratley, 2010; Shanahan & Shanahan, 2008); and writing (Graham, 2008). Helping students understand the multiple meanings of words so they can comprehend and use them in various contexts is the primary goal of vocabulary instruction at the secondary level (Baumann, Kame'enui & Ash, 2003; McKeown & Beck, 2006). Thus, for students with LD, significant attention is needed to determine ways to structure successful and sustained engagement with new vocabulary words and concepts (Bryant, Goodwin, Bryant, & Higgins, 2003; Ebbers & Denton, 2008; Jitendra, Edwards, Sacks, & Jacobsen, 2004).

Key themes in the field of vocabulary instruction include (a) helping students become aware of the semantic parts of words (Bos & Anders, 1990; Nagy, 2007; Scammacca et al., 2008); (b) dedicating instructional time to teaching word parts and meanings (Nagy, 2007; Nagy, Berninger, & Abbott, 2006); and (c) explicitly teaching strategies for forming connections between semantically related terms (Baumann & Kame'enui, 2004; Graves, 2006; Nagy et al.). Two categories of vocabulary instruction are necessary to help translate these themes into practice; (a) teaching the definitions of terms and (b) teaching students the skills and strategies needed to decipher words (Graves, 2006; Stahl & Kapinus, 2001). This delineation is referred to as non-generative and generative teaching strategies, respectively (Harris et al., 2011). For students with LD, both direct instruction in word meanings (non-generative) and building of capacity through the use of strategies (generative) are needed for successful learning (Bryant et al., 2003; Ebbers & Denton, 2008; Harris et al.; Jitendra et al., 2004; Pullen et al., 2010).

In the present study, an intervention called Content Acquisition Podcasts (CAPs) will be tested for the purpose of evaluating their effect on vocabulary performance of adolescents with and without LD. CAPs are multimedia-based instructional modules created using Mayer's CTML and accompanying instructional design features. Each CAP contains evidence-based vocabulary instruction for one critical vocabulary term or concept. An example of a vocabulary term used in the present study is convoys (a group of warships protecting merchant ships), while a concept is Nationalism (strong pride in one's country). Each CAP in this study lasted approximately 120 seconds. The evidence-based vocabulary instruction includes examples of explicit instruction (e.g., direct instruction in word meaning and word parts) and strategy instruction (e.g., the keyword mnemonic strategy; Mastropieri, Scruggs, & Levin, 1985). This is critical because empirical evidence in the field of vocabulary instruction holds that a blend of methods, including explicit and strategic instruction, should be used to achieve maximum learning effects (Baumann et al., 2000; Bryant et al., 2003; Ebbers & Denton, 2008; Jitendra et al., 2004). CAPs can be viewed on a computer, portable handheld device (e.g., iPods), or any other media player without the typical barriers of classrooms. CAPs have been used to promote effective learning for undergraduate teacher candidates (Kennedy, Hart, & Kellems, 2010); the present study was an attempt to advance this line of research.

Thus, the purpose of this experimental study was to explore use of CAPs to improve vocabulary learning for adolescents with LD enrolled in rigorous secondary-level content-area classrooms. Four configurations of CAPs with embedded evidence-based vocabulary instruction, (a) combination of explicit and strategy instruction, (b) just explicit instruction, (c) just strategy instruction, (d) no adherence to Mayer's model, were experimentally tested in an attempt to determine the most efficient and effective combination of multimedia and vocabulary instruction.

In summary, CAPs were used to determine if multimedia instruction that adheres to theoretical instructional design principles can be combined with evidence-based vocabulary instruction to promote learning for adolescents with LD. The study will add to the limited but growing evidence-base for the use of technology in vocabulary instruction for adolescents with LD.

CHAPTER II

LITERATURE REVIEW

It is important to critically examine the individual building blocks of success within content-area learning tasks when searching for logical, yet powerful ways to improve academic outcomes for adolescents with learning disabilities (LD). For example, success in a high school social studies course requires students to read and comprehend narrative and expository texts (VanSledright, 2008); participate in higher order thinking skills during reading (Faggella-Luby & Deshler, 2008), contribute to discussions and assignments using disciplinary knowledge (de la Paz, 2005; Weinberg, 1991); and create written products for a variety of purposes (e.g., informative, persuasive; Graham, 2008).

Although reading comprehension is critical to each of these disciplinary demands, an essential building block of reading comprehension is vocabulary knowledge (Ebbers & Denton, 2008; National Reading Panel, 2000; Rand Reading Study Group, 2002), including definitional, contextual, and functional awareness of terms and concepts that are both discipline-specific and discipline-generic (Conley, 2008; Shanahan & Shanahan, 2008). The ability to rapidly and accurately store and retrieve context-appropriate definitions of vocabulary terms and concepts through interactivity between working memory and long-term memory is difficult for many students with LD (Pullen et al., 2010; Roberts et al., 2008). Therefore, providing support for vocabulary learning, and later, structured memory retrieval is one of the cornerstones of academic success for this population of learners (Bryant et al., 2003; Ebbers & Denton, 2008; Jitendra et al., 2004; Pullen et al., 2010), and is the basis for this research study.

This chapter is divided into two major sections. The purpose of the first major section is to provide a foundational understanding of the cognitive structures and attributes of adolescents with LD as they relate to preventing efficient and effective learning. Accordingly, the section is divided into three subsections: (a) discussion of cognitive learning structures that underpin the theoretical foundation for this research study, including a brief review of how the academic demands of content-area classrooms affect adolescents with LD; (b) presentation of the study's theoretical framework, Mayer's cognitive theory of multimedia learning; and (c) review of a conceptual framework (Kennedy & Deshler, 2010) and the relevant empirical literature relating to multimedia-based instruction, to provide a basis for integrating high-quality multimedia instruction with evidence-based instructional practices.

The purpose of the second major section is to review literature relating to effective vocabulary instructional practices for adolescents. It is made up of two subsections. The first presents a broad review of essential theoretical and empirical literature relating to the field of vocabulary instruction; the second is a review of empirical studies in the field of vocabulary instruction for students with LD. The section concludes with a review of three studies in which researchers used multimedia methods to deliver vocabulary instruction to adolescents with disabilities (Horton, Lovitt, & Givins, 1988; Johnson, Gersten, & Carnine, 1987; Xin & Rieth, 2001). The chapter concludes with a statement of the purpose and corresponding research questions for the study.

Structure and Function of Memory for Adolescents with LD

Adolescents with LD face a multitude of challenges in school and beyond (Deshler & Shumaker, 2006; Roberts et al., 2008; Scammacca et al., 2008). These challenges include limited capacity to comprehend various types of texts (e.g., narrative, expository; Berkeley et al., 2011; Faggella-Luby & Deshler, 2008; Roberts et al.); communicate through writing (Graham, 2008); use higher order thinking skills to solve problems (Swanson, 2009; Swanson & Deshler, 2005); and retain essential information (e.g., vocabulary definitions, important facts/dates, procedures for various tasks; Bulgren et al., 2007; Scruggs et al., 2010; Swanson, 2001). Each of these challenges is rooted in issues related to imperfect cognitive processing, which includes the overall structure, speed, functionality, and interworking of short-term (STM), working memory (WM) and long-term memory (LTM; Davidson & Strucker, 2002; Swanson, 2001; Swanson & Saez, 2005; Swanson, Zhang, & Jerman, 2009). Therefore, instructional interventions and learning materials designed to help students improve academic and other outcomes must explicitly address the cognitive processing strengths and weaknesses of individual students.

In the first section that follows, three major types of memory (i.e., WM, STM, LTM) will be outlined, with specific attention given to their effect on the cognitive processing of adolescents with LD. Difficulty in cognitive processing presents significant challenges for students, and an equally challenging assignment for the educators who teach these struggling students (Deshler & Shumaker, 2006; Greene & Azevedo, 2007; Scruggs, Mastropieri, & Okolo, 2008). This review of the major types of memory and implications for adolescents with LD provides a rationale for the theoretical framework chosen for this study, and presented in the second section, Mayer's cognitive theory of multimedia learning (CTML; 2001, 2005, 2009). The CTML is grounded in theoretical and empirical literature relating to human cognition (Sweller, 2005; Mayer, 2005, 2009), and is intended to guide educators' efforts to support students during learning activities that require interactions between WM, STM, and LTM. The CTML provides a framework to guide instructional design that maximizes the cognitive capacity of all learners; however, in this study, the CTML will be offered as a guide for designing instruction that is a match for the cognitive needs of adolescents with LD.

Structure of Cognitive Resources

Given the presence of cognitive processing deficits in adolescents with LD, a key issue for researchers and practitioners to be aware of in promoting content-area learning is memory (Klingberg et al., 2002; Swanson, 2001; Swanson & Saez, 2005; Swanson et al., 2009). For the purposes of this study, three types of memory will be reviewed: working memory (WM), short-term memory (STM), and long-term memory (LTM). Although there is some degree of disagreement regarding the exact structure and function of these three types of memory (Ericsson & Kintsch, 1995), most agree that they are essential to the academic success and overall functioning of all students (Baddeley, 1986, 2008; Swanson, 2001, 2009; Swanson & Hoskyn, 2003).

Working memory. WM is defined as "a system for the temporary holding and manipulation of information during the performance of a range of cognitive tasks such as comprehension, learning, and reasoning" (Baddeley, 1986, p. 34). WM has also been described as mental workspace for manipulating information or schemas located within LTM (Stoltzfus, Hasher, & Zacks, 1996). In other words, WM is an individual's available cognitive processes for engaging incoming stimuli, retrieving information stored in LTM, and developing new schemas for storage in LTM (Carlson, Chandler, & Sweller, 2003). As such, WM is critical to academic success (Savage et al., 2005; Stringer & Stanovich, 2000; Wagner & Torgesen, 1987).

Several models of WM have been presented across the history of the field of cognitive psychology (Baddeley et al., 2009; Ericsson & Kintsch, 1995; Klingberg et al., 2002). The most prominent and influential was advanced by the British psychologist Alan Baddeley. Baddeley's original model (1986) was comprised of three interdependent elements of working memory, (a) a phonological loop, (b) a visuospatial sketchpad, and (c) a central executive that controls the other two systems. In this model, the central executive is key to the functionality of WM (Baddeley, 1986; Baddeley, Eysenck, & Anderson, 2009). Recently, Baddeley added the construct of an episodic buffer to better describe how WM and LTM work together to result in learning (Baddeley, 2006; Baddeley et al., 2009). This model of WM is useful in detangling some of the problems adolescents with LD face when engaged in academic learning tasks. A brief description of the three elements of Baddeley's model follows.

Phonological loop. According to Baddeley (1986), the phonological loop is a limited, speech-based store of verbal information within the mind. All incoming auditory stimuli enter the phonological loop for processing. It is divided into two subcomponents, a temporary, passive phonological input store and a subvocal, articulatory rehearsal process (Baddeley et al., 2009). The passive phonological input store functions like a mental tape recorder; however, information is only held for approximately two seconds before being erased or replaced with newer information (Baddeley, 1986). Because of the limited capacity of the phonological loop to interpret incoming speech and instantaneously use other WM resources to search for appropriate schemas located within LTM, the rate with which auditory information is presented is critical (Baddeley, 2008). This has significant implications for teachers and designers of multimedia instructional materials.

The process of recording and replacing information within the phonological loop is constant. Therefore, recorded information is rapidly and constantly erased or replaced with new information if not immediately acted upon through intentional rehearsal (Baddeley, 1986). Rehearsal may include the person repeating the information to him or herself, which functions to repeatedly rerecord the information within the phonological loop provided conscious attention is maintained on the information (Baddeley et al., 2009). If rehearsal is successful, the phonological loop transforms incoming information into phonological codes that include the acoustic, temporal, and sequential properties of the verbal information (Gilliam & van Kleeck, 1996). Phonological codes activate similar codes within LTM to update existing schemas for various concepts (Baddeley, 1986).

This process can be intentionally facilitated by instruction that provides cues to existing schemas, if the schemas are well organized (Swanson, 2001, 2009; Swanson et al., 2009). At the middle school and high school levels, teacher-driven strategy and skill instruction helps students remember key concepts, engage ideas and concepts from the perspective of an expert, and construct new understandings based on analyses of provided information (Bulgren et al., 2007; Deshler & Shumaker, 2006; Ferretti, MacArthur, & Okolo, 2001; Gersten et al., 2006; Scruggs et al., 2008).

In summary, the phonological loop is the mechanism people use to interpret auditory information, but its capacity is extremely limited. Successful coding of incoming auditory messages and connection with codes and schemas within LTM depends heavily on organization of prior knowledge within a learner's LTM stores, and the speed with which WM resources can locate and activate those schemas in LTM (Sweller, 2005). Typically, adolescents with LD have smaller banks of content-specific knowledge, and knowledge that does exist may be disorganized compared to students without LD (Johnson et al., 2010; Swanson, 2001; Swanson & Deshler, 2005). Based on this research, teachers of students with LD should (a) pay careful attention to their rate and density of speech given the intended audience (Baddeley, 2008); (b) make use of cues to prompt students to remember key information through strategic rehearsal (e.g., Scruggs et al., 2010; Swanson, 2009); and (c) prioritize critical content so extraneous information does not unintentionally overwrite available storage space within the phonological loop (Lenz, Deshler, & Kissam, 2006).

Visuospatial sketchpad. People do not only access information through auditory means. They also rely on visual information to facilitate understanding and remembering. Thus, it is important to combine auditory and visual cues to maximize instructional power (Baddeley, 2008; Mayer, 2009). Within Baddeley's model of WM, the visuospatial sketchpad is involved in the interpretation and creation of mental imagery and spatial mental models (De Beni, Pazzaglia, Meneghetti, & Mondoloni, 2007). The form and function of the visuospatial sketchpad is similar to that of the phonological loop, except visual images and spatial information are processed instead of auditory information (Baddeley, 2006). The visuospatial sketchpad is also extremely limited with respect to the amount of information that can be retained without rehearsal (Baddeley, 1986). The limited nature of both the phonological loop and the visuospatial sketchpad should guide instructional designers and teachers when selecting images and planning comments to be delivered during instructional settings (Mayer, 2001, 2005, 2009; Sweller, 2005). In other words, this model suggests that only the most important words and images with respect to a topic should be presented to learners in order to maximize limited capacity within WM (Mayer, 2009).

To illustrate, consider a typical high school world history course. Mr. Boeheim is leading a lecture from the front of the classroom; he has bulleted slides that are projected on a screen. According to Baddeley's model (1986), and Mayer's research (2009), Mr. Boeheim's auditory message is internalized using the phonological loop, but the visuospatial sketchpad is also being utilized via the text on the screen. But since both the phonological loop and visuospatial sketchpad are limited, students with cognitive processing deficits may find themselves overloaded given the structure of Mr. Boeheim's instruction. This is an example of Mayer's redundancy principle, which states that too much on-screen text when coupled with an audio message of essentially the same content results in cognitive overload and a lack of learning. Teachers and instructional designers need to find improved methods for designing and delivering course content to students to avoid this potential problem.

Interworking of the phonological loop and visuospatial sketchpad. The phonological loop and visuospatial sketchpad work closely together to help students succeed during learning tasks. For example, the phonological loop often attaches word-based labels to incoming images, which acts as a form of rehearsal for both auditory information and visuospatial stimuli (Baddeley et al., 2009). Baddeley (1986) theorized that the visuospatial sketchpad plays an important role in reading, as printed words and other images are visually encoded while a visuospatial frame is maintained so readers can accurately track their place (Baddeley; Baddeley et al.). Similarly, incoming audio messages can be reinforced and rehearsed in the phonological loop through visualization and attachment to visual images. This is one reason why instruction that includes visual and auditory stimuli is powerful (Mayer, 2008, 2009). However, as noted above, redundant instruction can be counterproductive in certain learners or under certain conditions (Mayer & Johnson, 2008).

Baddeley's original concepts of the phonological loop and visuospatial sketchpad (1986) was criticized for not fully addressing the complexities of activating schemas within LTM and combining existing and new information (Cowan, 2005; Hulme & Mackenzie, 1992). Because Baddeley describes WM (both the phonological loop and visuospatial sketchpad) as being extremely limited in overall capacity (about two seconds of recording capacity), and highly specific in function, uncertainty remained for how people consistently manage to learn new information through making updates to schemas within LTM (Tronsky, 2005). To address this limitation, Baddeley further developed his concept of a central executive and added a new construct, the episodic buffer, which details cognitive processes that were previously left unspecified.

Central executive and episodic buffer. Whenever a person attempts to store and process information, the central executive is at work (Baddeley et al., 2009; Tronsky, 2005). The central executive is considered by some to be the core of WM (Baddeley, 2008; Baddeley et al., 2009; Torgesen, 1996). "The central executive is analogous to an executive board that controls attention, selects strategies, and integrates information from several different sources. It is modality and domain free, acting as a link between subsystems that are dependent on auditory or visual processing" (Dehn, 2008, p. 22). Baddeley (1986, 2008) described several key functions of the central executive: (a) the ability to focus limited attention on key information while not attending to extraneous information; (b) switching cognitive resources between two or more simultaneous activities; (c) the process of selecting and executing plans and strategies; (d) developing capacity to allocate limited resources to any part of the WM system; and (e) extending the capacity to retrieve, hold, and manipulate information temporarily activated from LTM (Dehn, 2008).

To address critics who commented on the lack of specificity with respect to the connection between WM and LTM, Baddeley (2008) developed his concept of an episodic buffer. WM possesses abstract and conceptual knowledge that goes beyond information held and encoded within the phonological loop or visuospatial sketchpad (Cowan, Saults, & Morey, 2006). Thus, the episodic buffer works within the central executive and overall WM to conduct conscious and targeted searches for schemas within LTM (Baddeley et al., 2009). The episodic buffer works with both auditory and visuospatial codes to search and activate schemas within LTM (Mayer, 2009; Sweller, 2005). The episodic buffer, therefore, interfaces with episodic and semantic memories within LTM, and is capable of directly encoding new information into LTM schemas (Baddeley; Sweller, 2005).

Although methods for directly measuring the effectiveness and efficiency of the central executive are limited, there is evidence that individual differences in central executive functioning are responsible for struggles with tasks that occur within WM (Baddeley, 2008; Swanson, 2009; Swanson et al., 2009). This is an area where students with LD face significant difficulty, as large stores of content knowledge and higher order thinking skills are frequently required as part of secondary-level content-area coursework. Learning is significantly more challenging for adolescents with LD when they do not have adequate existing knowledge or schemas within LTM (Sweller, 2005). A functional understanding of interactions between WM, STM, and LTM is critical in order to develop a roadmap for the design of effective instruction.

Given that people can consciously control the episodic buffer, an opportunity presents itself for instructional designers and teachers to insert instruction that can be used to forge stronger links between WM and LTM. One example of instruction that researchers have created to strengthen communication and functionality between WM and LTM in students with LD is learning strategies (Deshler & Shumaker, 2006; Harris & Pressley, 2005; Swanson & Deshler, 2005). The episodic buffer is similar to the notion of metacognition in that the learner is aware of the cognitive task with which he is dealing; therefore, instruction that guides specific strategic acts has been shown to be beneficial for a wide variety of learning tasks (Deshler & Shumaker; Harris & Pressley; Scruggs et al., 2010).

Short-term memory. For some, WM and STM are synonymous (e.g., Baddeley, 1986; Baddeley et al., 2009; Mayer, 2009; Sweller, 2005). However, recent research (Swanson et al., 2009) has provided compelling evidence showing that, despite difficulty detangling the functions of one from the other, WM and STM perform separate functions, and individually contribute unique variance to explain achievement deficits in students. To illustrate, "STM is used to describe situations in which small amounts of material are held passively (e.g. digit or word span task) and then produced in an untransformed fashion (Swanson et al., 2009, p. 260). In other words, similar to the phonological loop, STM is like an audio recorder that is perpetually erasing itself and recording new information. Therefore, the active processes of WM rely upon a more passive STM to obtain and temporarily hold information to be processed, but STM does not by itself handle processing tasks (Swanson, 2009; Swanson et al.).

Similar to WM, STM is also limited. Therefore, students with LD are frequently challenged by a limited capacity to hold pieces of information in STM (Swanson, Cooney, & O'Shaughnessy, 1998). STM capacity can be increased through rehearsal, or if incoming information can be instantly linked to existing knowledge (Swanson et al., 2009). The difference between Baddeley's construct of WM and Swanson et al.'s functional separation of WM from STM has important implications for preparing and delivering instruction to adolescents with LD. During typical academic coursework, adolescents with LD are bombarded with incoming stimuli from their teachers and related materials (e.g., texts, presentation projections). Therefore, student capacity to hold information in STM, and then consciously or automatically make connections to schemas within LTM, involves several variables that must work in concert to produce efficient learning.

As noted, adolescents with LD may have difficulty with any or all of the cognitive processes involved in learning (Swanson, 2001). Given the presence of deficits, instructional designers and teachers must pay careful attention to the structure and function of each individual step in the cognitive process to help support student learning. Further, given the limitations of

STM, teachers must be cautious about how much information is presented to students in any given time period, and ensure that only critical information is delivered.

Long-term memory. LTM is the most stable of the three types of memory, and has the largest capacity for storage. Changes to schemas within LTM indicate that learning has taken place, and should be the goal of education (Sweller, 2005). There are two types of LTM: *episodic* memory and *semantic* memory. Episodic memory represents our memory of events and experiences. Episodic memory functions somewhat like a video recording of people's lives, yet memories are not necessarily stored in a linear fashion. Semantic memory is a structured record of facts, concepts, and skills that we have acquired. The information in semantic memory is derived from episodic memory, such that we can learn new facts or concepts from our experiences (Baddeley et al., 2009; Sweller).

LTM should not be thought of as a passive receptacle for information and memories. Instead, LTM is active, and works alongside WM to promote active learning and engagement in tasks (Sweller, 2005). Some have promoted a construct of long-term working memory (LTWM; Ericsson & Kintsch, 1995). In Ericsson and Kintsch's model, difficulty in separating function between LTM and WM given processing tasks not related to semantic memories provides justification for combining LTM and WM into one cognitive construct (Sweller). Sweller rejected this combined construct given the usefulness of observing the unique processes within WM and LTM.

Adolescents with LD are likely to have incomplete, disorganized, and potentially insufficient information stored within LTM to be successful during challenging academic tasks that are highly specific to the various content areas at the secondary level (Brownell, Mellard, & Deshler, 1993; Johnson et al., 2010; Stanovich, 1986; Swanson, 2001). Limitations of knowledge and schemas within LTM directly relate to additional cognitive load within WM and STM, and frequently result in the loss of information and opportunity to create lasting schemas (Swanson & Hoskyn, 1998; Sweller, 2005). Sweller reported, "schemas in LTM act as a central executive for WM", and goes on to say, "organized information in LTM directs the manner in which information is processed in WM" (p. 25). Therefore, the structure of instruction, especially for students with LD, is critical to promote efficient learning without overtaxing limited WM and STM capacity (Marcus, Cooper, & Sweller, 1996; Swanson, 2001).

Summary of cognitive limitations on the academic achievement of adolescents with LD. Adolescents with specific learning disabilities typically have difficulty with tasks related to cognitive processing (Brownell et al., 1993; Carnine, 1991; Deshler & Shumaker, 2006, 1988; Swanson, 2001; Swanson, Zheng, & Jerman, 2009). For example, problems during cognitive processing can result in inefficient processing of incoming information within STM and WM, which in turn creates problems of access and transfer of information stored in LTM (Baddeley et al., 2009; Johnson et al., 2010; Swanson, 2001, 2009; Swanson et al., 2009). In classrooms, problems with cognitive processing often result in student frustration, inattention, and lack of learning (Brownell et al.; Swanson & Hoskyn, 2003; Swanson & Deshler, 2005; Swanson, 2001).

A recent meta-analysis by Swanson and colleagues (2009) showed that students with cognitive memory impairments scored on average one standard deviation lower than chronologically matched students when effect sizes from various measures of cognitive and academic performance were combined. Researchers have noted similar cognitive processing deficits in elementary-age students, which can have a snowball effect on the overall achievement of adolescents stemming from the cumulative lack of cognitive and skill development in LTM

(Stanovich, 1986; Swanson, 2001). When overall achievement level is held constant, older students perform worse on measures of memory performance compared to elementary-age students, suggesting that problems that begin at an early age not only persist but get worse (Stanovich; Swanson et al.). This finding is consistent with Sweller's contention (2005) that limitations of knowledge within LTM results in significant difficulties during processing tasks often required during academic learning. In summary, the WM capacity and processing speed for students with LD has a baseline that is lower than that of peers without disabilities (Swanson & Saez, 2005), and is further hindered when voluminous and complex content-specific tasks are introduced (Deshler & Shumaker, 2006; Scruggs & Mastropieri, 2005).

Challenges in content-area coursework. Content-area courses, especially in middle and high school, require students to learn knowledge and disciplinary dispositions in order to successfully complete tasks that involve higher order thinking skills (Lee & Spratley, 2010; Moje, 2008; Weinberg, 1991). For example, individual courses at the secondary level require students to posses and be able to demonstrate combinations of strong underlying academic skills (e.g., comprehension, writing; Shanahan & Shanahan, 2008); access to stores of discipline-specific background knowledge (Conley, 2008; Weinberg); and discipline-specific habits of mind (Moje, 2007, 2008) to help construct meaning when interacting with various learning tasks. For students with LD and others who struggle learning, academic demands frequently overwhelm available cognitive processing capacity and stores of schemas in LTM (Swanson, 2001; Swanson & Deshler, 2005).

Compared to elementary-level learning materials, academic texts at the secondary level are longer and significantly more complex with respect to number of new and/or challenging vocabulary terms (Ebbers & Denton, 2008), and the overall complexity of sentences that contribute to the readability of texts (Conley, 2008; Moje, 2007; Shanahan & Shanahan, 2008). Readability is related to the structure and purpose of texts (e.g., expository, narrative) and the vocabulary and background knowledge necessary to read and comprehend the text; however, levels of difficulty for individual texts reflect significant variability across the different content areas (Faggella-Luby & Deshler, 2008; Lee & Spratley, 2010). For example, academic texts in high school contain more abstract concepts than middle school discourse (Christie, 2002); furthermore, authors at the secondary level use literary vocabulary, technical content words, and complicated sentences to convey information (Berman & Ravid, 2009; Harman, 2009). In summary, adolescents with LD face significant academic demands stemming from the unique academic challenges that arise as students move from class to class during their school day.

In the context of rigorous curricular demands in middle and high school classrooms, when the teacher begins a lecture or other presentation of content-rich material, students with LD may have trouble keeping pace due to processing issues within WM, STM, LTM, or each of these types of memory (Brownell et al., 1993; Johnson et al., 2010; Swanson, 1999, 2001; Swanson & Deshler, 2005). This does not mean these students cannot successfully keep pace in these classrooms, but to do so, they typically need access to learning strategies or other instructional supports (Fagella-Luby & Deshler, 2008; Swanson & Deshler). Therefore, it is critical to pair understanding of adolescents' cognitive processing limitations with instructional practices that minimize existing limitations within repertoires of students' academic skills.

Because multimedia instruction can be carefully controlled with respect to audio and visual stimuli, it has the potential to deliver high-quality instruction to address the cognitive learning needs of students with LD. A validated method for designing and delivering effective instruction is Mayer's cognitive theory of multimedia learning (CTML; 2001, 2005, 2009). The

CTML is the theoretical framework for this research study.

The Cognitive Theory of Multimedia Learning

Theoretical Grounding for the CTML

Mayer's CTML is grounded in the dual coding and processing theory (Clark & Paivio, 1990; Paivio, 1986, Paivio, 1990) and the cognitive load theory (Chandler & Sweller, 1991; Clark, Nguyen, & Sweller, 2006; Sweller, 2006), and the triarchic model of cognitive load (DeLeeuw & Mayer, 2008). In this section, critical elements of creating multimedia learning materials will be discussed, including: (a) the dual processing theory, (b) cognitive load theory, (c) the triarchic model of cognitive load, and (d) the CTML, with specific attention given to how the cognitive learning needs of students with LD are considered and supported through Mayer's model.

Dual processing theory. The dual coding and processing theory holds that humans interact with their environment through visual and auditory inputs (Paivio, 1986). The dual coding and processing theory also states that if pictures are introduced and held in visual working memory (e.g., visuospatial sketchpad), while spoken words are held in auditory working memory (e.g., phonological loop), learning is enhanced (Mayer, 2009; Mayer & Anderson, 1991). Thus, making use of both inputs strengthens the capacity for learning, yet the two channels can either individually or collectively become overwhelmed when stimuli overwork available resources on either channel (Mayer; Paivio). This is consistent with the previous discussion of a limited WM and its implications for teachers and instructional designers (e.g., Baddeley, 1986, 2006).

Mayer specifically subscribes to Baddeley's model (1986) of an active, but limited WM, including a phonological loop, visuospatial sketchpad, and central executive to explain how people process environmental stimuli. Because utilizing auditory and visual processing capacity can maximize learning, Mayer grounds his CTML in part on the dual processing theory. To illustrate, Mayer defines multimedia instruction as instruction containing visual and auditory components (Mayer, 2009). In this study, carefully designed multimedia instruction will be used to promote vocabulary learning for adolescents with LD.

Cognitive load theory. Cognitive load theory (Chandler & Sweller, 1991; Clark et al., 2006; Sweller, 2006) is based on the idea that cognitive processes within WM, STM, and LTM are limited and can easily be overwhelmed by environmental stimuli. In other words, human cognitive capacity is limited and can be overwhelmed with too much incoming information (Chandler & Sweller). Cognitive load theory holds that the cognitive burden on learners can be reduced through streamlining inputs via careful design of instructional materials that facilitate automaticity of cognitive processes (Chandler & Sweller; Clark et al.; Sweller). This includes maximizing the use of visual and auditory input channels (e.g. dual processing theory), and reducing extraneous stimuli that function to distract learners from critical information. Cognitive load theory is relatively simple to understand but difficult to translate into effective and efficient instruction for students.

As noted in the preceding discussion, adolescents with LD have difficulty in processing complex and voluminous information during academic instruction. Part of their difficulty can be attributed to overtaxed cognitive resources, which could be the result of overload in the phonological loop or the visuospatial sketchpad, or both. In addition, inefficient processing of the central executive or episodic buffer during communication with schemas in LTM can be attributed to an overload in cognitive resources (Sweller, 2005). Considering how easy it is to overwhelm cognitive resources, the instruction provided in this study addressed the limited capacity of students' cognition.

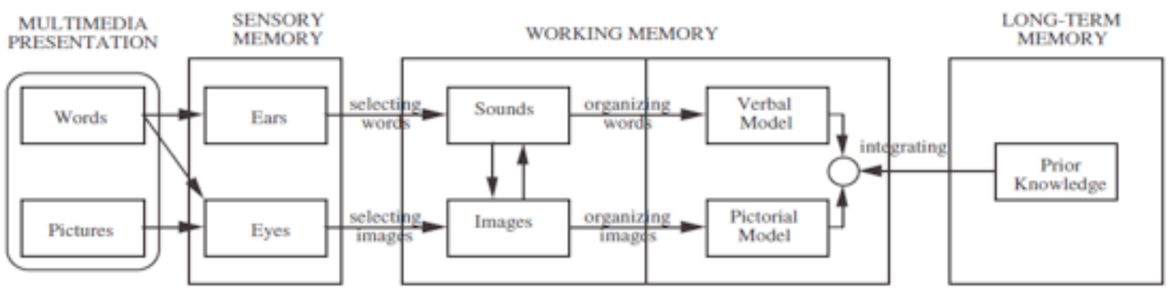
Triarchic model of cognitive load. Learners' cognitive capacity is influenced by three kinds of cognitive load during learning (Mayer & Johnson, 2008). This has been referred to as the triarchic model of cognitive load (DeLeeuw & Mayer, 2008). To monitor the cognitive load placed on learners, instructional materials should be designed in light of three principles, each addressing a each specific element in the triarchic model of cognitive load by (a) limiting extraneous processing, (b) managing essential processing, and (c) fostering generative processing (Mayer, 2009).

Extraneous processing refers to non-essential cognitive attention and processing consumed by information that is not critically relevant to understanding the material being presented (Mayer, 2009). Essential processing is what happens cognitively for learners in terms of actively developing mental representations of information being presented; however, the difficulty or complexity of the material can help or hinder this process (Mayer; Mayer & Johnson, 2008). Generative processing is deep, self-motivated processing that results in movement of newly constructed information in working memory to long-term memory (Mayer; Mayer & Johnson). The triarchic model of cognitive load is a cornerstone of Mayer's cognitive theory of multimedia learning (CTML).

The CTML. The CTML is based on three assumptions about human cognition: (a) "Humans possess two separate channels for processing visual and auditory information"; (b) "Humans are limited in the amount of information that they can process in each channel at one time"; and (c) "Humans engage in active learning by attending to relevant incoming information, organizing selected information into coherent mental representations, and integrating mental representations with other knowledge" (Mayer, 2009, p. 63). This is consistent with the dual coding theory (Paivio, 1986), cognitive load theory (Sweller, 2005), the triarchic model of cognitive load (DeLeeuw & Mayer, 2008), and Baddeley's model of WM (1986). Therefore, the CTML is a construct with potential utility for designing and delivering multimedia-based instruction to adolescents with LD.

The three underlying assumptions of the CTML provide a theoretical guide for designers of instructional materials seeking to improve the capacity of learners to (a) select key words and pictures during instruction; (b) organize critical information into their working memory; and (c) integrate new knowledge with their prior knowledge (Mayer, 2001, 2005, 2009). The CTML is depicted graphically in Figure 1.

Figure 1. Mayer's cognitive theory of multimedia learning.



Mayer (2009) refers to the CTML as a student-centered learning theory. This is a critical distinction from other technology-centered interventions, which lack Mayer's specific attention to issues related to cognitive processing. The theory posits:

> Meaningful learning occurs when learners are able to pay attention to relevant portions of the words and graphics as they are registered in sensory memory, mentally organize them into coherent cognitive structures in working memory, and connect the verbal and pictorial representations with each other and with relevant knowledge retrieved from long-term memory. (Mayer & Johnson, 2008, p. 380)

Grounded in the triarchic model of cognitive load, and in response to the three assumptions of the CTML, Mayer has outlined 10 interdependent, research-validated design principles that, when brought together, constitute a roadmap for designing instructional materials that will be effective for fostering learning (Mayer, 2009). Mayer's instructional design principles and a description of each are provided in Figure 2. The working memory of students with LD is vulnerable to overload with incoming stimuli and is simultaneously hindered by inefficient processing speed (Johnson et al., 2010; Swanson & Baez, 2005; Swanson, Cooney, & McNamara, 2004; Swanson et al., 2009). Hence, given its grounding in how cognition works through information processing, the CTML is a logical choice for researchers and practitioners seeking to design instruction that matches the cognitive learning needs of students with disabilities.

Figure 2: Mayer's design principles as aligned with the triarchic model of cognitive load (adapted from Kennedy, Hart, & Kellems, 2010).

Triarchic Model of Cognitive Load (DeLeeuw & Mayer, 2008)	Research-Based Instructional Design Principles (Mayer, 2009)	Brief Description of Mayer's Instructional Design Principles (Mayer, 2009)
Limit Extraneous Processing	Coherence Principle	Learning is enhanced when irrelevant or extraneous information is excluded
	Signaling Principle	Learning is enhanced when explicit cues are provided that signal the beginning of major headings or elements of the material being covered
	Redundancy Principle	Learning is enhanced when extensive text (transcription) on screen along with spoken words and pictures is not used. Carefully selected words or short phrases, however, augment retention (Mayer & Johnson, 2008)
	Spatial Contiguity Principle	Learning is enhanced when on-screen text and pictures are presented in close proximity to one another to limit eye shifting during instructional presentations

	Temporal Contiguity Principle	Learning is enhanced when pictures and text correspond to the audio presentation
Manage Essential Processing	Modality Principle	Learning is enhanced when spoken words and pictures are used as part of instruction
	Segmenting Principle	Learning is enhanced when multimedia presentations are divided into short bursts (5-7 minutes) as opposed to longer modules
	Pretraining Principle	Learning is enhanced when instructional messages contain an orienting message to introduce the forthcoming content
Foster Generative Processing	Multimedia Principle	Learning is enhanced when pictures and spoken words are used instead of words alone
	Personalization, Voice, and Image Principles	Learning is enhanced when narration is presented in a conversational style instead of more formal audio presentations

The 10 instructional design principles listed in Figure 2 provided the roadmap for creation of the multimedia instructional materials to be used in this research study to determine if, by adhering to Mayer's model, the multimedia instructional materials do, indeed, limit extraneous processing, foster active learning and processing, and promote successful functioning within cognitive processes for students with LD.

Summary

Adolescents with LD need instruction that maximizes their limited WM capacity and simultaneously provides support for activation of existing schemas in LTM, or developing new schemas. Given the prevailing structure of instruction within many content-area classrooms (e.g., dominance of lecture format), adolescents with LD frequently encounter a mismatch between the capacity of their cognitive resources and the support offered by teachers (Johnson et al., 2010; Savage, et al., 2005; Stringer & Stanovich, 2000; Swanson, 2001; Swanson & Deshler, 2005; Wagner & Torgesen, 1987). Technology-based solutions, when designed from theoretically sound pedagogical principles, can be a viable tool for schools to use to augment instruction (Boone & Higgins, 2007; McKenna & Walpole, 2007; Torgesen & Barker, 1995).

Given the specific cognitive processing needs of students with LD, the use of multimedia instruction that specifically addresses issues related to cognitive load and processing is a logical theoretical grounding for an intervention. Furthermore, key components of effective instruction for students with LD (e.g., the use of explicit and strategic instruction) also lend themselves well to packaging and delivery using multimedia tools. This is critical because, in reality, many uses of technology to deliver or augment literacy instruction are distracting, disruptive, or altogether ineffective if they are not produced with the individualized cognitive needs of the target learner in mind (Austin, 2009; Dalton & Strangman, 2006; Mayer, 2009; Mayer & Johnson, 2008). Therefore, as professionals design multimedia instructional materials that address learning demands presented by text or content, Mayer's CTML and accompanying instructional design principles may be a pathway to ensure that the look and sound of materials adhere to theoretical principles of multimedia learning and cognitive learning needs of students with LD.

Multimedia Learning Design and Instruction

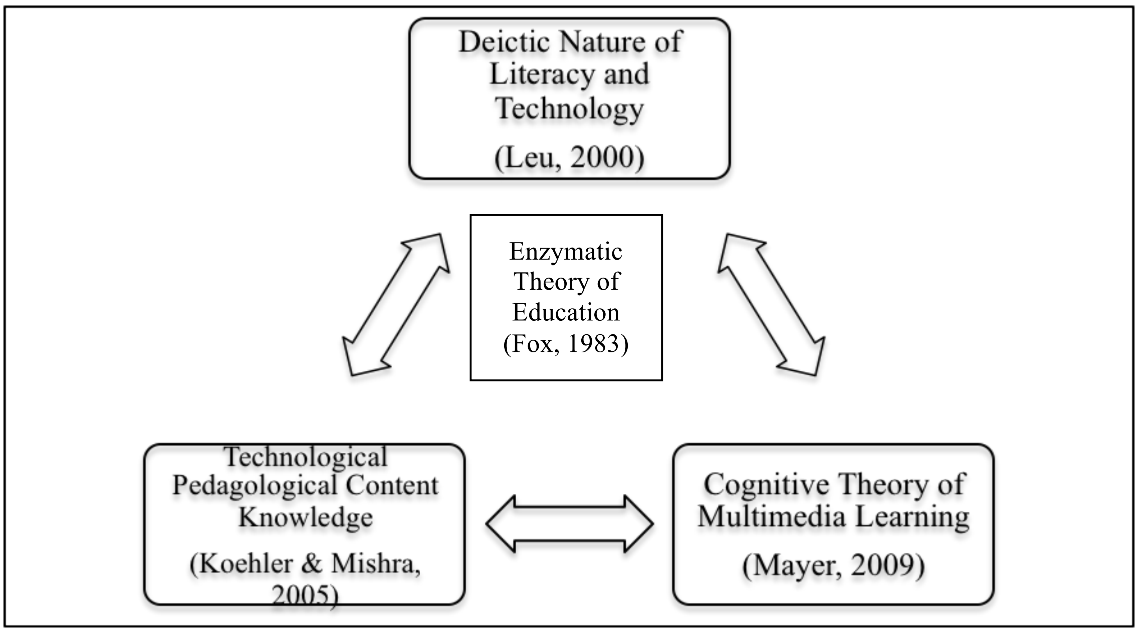
Considerable progress has been made in designing and validating interventions and instructional protocols that markedly improve academic outcomes for students with LD. Increasingly, this has included technology-based solutions as a result of the rapid development of technology tools, primarily focused on reading (Bouck, Maeda, & Flanagan, 2011; Okolo & Bouck, 2007). Developments in technology-based supports, especially in the area of literacy instruction for students with LD, have promising implications for instruction and learning (McKenna, Labbo, Kieffer, & Reinking, 2006). Although the evidence base for using technology in the literacy instruction of students with LD is relatively small (Alper & Raharinirina; 2008; Bouck et al.; Okolo & Bouck), curriculum designers and educators have the opportunity to integrate validated instructional practices with technology to markedly improve the design and implementation of instructional protocols and practices (Bouck et al.; Kamil, 2003; McKenna et al.).

Before specific technology-based instructional programs or strategies are discussed, it is important to demonstrate a link between the cognitive learning needs of adolescents with LD and the design of new approaches for learning. This requires careful attention to the underlying theoretical principles that ground instructional practices. Kennedy and Deshler (2010) outlined a conceptual framework (see Figure 3) for designing and packaging multimedia-based instruction that delivers evidence-based practices.

Conceptual framework. Kennedy and Deshler's (2010) conceptual framework for multimedia instruction is organized around four major theoretical principles that individually and collectively influence design and delivery of instruction for students with LD: (a) the deictic relationship between technology and literacy (Leu, 2000); (b) technological pedagogical content knowledge (Koehler & Mishra, 2005); (c) multimedia instructional design principles (Mayer, 2009); and (d) the enzymatic theory of education (Fox, 1983; Larsen, 1995). The purpose of this conceptual framework is to ground the current research further within validated instructional models for adolescents with LD.

Deictic nature of literacy and technology. Teaching students with LD — at any level or in any content area — is a complex undertaking. This complexity is sustained and perpetuated, at least in part, by the deictic nature of technology and literacy (Leu, 2000). The concept of dexis within the field of literacy and technology means that the overall nature and essence of literacy and technology are changing so rapidly and thoroughly that it is difficult to define and describe either, let alone in tandem (Leu). In a sense, the seemingly obvious questions "what is literacy" and "what is instructional technology" (and their respective answers) have become moving targets. Therefore, for researchers and practitioners seeking to understand the interrelated and dynamic relationships between literacy and technology, the deictic nature of this relationship makes experimental rigor demanded in today's research climate a complex proposition (Leu).

Figure 3. Kennedy and Deshler's conceptual framework.



Technological pedagogical content knowledge (TPACK). As educators consider technology as a strategy for augmenting instruction, consideration should be given to the capacity of teachers to rapidly integrate technology within existing teaching repertoires. Technology can play a role in helping teachers structure individualized instruction; however, the use of technology should be augmentative and logical in terms of its impact on the overall instructional plan (Larsen, 1995; Maccini, Gagnon, & Hughes, 2002). Researchers have developed an instructional design framework that seamlessly integrates technology, content, and pedagogy for design and delivery of various types of content, known as technological pedagogical content knowledge, or TPACK (Koehler & Mishra, 2005). Koehler and Mishra described TPACK as an extension of Shulman's (1987) construct of pedagogical content knowledge. TPACK is a potentially helpful construct for conceptualizing and organizing the role of technology for delivering instruction when teaching students with LD across a variety of instructional settings.

The TPACK framework is potentially useful for selecting and embedding technology that complements generic instructional practices given different instructional settings and the unique learning needs of students. However, recognition that technology should complement existing approaches to instruction, not supplant it, leaves a significant issue to be addressed, especially for the typical educator responsible for the education of students with LD; that is, the actual "looks and sounds" of specific programs or interventions.

A conceptual framework put forth by Kennedy and Deshler addresses the issues of instructional "looks and sounds" through utilization of Mayer's CTML. The CTML as an instructional design framework is flexible enough to be partnered with evidence-based instruction from a limitless assortment of content areas or grade levels.

Principles of multimedia instruction. Educators should consider the impact technology has on the cognitive processes of the intended audience (Boone & Higgins, 2007; Mayer, 2009). Hence, most researchers agree that technology should not be used gratuitously during instruction (King-Sears & Evmenova, 2007). Instead, instruction should reflect multimedia design principles that are matched with the cognitive learning needs of students as much as being a logical addition to the overall plan for teaching. Mayer's CTML satisfies these requirements for effective multimedia instruction.

Enzymatic theory of education. Finally, Fox's (1983) enzymatic theory of education (ETE) completes the conceptual framework and vision for use of multimedia instruction to promote learning among students with LD. The ETE is a student-centered learning theory

(Larsen, 1995) and is a logical match given the other elements of the conceptual framework (i.e., deictic nature of literacy, TPACK, and the CTML). The ETE holds that students with LD need instruction that facilitates, enhances, and accelerates inner cognitive processes and overall motivation (Fox, 1983; Larsen, 1995). In this model, students are encouraged and expected to be catalysts in their own learning, as opposed to passive recipients of information.

To provide instruction in line with the ETE, practitioners are to select or design instructional materials that are grounded in theory and are a logical match for the demands of the intended audience. To create instruction with multimedia instruction that is of use for students with LD, it is important to consider all aspects of a computer program, including all dimensions of graphics, text, feedback types, motivation, and the nature and amount of learner control (Larsen, 1995). Mayer's CTML and accompanying instructional design principles is a logical method for authoring multimedia instruction that facilitates learning among students with LD. Further, educators who develop their teaching repertoire within a TPACK framework and consistently create multimedia instructional materials that adhere to theory-based instructional design and learning principles will potentially find students who are engaged and successful.

In summary, evidence-based practices for literacy instruction (e.g., Torgesen et al., 2007) and instructional design frameworks (e.g., TPACK, Universal Design for Learning; Mayer's CTML) can guide construction of technology-based practices and interventions that empower learning of students with LD.

Research in the field of multimedia instruction. Instructional technology (IT), also referred to as computer-aided instruction (CAI), is software, hardware, or other media that explicitly or indirectly delivers instruction or facilitates learning for a student (or group of students) in an area of difficulty. An example of IT is using software to teach students reading comprehension strategies that they can apply during independent reading. Similar to assistive technology (AT), IT can help students gain access to content; however, the primary goal of IT is not access. Instead, educators who use IT to teach literacy skills to students with LD attempt to remediate students' specific deficiency areas (Boone & Higgins, 2007; Torgesen & Barker, 1995) and build capacity within content areas (Maccini, Gagnon, & Hughes, 2002).

Numerous lines of research have been undertaken in the field of LD to promote the development of strong literacy and overall learning skills for students (cf. Deshler & Schumaker, 2006; Harris & Graham, 2005; Scruggs et al., 2010). Each of these lines of research shares a common attribute: They focus on building capacity within children to become proficient learners (across various contextual settings) without the need for ongoing support from teachers or others.

IT, when designed from theoretically sound pedagogical principles, may be a tool that schools can use to augment traditional face-to-face literacy instruction (Boone & Higgins, 2007; McKenna & Walpole, 2007; Torgesen & Barker, 1995). While sustained lines of research in the area of IT are beginning to emerge (cf. Anderson-Inman, 2009), significant opportunity exists to forge innovative partnerships between evidence-based practices and multimedia packaging and delivery systems. However, technology should never be chosen based on the assumption that any use of technology is effective use of technology.

IT and elements of reading. Grounded in instructional theory for reading, Torgesen and Barker (1995) called for computer-based programs to provide students with repetitive practice of the elements of language development being taught during face-to-face instruction. Although this application of technology use has been criticized for being reductionist (Poplin, 1995), Torgesen and Barker argued that students with phonologically based reading problems need more explicit instruction and opportunities to practice than any other group; hence, the use of technology to provide a combination of instruction and practice is logical and desired, they claimed.

A cutting-edge example of IT providing basic reading instruction is research being conducted by Escalle, Magnan, Bouchafa, and Gombert (2008). Specifically, for students with dyslexia, they used a computer game with audio-visual phoneme discrimination tasks along with phonological units and orthographic units to boost literacy skills; across two experiments, students who were exposed to the program made significant gains versus students in a control condition (Escalle et al.). In addition to new research being conducted, numerous IT-based reading programs (e.g., Read 180, DaisyQuest) provide students with a range of skill development options, including sound and word-level remedial instruction and reading comprehension instruction. Some of these programs have demonstrated positive records of student improvement (Slavin, 2009, 2008).

IT-based reading comprehension instruction. Anderson-Inman and her colleagues from the National Center for Supported eText (NCSeT) have undertaken a line of research that backs the concept of supported electronic text (eText). Supported eText is designed to help students gain access to text through simple changes to font size, color, and the availability of other tools that are assistive in nature; however, the intent of this innovation and research is not limited to promoting access (Anderson-Inman, 2009). Instead, this research group seeks to improve student decoding, fluency, and reading comprehension through various embedded supports such as electronic dictionaries, links to outside resources, and utilization of cognitive learning strategies (Anderson-Inman & Horney, 2007).

Empirical data from the NCSeT group has established a record of positive outcomes among students from various age groups and performing in various content areas (Anderson-

Inman, 2009). Another group whose research has been influential with respect to promoting literacy learning by changing the structure of electronic text and embedding learning supports is the staff at the Center for Applied Special Technology (CAST) (www.cast.org; Proctor, Dalton, & Grisham, 2007; Rose & Meyer, 2002).

In another study, the reading program Collaborative Strategic Reading (CSR; Klingner & Vaughn, 1996) was transformed into an IT-based program and used to teach reading comprehension skills to students with disabilities (Kim et al., 2006). Significant findings favored students who had exposure to the form of the program using IT. Maccini, Gagnon, and Hughes (2002) conducted a review of technology-based practices for secondary students with LD and made the following recommendations: (a) use technology systematically and strategically in instruction; and (b) incorporate effective instructional design principles within technology-based instruction (Kelly et al., 1986; Kelly et al., 1990).

In these studies, researchers began with theoretically based instructional principles and introduced logical uses of IT to deliver literacy instruction. This research shows that (a) IT can be useful for promoting literacy learning for students with LD, and (b) programs of research can be infused with IT to reimagine and repackage various evidence-based practices for literacy learning.

This concludes the first major section of this literature review on the cognitive structures and attributes of adolescents with LD, as they relate to preventing efficient and effective learning. The second major section of this review is on effective vocabulary instruction for adolescents with LD.

Evidence-Based Vocabulary Instruction

Vocabulary instruction has a strong theoretical and empirical base in the field of general education (cf. Baumann, Kame'enui, & Ash, 2003; Graves, 2006; Stahl & Fairbanks, 1986), and a growing base in special education (Bryant et al., 2003; Ebbers & Denton, 2008; Harris, Shumaker, & Deshler, 2011; Jitendra et al., 2004; Pullen et al., 2010). Specifically, researchers have reported that a key strategy for fostering student capacity to develop decontextualized understandings of complex word meanings is multiple exposures to individual words in and out of context (McKeown & Beck, 2006; Stahl & Fairbanks).

Helping students understand the multiple meanings of words so they can comprehend and use them in various contexts is the primary goal of vocabulary instruction at the secondary level (Baumann et al., 2003; McKeown & Beck, 2006). Thus, for students with LD, significant attention is needed to determine ways to structure successful and sustained engagement with new vocabulary words and concepts (Bryant et al., 2003; Ebbers & Denton, 2008; Jitendra et al., 2004). Throughout this section of the review, frequent connections will be made to the preceding section on cognitive learning structures and attributes of adolescents with LD. This is to ensure that the intervention developed for and experimentally tested in this study reflects best practices from cognitive science and vocabulary instruction for adolescents with LD.

In this review, a well-known framework for organizing vocabulary instruction (Graves, 2006) will be highlighted, followed by an introduction to an emerging framework to help teachers shape vocabulary instruction within the various content areas (Harmon, Wood, & Medina, 2009). Following this discussion, core knowledge related to vocabulary instruction from the field of special education will be reviewed in detail. This review will draw heavily on three recent reviews of literature for vocabulary instruction for students with LD conducted by Bryant and colleagues (2003), Jitendra and colleagues (2004), and Ebbers and Denton (2008). In each of these reviews, computer-aided vocabulary instruction was offered as an emerging method for teaching vocabulary, but each concluded that more research in this area is necessary before any conclusive evidence can be drawn. Other recent research on vocabulary instruction for students with LD will also be reviewed (e.g., Harris et al., 2011; Pullen et al., 2010).

The section concludes with a rationale for why multimedia instruction may be a conceptual and logical fit for LD students' cognitive processing and academic skill needs. The purpose of this study is grounded in a combination of the previous discussion on cognitive learning, the forthcoming discussion on evidence-based vocabulary instruction, and finally, a review of three experimental studies where researchers used multimedia based instructional materials to provide vocabulary instruction to adolescents with LD (Horton, Lovitt, & Givens, 1988; Johnson, Gersten, & Carnine, 1987; Xin & Rieth, 2001). The research questions for this study emerge following the review of literature for vocabulary instruction with adolescents with LD.

Frameworks for Designing and Delivering Effective Vocabulary Instruction

Dale (1965) outlined four incremental stages of word learning that are applicable to vocabulary learning: (a) Stage 1—Never having seen the term before; (b) Stage 2—Knowing there is such a word, but not knowing what it means; (c) Stage 3—Having context-bound and vague knowledge of the word's meaning; and (d) Stage 4—Knowing the word well and remembering it, including the ability to name synonyms, antonyms, and other related concepts (cited in Stahl & Bravo, 2010, p. 567). More recently, Beck, McKeown, and Omansen (1987) and Bravo and Cervetti (2008) described continua for "knowing" vocabulary terms. While both are similar, Bravo and Cervetti's continuum for knowledge of terms ranged from (a) a student having no control of a term (never seen or used the term), to (b) a student possessing passive control (can provide definition and a synonym), and, finally, to (c) a student demonstrating active control (term can be used during various reading, writing or speaking activities). The baseline for content-specific vocabulary knowledge for adolescents with LD is likely to reflect limited knowledge, which presents problems for providing instruction that takes advantage of existing schemas in LTM (Harris et al., 2011; Roberts et al., 2008). Therefore, providing instruction that helps students advance beyond Bravo and Cervetti's stage of passive control (know the term, but cannot apply the meaning) is a challenging endeavor that requires both effective instructional practice and an understanding of cognitive functioning.

To help students make progress with respect to Dale's (1965) stages or Bravo and Cervetti's (2008) continuum for mastering numerous vocabulary terms, teachers must design and implement a consistent and evidence-based suite of vocabulary interventions (Ebbers & Denton, 2008; Harris et al., 2011). Two instructional frameworks, Graves (2006) and Harmon and colleagues (2009), provide conceptually sound frameworks for designing and implementing vocabulary instruction. While neither framework is necessarily intended to provide instruction to students with LD, nor be partnered with multimedia-based instruction, an argument will be made that these two frameworks provide ample opportunity to interface with evidence-based practices and theoretical instructional design principles associated with both.

Graves' framework. Graves' (2006) framework for vocabulary instruction is a compelling organizational tool for planning and implementing vocabulary instruction. Each strand of the framework is built from key theoretical and empirical research on vocabulary instruction from the past 30 years (cf. Baumann et al., 2003; Heibert & Kamil, 2005; Stahl & Fairbanks, 1986). The four strands of the framework are as follows: (a) provide rich and varied language experiences; (b) teach individual words; (c) teach word-learning strategies; and (d) foster word consciousness. Graves' framework encompasses key practices known to promote vocabulary knowledge; therefore, teachers and others may use it as a logical starting place for planning and delivering high-quality vocabulary instruction.

Key themes in the field of vocabulary instruction include the need to help students become aware of the semantic parts of words (Bos & Anders, 1990; Nagy, 2007; Scammacca et al., 2008) and to dedicate instructional time to teaching word parts and meanings (Nagy; Nagy, Berninger, & Abbott, 2006), as well as strategies for forming connections between semantically related terms (Baumann & Kame'enui, 2004; Graves, 2006; Nagy et al.). Two categories of vocabulary instruction help translate these themes into practice. The first is basic instruction in the definitions of terms, and the second is teaching students the skills and strategies needed to decipher words (Graves; Stahl & Kapinus, 2001). This delineation is referred to as generative and non-generative teaching strategies, respectively (Harris et al., 2011). For students with LD, both direct instruction in word meanings (non-generative) and building capacity within students through the use of strategies (generative) are needed for successful learning (Bryant et al., 2003; Ebbers & Denton, 2008; Harris et al.; Jitendra et al., 2004; Pullen et al., 2010).

Numerous validated methods are available for implementing the ideas within Graves' framework (e.g., Baumann et al., 2003); however, at the secondary level, some content specialists struggle with effective and efficient methods for incorporating vocabulary instruction into daily repertoires of practice (Harmon et al., 2009). Therefore, content-area teachers may require access to vocabulary instruction that is tailored to reflect the demands of the various disciplinary areas from both a content and logistical standpoint.

Framework for discipline-specific vocabulary instruction. Successful comprehension when reading discipline-specific texts (e.g., social studies, science, mathematics) requires broad reading skills (Faggella-Luby & Deshler, 2008; Shanahan & Shanahan, 2008) but also knowledge of domain-specific language structures that facilitate higher order thinking skills (Fang, 2006; Harmon et al., 2009). Therefore, vocabulary instruction within specific content areas should reflect a domain specificity that is frequently lacking from general approaches to teaching word meanings (Harmon et al.).

To address this limitation and need within the field, Harmon and colleagues (2009) proposed a framework for identifying and then designing instruction to address the domain-specific characteristics of vocabulary terms. The categories of their framework are (a) technical terms, (b) nontechnical terms, (c) function words and word clusters and phrases, (d) unique representations, and (e) common roots. Teachers may use this framework to reflect on the demands of vocabulary within their content area and, based on their findings, make instructional decisions that promote optimal learning within the content area and support the cognitive learning needs of individual students. In this study, Harmon et al's framework will be used to create vocabulary instruction for world history course; therefore, the following description of their framework and corresponding examples will refer to examples from history.

Technical terms. Technical terms are words or phrases that represent specific concepts within disciplinary areas (Harmon et al., 2009). Examples of technical terms include *civil war, imperialism,* and *communism*. Accordingly, the definitions of technical terms are tied to the conceptual idea implied by the term and require sufficient contextual/background knowledge to fully master the meaning (Conley, 2008; Harmon et al.; Shanahan & Shanahan, 2008; VanSledright, 2008). Not surprisingly, many key vocabulary terms in social studies classes are technical terms. Therefore, instructional activities must take into account the substantial background and contextual knowledge necessary to make sense of technical terms (Harmon et al.). This recommendation is also consistent with the need to help students make structured cognitive connections between WM and LTM (Swanson, 2001, 2009). When technical terms are presented to students, but sufficient schemas within LTM are not developed, or carefully facilitated through explicit or strategic instruction, cognitive resources are likely to become overwhelmed, and students will not retain knowledge of the term. Teachers should use a blend of explicit and strategic instruction to help students build the necessary schemas to efficiently master critical technical terms in the various content areas (Bryant et al., 2003; Ebbers & Denton, 2008; Jitendra et al., 2004).

Nontechnical terms. While technical terms are specific concepts, nontechnical terms are words that have multiple meanings that change based on usage and context (Harmon et al., 2009). Nontechnical terms can also vary from having very specific to very general meanings depending on usage. For example, in social studies, nontechnical terms such as *organization, timeline,* and *race* all carry fairly variable meanings, and in other subjects, each of these words can mean something completely different (Harmon et al.).

Not surprisingly, the use of nontechnical terms during learning activities can cause problems for students with LD (Jitendra et al., 2004). Thus, the ability to quickly recognize a nontechnical term, process the definition between WM and LTM, and determine whether the students' existing definition of the term meets the context in which it currently appears requires rapid cognitive processing and sufficient background knowledge (Swanson & Hoskyn, 2003; Swanson, 2001). Also, depending on students' familiarity with the term, the amount of cognitive load required to complete the processing task will vary. Therefore, teachers need to consider strategies to review assigned texts and learning materials for both technical and nontechnical terms and plan instruction accordingly.

Content-area courses at the secondary level are filled with technical and nontechnical terms suggesting that teachers must prioritize essential terms that will be taught (Beck et al., 2003). In addition to selecting high-priority terms, teachers may turn to computer-based instruction as a pathway to efficiently deliver effective instruction (Kamil et al., 2008; Xin & Rieth, 2001). Computer-aided instruction as a strategy to deliver efficient and effective vocabulary instruction will be discussed at length to conclude this literature review.

Function words and word clusters and phrases. Function words and word clusters and phrases are used repeatedly in disciplinary texts (Harmon et al., 2009). These words and phrases connect conceptual ideas and signal special relationships between ideas (Marco & Luzon, 1999). For example, in social studies, the phrases "the result of" and "and another example of" are frequently included in narrative and expository texts and have implied meanings that the reader must pick up on in order to comprehend the text (Harmon et al.). For many students, the implied meaning of seemingly obvious disciplinary phrases must be explicitly taught (Shanahan, 2009).

Content-area teachers may be giving insufficient attention to function words and word clusters and phrases because the words themselves do not seem to be difficult to learn or remember. However, a lack of explicit attention given to these frequently used language conventions may result in breakdowns in comprehension for struggling students (Harmon et al., 2009; Shanahan, 2009). To date, this is an area of vocabulary instruction where only limited research has been conducted. However, it seems logical that teachers who use combinations of explicit and strategic instruction, combined with a thorough understanding of discipline-specific text structures, are well positioned to help students make sense of these types of function words and word clusters and phrases.

Unique representations. Each content area has specific terms, abbreviations, and other symbols that are unique to that discipline (Harmon et al., 2009). Thus, in social studies, for example, there is an abundance of content-specific terms and abbreviations. Examples include WWI, WWII, JFK, and the USSR. This is another case of when the expertness and corresponding instructional assumptions of content specialists can work against students with LD and others who struggle. That is, teachers' automatic use of common abbreviations may work against students with LD and other learners who struggle when they have not had ample opportunity to master the full version of the abbreviated term. In short, whether during lectures or readings, when abbreviations, codes, and other unique representations are used, teachers must carefully monitor student learning. Abbreviations such as JFK and WWII have fully permeated American culture; however, direct instruction must still be provided to students to ensure cognitive connections at the individual level are made.

Common root words. Finally, each discipline has a bank of common root words that are used over and over within various terms to convey meaning (Harmon et al., 2009). For example, Milligan and Ruff (1990) analyzed several elementary- and secondary-level social studies textbooks and estimated that 71% of terms had common roots. Examples included -demo (democracy, demonstration) and -merc (mercantilism, merchant). From a teacher's perspective, being cognizant of common word parts may help promote students' word consciousness (Graves, 2006), which in turn helps build capacity within students to expand the bank of words that they know (Baumann et al., 2003).

An effective practice for teaching common roots and other word parts is promoting semantic awareness, accomplished through explicit instruction and use of graphic organizers (Ebbers & Denton, 2008; Nagy, 2007; Nagy et al., 2006). The use of graphic organizers helps students see connections among semantically similar terms and promotes the use of both auditory and visuospatial channels for cognitive input (Deshler & Shumaker, 2006; Lenz et al., 2004). For students with LD, semantic awareness is an effective practice recommended by several reviews of the literature on this topic (Bryant et al., 2003; Ebbers & Denton, 2008; Jitendra et al., 2004).

In summary, Graves' (2006) and Harmon and colleagues' (2009) frameworks provide a useful scaffold for understanding the elements of effective vocabulary instruction and designing instruction that meets the specific characteristics of the various disciplinary areas. In this study, multimedia-based vocabulary instruction for social studies will be created for adolescents with LD. These two frameworks provide grounding for selection of evidence-based practices to be included within the intervention.

Research on Vocabulary Instruction

Vocabulary knowledge is a key lever in literacy and overall academic achievement for adolescents with LD (Roberts et al., 2008; Scammacca et al., 2008). Thanks to increased attention to this issue, the empirical evidence base on vocabulary instruction for students with disabilities is growing (e.g., Bryant et al., 2003; Ebbers & Denton, 2008; Harris et al., 2011; Jitendra et al., 2004; Pullen et al., 2010). The growth of evidence-based vocabulary interventions is critical, as vocabulary knowledge is closely related to reading comprehension (Anderson & Freebody, 1981; Joshi, 2005; National Reading Panel [NRP], 2000; RAND Reading Study Group, 2002). However, the field still needs evidence-based interventions to support adolescents who struggle with vocabulary learning at the secondary level (Ebbers & Denton). As noted, some of these instructional practices focus on providing direct instruction for the meaning of words while others build capacity within students to decipher terms on their own. Some powerful strategies do both.

With respect to vocabulary instruction at the secondary level, students with LD benefit from (a) multiple opportunities to learn words through direct or explicit instruction (Ebbers & Denton, 2008; Swanson & Hoskyn, 2001); (b) strategic approaches to learning new terms and concepts, including mnemonics (Bryant et al., 2003; Jitendra et al., 2004; Scruggs et al., 2010); (c) semantic feature analyses of specific terms or concepts (Bos & Anders, 1990; Ebbers & Denton; Harris et al., 2011; Roberts et al., 2008); and (d) computer-aided approaches (Horton et al., 1988; Johnson et al., 1987; Xin & Rieth, 2001).

Innovation in the area of vocabulary instruction should have theoretical grounding in one or more of these approaches to instruction. While the benefits of explicit and strategy instruction, including the keyword mnemonic strategy (Scruggs et al., 2010), have been well documented in the literature (cf. Faggella-Luby & Deshler, 2008; Roberts et al., 2008; Scammacca et al., 2008; Scruggs et al., 2010), published empirical findings and recommendations to the field on the use of computer-aided approaches are still limited (Kennedy & Deshler, 2010). This research study is an attempt to address this gap in the literature.

Overview of research from general education. The goal of vocabulary instruction is to provide students with a depth of understanding of terms so that they can produce more than a simple definition or synonym (McCardle, Chhabra, & Kapinus, 2008). However, some words have multiple meanings, leaving readers to rely on context to determine the appropriate meaning (Nagy & Scott, 2000). Snow, Burns, and Griffin (1998) reported that students can boost vocabulary knowledge through wide reading; however, students with challenges related to reading are unlikely to read with sufficient breadth and depth to experience such gains (Jitendra et al., 2004; Stanovich, 1986). For struggling readers, determining the meaning of unknown terms through contextual clues is extremely challenging (Jitendra et al.). Therefore, the use of strategies and explicit instruction is needed on a consistent basis to help students improve their respective banks of vocabulary terms (Baumann et al., 2003; Bryant et al., 2003; Ebbers & Denton, 2008; NRP, 2000).

Based on a review of eight empirical studies on vocabulary instruction, Mezynski (1983) found that effective instruction can result in (a) an increase in students' breadth of word knowledge, (b) active processing of words, and (c) augmenting amount of practice with new terms required for mastery. Relatedly, in their seminal meta-analysis, Stahl and Fairbanks (1986) found that the combination of providing students with definitions and authentic opportunities to use words in context was the strongest pathway to improve reading and comprehension. Finally, Blanchowicz and Fisher (2000) summarized empirical results for effective vocabulary instruction into four principles: (a) "students should always be active in developing their understanding of words and ways to learn them; (b) students should personalize word learning; (c) students should be immersed in words; and (d) students should build on multiple sources of information to learn words through repeated exposures" (p. 504).

Specific methods for translating Blanchowicz and Fisher's (2000) principles and Graves' (2006) and Harmon et al.'s, framework (2009) into instructional practices teachers can use are reported in the literature. They can be broken into two broad types: explicit instruction and strategic instruction (Bryant et al., 2003; Ebbers & Denton, 2008; Jitendra et al., 2004). Teachers typically provide explicit instruction to students in a direct manner; instruction is crafted using evidence-based practices so students can create new schemas in LTM for the information being provided (Archer & Hughes, in press; Rosenshine, 1987). Conversely, while strategy instruction may also originate with the teacher, the goal is to build capacity within students to engage content without requiring extended direction from the teacher (Deshler, 2005). Recent research shows that a blend of explicit and strategic instruction is effective in promoting word knowledge (Ebbers & Denton; Harris et al., 2011).

In addition to being provided using explicit or strategic methods, or both, vocabulary instruction can be further sorted into instructional subtypes. That is, it can be either generative or non-generative in nature (Harris et al., 2011). Non-generative vocabulary instruction is most commonly associated with more direct forms of instruction; for example, the teacher tells the meaning of a term to the students or directs them to find the answer in the dictionary (Baumann et al., 2003). Generative vocabulary instruction, on the other hand, builds skill capacity within students to figure out the meaning of unknown terms through analyses of known word parts, including suffixes, prefixes, and root words (Harris et al.).

A combination of generative and non-generative approaches to vocabulary instruction is needed to help adolescents with LD be successful in content-area courses (Ebbers & Denton, 2008; Harris et al., 2011; Jitendra et al., 2004). These types of instruction will be further addressed in the next section.

Key reviews of vocabulary instruction for students with LD. Since 1993, three high-quality reviews of the literature have been published in the area of vocabulary instruction for students with LD. These reviews, conducted by Bryant and her colleagues (2003), Jitendra and her colleagues (2004), and Ebbers and Denton (2008), are a logical starting point for compiling and analyzing the existing knowledge in this field. In the following discussion the key findings from these reviews will be discussed, and gaps in the existing literature will be identified.

Bryant and colleagues' review. Bryant et al. (2003) reviewed six empirical studies spanning four key categories for vocabulary instruction: (a) computer-aided instruction (Johnson, Gersten & Carnine, 1987); (b) fluency-building vocabulary practice activities (Stump et al., 1992); (c) mnemonic strategy instruction (Condus, Marshall, & Miller, 1986; Mastropieri, Scruggs, & Fulk, 1990; Mastropieri, Scruggs, Levin, Gaffney, & McLoone, 1985); and (d) concept enhancement instruction (Bos & Anders, 1990). A key finding from this review is that a variety of instructional activities can lead to increases in vocabulary knowledge. Simple, one-approach methods (e.g., non-generative approaches such as using a dictionary or using contextual clues) are not sufficient for students with LD (Bryant et al.). In addition, students with LD retain more new vocabulary terms when the number of new terms is limited, and vocabulary instruction is a consistent element of classroom instruction (Bryant et al.; Ebbers & Denton, 2008; Jitendra et al., 2004). These findings are consistent with research on improving the overall cognitive functioning of adolescents with LD (Deshler & Shumaker, 2006; Johnson et al., 2010; Swanson, 2001; Swanson et al., 2009) in suggesting that teachers should prioritize essential terms to be taught during class and develop a series of generative and non-generative methods for teaching those terms (Lenz, Deshler, & Kissam, 2004). Finally, when students need additional practice or support for learning vocabulary terms, computer-aided instruction may be a tool teachers and students use for success (Bryant et al.; Johnson et al.).

This review is influential because it was the first of its kind in the field of vocabulary instruction for students with LD; however, because the authors only reviewed six studies, and no cumulative effect sizes were reported, its conclusions and recommendations must be interpreted with caution. Despite these limitations, Jitendra and her colleagues replicated the findings from Bryant et al. during a similar review, as illustrated in the following.

Jitendra and colleagues' review. Jitendra and her colleagues (2004) reviewed 19 empirical studies spanning 6 types of instruction: (a) keyword mnemonic strategy instruction, (b) cognitive strategy instruction, (c) direct instruction, (d) constant time delay, (e) activity-based methods, and (f) computer-aided instruction. Although these authors used different categories in their review, there is significant overlap with the categories noted in the Bryant et al. review (i.e., computer-aided instruction, keyword mnemonic strategy, cognitive strategy instruction, and direct instruction). Therefore, these practices are likely to have strong empirical bases, and can be recommended to practitioners to improve vocabulary-related outcomes for adolescents with LD.

Jitendra and colleagues calculated mean effect sizes (ES) based on available empirical results from four of the six categories. The categories, number of studies, and mean effect sizes were as follows: (a) keyword mnemonic strategy: $n = 5$; mean ES = 1.92; (b) cognitive strategy instruction: $n = 10$; mean ES = 1.10; (c) direct instruction: $n = 3$; mean ES = 9.78; and (d) computer-aided instruction: $n = 2$; mean ES = 0.16 (Jitendra et al., 2004). With the exception of computer-aided instruction, the mean ES for these types of vocabulary instruction demonstrates strong effects for student performance. The overall mean ES for vocabulary instruction for students with LD across all 19 studies was 1.49. Therefore, effective vocabulary instruction for students with LD can include direct instruction and strategy instruction, especially the keyword mnemonic strategy (Bryant et al., 2003; Jitendra et al., 2004). The empirical basis for the keyword mnemonic strategy as described primarily by Mastropieri, Scruggs, and their colleagues is a pillar in the field of vocabulary instruction for adolescents with LD. Therefore, detailed attention should be given to this intervention.

Keyword mnemonic strategy. An effective method for teaching the meaning of vocabulary terms is the keyword mnemonic strategy (Atkinson, 1975; McDaniel & Pressley, 1989; Scruggs et al., 2010). The keyword mnemonic method requires the teacher or student to select a keyword, which is an acoustically similar word to the vocabulary term being taught. It is critical that the keyword be a word (or words) that the intended audience is familiar with. For example, if the vocabulary term is *alliance*, a good keyword might be "a lion" because "a lion" sounds like *alliance*, and every student can immediately conjure up a mental image of a lion. A picture is then created to show the keyword interacting with the definition of the original vocabulary term. In the example of alliance, the picture might show a lion out on the hunt with a bear because the two had teamed up for mutual support and defense. The combination of keyword and picture provides a remembering system (e.g., mnemonic) for the student. The keyword method is effective when teachers create the keywords and pictures (e.g., Scruggs & Mastropieri, 1989), and when students create the learning materials (e.g., King-Sears, Mercer, & Sindelar, 1992).

The keyword mnemonic method has a strong history in the empirical literature for general education students (Baumann et al., 2003; NRP, 2000), and for teaching students with disabilities (Scruggs et al., 2010). To illustrate, the keyword mnemonic method has been used to teach secondary-level content to adolescents with disabilities in 21 empirical studies; the mean effect size on student learning from these studies is 1.47 (Scruggs et al.). The keyword method has been used to teach students with disabilities in a wide variety of content-area courses, including science (King-Sears et al., 1992), American history (Scruggs & Mastropieri 1989), and teaching English vocabulary words (Terrill, Scruggs, & Mastropieri, 2004).

One criticism of the keyword method is the time it takes to create effective pictures to be used in instruction. Also, selecting keywords that are acoustically similar to original terms and already known by all potential users of the device can be time consuming and complex. However, through technology, it has become easier to find and/or create images, which in turn has made creating effective mnemonic devices more practical. However, since the keyword mnemonic strategy uses visual imagery, and meets criteria from Graves' (2006) and Harmon et al.'s (2009) frameworks, it is a logical intervention to select when designing and implementing vocabulary instruction for adolescents with LD.

Computer-aided instruction did not yield a strong mean effect size in Jitendra et al.'s (2004) review of vocabulary instruction for students with LD; furthermore, there are a limited number of studies in this area (Horton, Lovitt, & Givens, 1988; Johnson et al., 1987; Xin & Rieth, 2001). Jitendra et al. (2004) and Bryant et al. (2003) both point out that more research is needed in this emerging and promising area. Although to date no research team has done so, it might be logical to pair the keyword mnemonic strategy with computer-aided instruction to provide effective and efficient vocabulary instruction. This study will be the first to undertake such a pairing.

A limitation of the review by Jitendra and colleagues is that two teams of researchers (Mastropieri and her colleagues, and Bos and her colleagues) conducted 16 of the 29 reviewed studies. In addition, all but one of the studies were conducted between 1982 and 1996. This is not a limitation of Jitendra and colleagues' review so much as an observation of the field's limited attention to this critical topic. While further research has been completed in recent years (Harris et al., 2011; Pullen et al., 2010), there is a clear need for additional research in this area.

Ebbers and Denton's review. Ebbers and Denton (2008) organized their discussion into the following approaches to effective vocabulary instruction for adolescents with LD: (a) creating a verbal learning environment that fosters word consciousness, (b) carefully selecting words to teach and teaching specific word meanings, (c) providing explicit instruction and active engagement, (d) promoting cognitive engagement with words, (e) providing multiple exposures to words in a variety of contexts, and (f) teaching a word-learning strategy with contextual and morphemic analysis, including independently inferring meaning from context clues and morpheme clues.

Each of these approaches to teaching vocabulary is grounded in either emerging or solid empirical research. Further, they can be sorted into subcategories of vocabulary instruction: explicit instruction and strategic instruction, and generative and non-generative approaches to instruction.

In the following discussion, Ebbers and Denton's categories for (a) creating an environment to foster word consciousness, (b) carefully selecting words to teach, and (c) providing explicit instruction will be analyzed under the heading of explicit instruction and largely corresponds with non-generative approaches to vocabulary instruction. This leaves (d) promoting cognitive engagement with words, (e) providing multiple exposures to words in a variety of contexts, and (f) teaching word learning strategies to be analyzed under the heading for strategy instruction and generative approaches for vocabulary instruction. Analyses within these categories will be linked to the aforementioned reviews by Bryant et al. (2003) and Jitendra et al. (2004) to conclude this discussion on effective practices for providing vocabulary instruction to students with LD.

Explicit and non-generative vocabulary instruction. The National Reading Panel (NRP, 2000) found that explicit instruction leads to gains in vocabulary knowledge. In addition, adolescents with reading difficulties have also been found to benefit from explicit and direct instruction in word meanings (Ebbers & Denton, 2008; Scammacca et al., 2007). Specifically, a key method for explicit vocabulary instruction is providing students with multiple exposures to terms in meaningful contexts across a prolonged period of time (Beck & McKeown, 1983; McKeown, Beck, Omanson, & Pople, 1985). In addition to being direct and explicit, vocabulary instruction must be ongoing in the repertoires of classroom teachers (Graves, 2006). Instruction might include modeling, guided practice, checking for understanding, and multiple opportunities for practice with explicit and timely feedback (Jitendra et al., 2004; Swanson & Hoskyn, 2001). That is, definitions, pronunciations, spellings, syllables, and attention to other word parts (e.g., prefix/suffix, root words) are systematically relayed from the teacher to students (Ebbers & Denton).

Researchers have identified key components of explicit lessons that make instruction more effective for struggling readers (Mastropieri & Scruggs, 2002; Scruggs et al., 2010; Swanson & Deshler, 2003). Explicit instruction typically includes (a) a statement of the objective or purpose of the lesson, including a rationale for learning; (b) modeling of skills and strategies, including clear explanation of concepts with examples and nonexamples; (c) guided practice with teacher scaffolding; (d) specific positive feedback to confirm correct responses or clear corrective feedback to clarify misconceptions; (e) independent practice with teacher monitoring (returning to guided practice if the student is not successful); (f) teaching students how they can generalize the learning or use it in different situations; (g) monitoring student learning to assure that critical concepts and skills are mastered; and (h) periodic cumulative review with multiple opportunities for practice (Ebbers & Denton, 2008; Mastropieri et al., 2003).

Strategy instruction. Pressley and Harris (2006) defined strategies as: "Strategies are knowledge of procedures, knowledge about how to do something—how to decode a word, comprehend a story better, compose more completely and coherently, play first base better, and so on" (p. 77). More specifically, Pressley et al. (1985) said,

> A strategy is composed of cognitive operations over and above the processes that are natural consequences of carrying out the task, ranging from one operation to a sequence of independent operations. Strategies achieve cognitive purposes (e.g., comprehending, memorizing) and are potentially conscious and controllable activities. (p. 4)

Strategy instruction has a long history in the field of empirical research in the area of learning disabilities (Deshler, Ellis, & Lenz, 1991). As noted by Pressley and Harris (2006), the goal of strategy instruction is to give students specific instruction about the steps of various learning tasks so that metacognition can be shaped, supported, and encouraged. Students with LD typically do not think or act strategically when it comes to academic tasks without prompting (Swanson, 2001); hence, this line of theoretical and empirical research is critical.

The keyword mnemonic strategy is a clear example of how cognitive learning strategies can promote vocabulary learning for adolescents with LD. Two further examples of strategic instruction in the field of vocabulary learning are semantic mapping and semantic feature analysis. These generative approaches to cognitive strategy vocabulary instruction have been found effective with students with and without disabilities (Baumann et al., 2003; Bos & Anders, 1990; Bos et al., 1989; Bryant et al., 2003; Ebbers & Denton, 2008; Jitendra et al., 2004; NRP, 2000).

Jitendra and colleagues (2004) reviewed 10 studies that used either semantic mapping or semantic feature analysis as part of the experiment to teach vocabulary terms to students with disabilities. Results indicated large effects (mean ES = 1.10) for this form of cognitive strategy instruction. Instructors who use semantic mapping during vocabulary instruction frequently use graphic organizers to help students recognize relationships between known terms or concepts and new terms or concepts (Graves, 2006). Thus, semantic mapping is a way for teachers to activate students' prior knowledge. As noted, effective instruction promotes ease of transfer from WM to LTM and vice versa (Swanson, 2001, 2009; Sweller, 2005).

Semantic feature analysis is used to teach students to examine elements of words, including common prefixes, root words, suffixes, and other word parts, and then use that knowledge to make connections and build understanding with other terms (Ebbers & Denton, 2008). Helping students become active examiners of words and word parts is an efficient method for promoting vocabulary learning (Bos & Anders, 1990). Graphic organizers are frequently used to help students construct and see relationships among terms and various word parts in visual form. Humans access information in the world around them through audio and visual inputs (Baddeley, 1986). Not surprisingly, therefore, use of visual devices in vocabulary instruction is a supported practice. For example, Bos and Anders found that students with LD who were taught using semantic feature analysis techniques learned definitions of more terms than students who were taught to use more direct approaches to vocabulary learning. Learning gains sustained across a six-month period of time (Bos & Anders).

Review of Studies Using Multimedia-Based Vocabulary Instruction for Adolescents with LD

A comprehensive search was conducted for studies that used multimedia-based instructional materials to deliver vocabulary instruction to adolescents with LD. The process of locating articles for inclusion in this review of the literature took place in three steps. First, a systematic online database search was carried out (i.e., Google Scholar, Wilson Web, Academic Premier, PsycInfo, and ProQuest Dissertation Abstracts). Search terms included combinations of the words *vocabulary instruction, multimedia instruction, computer-aided instruction*, and *adolescents with LD*. Second, reference lists of articles located through the database search were analyzed for articles, books, or papers not initially uncovered. Third, a hand search of prominent journals in the field of special education (e.g., *Journal of Special Education; Journal of Special Education Technology; Learning Disability Quarterly; Learning Disability Research and Practice*) was performed dating back to 1985.

Although several articles use computer-aided instruction to deliver various elements of literacy instruction, studies included in this review will be limited to articles focused on vocabulary instruction for adolescents with LD. Three studies met these criteria, Horton and colleagues (1988), Johnson and colleagues (1987), and Xin and Rieth (2001). It is surprising that only three studies met the criteria for this review and that the most recent study was published in 2001, approximately 10 years ago.

Horton et al., 1988. Six students with LD in a ninth-grade social studies course participated in the study, which used a one-group, pretest-posttest design. Students with LD worked at individual desktop computer terminals. The intervention computer program taught word meanings to students through a form of direct instruction and corrective feedback. The definition for a term was shown on the screen. Students were then provided a list of distractors and were required find and click on the correct term. No pictures or other graphics were used. Students received feedback on their response and were required to try again when errors were made. Following instruction, students were given a posttest consisting of multiple-choice items. Students made significant improvement (from 26% to 68% correct) between the pretest and posttest.

The study has several limitations. First, only a small number of students participated, and no comparison group was used. Second, the computer program used to deliver instruction was not described in detail by the authors, making replication extremely difficult, and likely impossible. Third, the instructional or theoretical framework used to design the computer-aided instruction was not discussed. In summary, although this is one of three studies that met the search criteria, it has limited implications for the current study.

Johnson et al., 1987. Twenty-five high school students with LD were randomly assigned to two forms of computer-aided instruction: the Large Teaching Set (LTS; Davidson & Eckert, 1983) and the Small Teaching Set (STS; Carnine, Rankin, & Granzin, 1984). Both the LTS and STS are used to provide direct instruction (DI) to students and provide feedback on responses. The key difference between the two is the LTS cannot be individualized, it provides instruction for 25 preselected vocabulary terms, and it does not conduct a cumulative review. On the other hand, instructors using the STS can select which vocabulary terms are taught using the program (based on pretest results), words are presented in groups of seven, and students cannot move on until mastery is demonstrated through answering multiple-choice questions. In addition, there is a cumulative review at the end of the STS program. Both the STS and LTS provide direct instruction in word meanings and provide the reinforcement "good job" when correct answers are given.

A pretest-posttest-maintenance design was used for this experiment. Students in the STS group took less time to reach mastery on the vocabulary terms in the study than students in the LTS group. This finding is important because computer-aided instruction is intended to improve efficiency in learning. However, on both the posttest and maintenance probes, students in the STS group did not outperform students in the LTS group. Therefore, while learning was made more efficient, it was not necessarily made more powerful. However, both groups moved from a pretest mean of approximately 50% to a posttest mean of approximately 80%, indicating the computer-aided instruction can promote vocabulary growth in adolescents with LD. Students were also given an open-ended test of word meanings. Students in neither group performed well on this assessment (mean posttest score of 35%). The researchers noted that they were not surprised by this result, given that the format of instruction within the computer program was based on correctly answering multiple-choice questions following direct instruction. Students from both groups expressed overall satisfaction with using the computer to learn vocabulary terms.

In summary, the study by Johnson and colleagues (1987) has important implications for the current study. First, computer-aided instruction can be efficient when the number of terms is kept to a manageable number (seven, in this study). Second, computer-aided instruction can help adolescents with LD learn vocabulary terms when direct instruction is provided. Third, students enjoy using computers to learn new vocabulary terms. The computer programs, LTS and STS, only provided one form of vocabulary instruction, direct instruction. Also, students demonstrated mastery within the program by selecting correct multiple-choice responses. There may have been differences in student performance if other types of vocabulary instruction such as generative instruction, including the keyword mnemonic strategy, had been provided. Future research should explore combinations of methods for vocabulary instruction packaged together using computer-aided methods.

Xin and Rieth, 2001. A total of 76 fourth-, fifth-, and sixth-grade students receiving instruction in a resource room were randomly assigned to one of two instructional conditions. In this study, the theoretical principle of anchored instruction (AI; Cognition and Technology Group at Vanderbilt, 1990) was used to design multimedia-based vocabulary instruction. "Anchored instruction refers to a multimedia environment created by video programs that serves as an "anchor" or "situation" to help learners develop skills" (Xin & Rieth, 2001, p. 88). Therefore, it is critical that the selected anchor holds relevance for the students, and can be linked to existing schemas in LTM.

A pretest-posttest-control group design was used. A total of 50 vocabulary terms were selected for use in the study. The AI group saw a documentary on earthquakes that used the 50 vocabulary terms in context. In addition, students in the AI group were given reading passages containing critical information regarding the vocabulary terms, and teachers led discussions on what they had seen in the video and read in the passages. Control-group students were provided with the same instructional sequence as the AI group, except no video was used. These students were also given access to dictionaries and printed definitions of terms to augment their classroom instruction.

The measures for the study were word definitions, sentence cloze, and passage comprehension. Students in the AI group statistically outperformed students in the comparison condition on the test of word definitions, but not on the other two measures. A satisfaction survey given to students also noted that students enjoyed learning vocabulary through the AI method.

The study by Xin and Rieth (2001) was the first of its kind to use multimedia-based instruction to deliver vocabulary instruction to students with LD. However, the students in the study were upper-elementary-age students, and although many consider students in the fourth grade and above to be adolescents, significant differences exist between elementary and middle and high schools (Carnegie Council for Advancing Adolescent Literacy, 2010; Conley, 2008). Furthermore, use of AI as described by Xin and Rieth requires access to videos that are either commercially produced or have to be teacher-created. This suggests that the usability of this intervention may be limited by the capacity of teachers to find appropriate videos that contain relevant demonstrations of vocabulary terms.

The work of Xin and Rieth (2001) has significant implications for the current study. First, the researchers combined a theoretically sound instructional approach (AI) with evidence-based vocabulary instruction during face-to-face class time. Second, the researchers were able to use their intervention to create significant differences in word knowledge, but improvements in comprehension and cloze completion were not significant. This is similar to the results of the Johnson et al. (1987) study by showing that it is possible to improve basic word knowledge, but that advancing skills for comprehension and related tasks using computer-aided instruction is more challenging. Xin and Rieth hypothesized that the lack of significance on transfer items may be related to the limited scope of their experiment and the dosage of the intervention. In addition, reading comprehension requires much more than a strong vocabulary (Mastropieri et al., 2003). Therefore, it may be logical to use computer-aided approaches to vocabulary instruction such as those described in Horton et al. (1988), Johnson et al.,and Xin and Rieth to promote word learning, and then partner with evidence-based approaches to reading comprehension instruction such as those noted in reviews by Mastropieri and colleagues and Faggella-Luby and Deshler (2008).

Gaps in the literature. As mentioned, only three of the studies examined met the criteria for inclusion in this review. Regardless of the findings or quality of these studies, more research in the area of computer-aided vocabulary instruction for adolescents with LD is needed, as specified in the following.

First, in the two studies where the method was reported, researchers used one method to deliver vocabulary instruction incorporating the multimedia materials at their disposal. Johnson and colleagues (1987) used DI, whereas Xin and Rieth (2001) used AI. Given the reviews by Bryant et al. (2003), Jitendra et al. (2004), and Ebbers and Denton (2008), it is clear that multiple approaches to vocabulary instruction are needed to promote enduring learning for adolescents with LD. Therefore, future research in this area should package various combinations of explicit and strategic instruction and generative and non-generative methods to determine if it is possible to augment vocabulary learning using such configurations.

Second, students in each of the studies expressed satisfaction with the use of computer-aided instruction to teach vocabulary terms. Given the age of the studies (1986, 1987, 2001), it is likely that students in 2011 are more familiar with uses of technology in instruction and have skills that facilitate learning using CAI (e.g., Microsoft PowerPoint, Excel, Word; Apple's iMovie, podcasts) Third, no study used a strategy such as the keyword mnemonic strategy within CAI. Therefore, the limited published research on this topic may present a significant opportunity to pair the keyword mnemonic strategy (based on visual imagery) with a multimedia-based instructional approach. In addition given the strong empirical record of the keyword mnemonic strategy and other strategic approaches to vocabulary instruction, it is logical that these interventions be paired with multimedia methods for instructional design and delivery.

Statement of Purpose for Multimedia-Based Vocabulary Instruction

The largest limitation of the existing research on CAI is the scarcity of detail describing the "looks and sounds" of instruction. Although Xin and Rieth (2001) used AI as their theoretical framework, they did not pay explicit attention to the content of the video with respect to audio and visual stimuli. For example, Mayer (2009) outlined 10 instructional design principles to guide researchers and instructors when creating multimedia instruction that adheres to the triarchic model of cognitive load (DeLeeuw & Mayer, 2008), and promotes active processing (Sweller, 2005). Each word and image within instructional materials designed according to Mayer's model is carefully selected given the cognitive processing needs of the intended audience. Therefore, given the cognitive needs of adolescents with LD during content-area learning tasks, instructional materials should not be left to chance with respect to their audio and visual makeup. However, when instructors purchase a video or download something from the Internet to use during instruction, there is no precise way to ensure the material adheres to a validated instructional model, such as that presented by Mayer. This study is an attempt to address these limitations and add to the literature in this critical area.

The research questions and activities of this study are based on the aforementioned review of cognitive learning structures, multimedia learning theory, the conceptual framework for multimedia instruction (Kennedy & Deshler, 2010), and the best practices for advancing vocabulary instruction for adolescents with LD. Adolescents with LD face significant academic challenges in content area courses, yet their cognitive processing needs are frequently overlooked when instruction (multimedia or not) is provided. Facilitating cognitive processing needs through careful use of multimedia instruction in partnership with evidence-based instruction may be a pathway to promoting significant learning gains for this population of students.

Research Questions

1. If created using Mayer's CTML as the instructional design framework, to what extent can computer-aided vocabulary instruction that delivers a blend of evidence-based explicit and strategic vocabulary instruction improve vocabulary knowledge and retention of important terms in world history for adolescents with LD?
2. If created using Mayer's CTML as the instructional design framework, to what extent can computer-aided vocabulary instruction that delivers evidence-based explicit vocabulary instruction improve vocabulary knowledge and retention of important terms in world history for adolescents with LD?
3. If created using Mayer's CTML as the instructional design framework, to what extent can computer-aided vocabulary instruction that uses the keyword mnemonic strategy improve vocabulary knowledge and retention of important terms in world history for adolescents with LD?
4. To what extent are adolescents who are taught vocabulary terms in world history using computer-aided instruction satisfied with this approach to instruction?

CHAPTER III

METHODS

Participants

Two world history teachers in this study were responsible for teaching 12 total sections of the course to approximately 300 students. The participants were 278 urban high school students (9^{th}-12^{th} graders) enrolled in one high school's required world history course. Permission to conduct research was secured from the University of Kansas Human Subjects Committee, the participating school district's research review board, the principal of the school, parents of all students, and the students. All students in the school are required to take a course in world history course to be eligible for graduation; most students take the course during their 10^{th}-grade year, although some enroll in the course as 9^{th} graders; some repeat the course during their 11^{th} or 12^{th} grade years.

Two subgroups of students participated: (a) students with learning disabilities in a specific area related to reading (SWDs; n = 30) and (b) students without disabilities *and* students who receive special education services for a reason other than a reading disability (NSWDs; n = 248). For the purpose of this study, all students in the SWD group had an individualized education program (IEP) stemming from a diagnosis of specific learning disability related to reading. Although some students in the NSWD group also had an IEP (primarily students with an Emotional/Behavioral Disorder diagnosis), they were grouped with the students without disabilities for the purpose of this study's activities and analyses.

Demographic information and first-semester GPA in the world history course were collected for each student. First-semester GPA in world history was used to sort students into one of three levels of achievement status: (a) High Achiever—85% or above; (b) Typical

Achiever—84%-70%; and (c) Low Achiever—69% and below. Permission to collect individual IQ scores, socioeconomic status, and other assessment information could not be obtained from the school district's human subjects review board. However, given that nearly every 10th grader in the school is enrolled in one of the 12 sections of world history participating in this project, and 78% of students at this school receive free or reduced-price lunch, it was assumed that approximately three quarters of students in the study received free or reduced lunch.

Using a table of random numbers, students were randomly assigned into one of four experimental conditions. Two stratification variables were used to proportionately sort students into the four groups: disability status (SWD or NSWD) and achievement status (high, typical, low). The four experimental conditions were (a) Content Acquisition Podcasts (CAPs), containing both explicit instruction and the keyword mnemonic strategy; (b) CAPs containing only explicit instruction; (c) CAPs containing only the keyword mnemonic strategy; and (d) Instructional videos with the same audio track as the other three conditions, but no other features or adherence to Mayer's design principles. Table 1 displays the demographic information for this study.

Setting

The school district is located in an urban, Midwestern community of 146,867 residents. The selected high school currently has a student enrollment of 987, 78% of which receive free and/or reduced-price lunch. Students are evenly split between males (50.56%) and females (49.44%). African American students represent the largest ethnic group (67.48%); Caucasian students are the next largest group at 21.88%, and Hispanic students constitute 8.11%.

Table 1

Demographic Information

	N	Male	Female	AA	C	H	O	Avg. GPA
Total Students	278	52.9	47.1	63.3	16.9	10.4	9.4	70.9
Group 1	70	51.4	48.6	61.4	17.1	5.7	15.7	70.7
Group 2	67	55.2	44.8	65.7	19.4	11.9	3.0	69.5
Group 3	70	52.9	47.1	57.1	22.9	12.9	7.1	71.8
Group 4	71	52.1	47.9	69.0	8.5	11.3	11.2	71.6
NSWD	248	49.6	50.4	63.3	15.7	11.7	9.3	71.2
Group 1	63	49.2	50.8	65.1	15.9	6.3	19.0	71.2
Group 2	60	53.3	46.7	63.3	20.0	13.3	3.3	70.1
Group 3	62	50.0	50.0	56.5	21.0	14.5	8.1	72.0
Group 4	63	46.0	54.0	68.3	6.3	12.7	12.7	71.8
SWD	30	80.0	20.0	73.3	26.7	0	0	68.0
Group 1	7	71.4	28.6	71.4	28.6	0	0	66.7
Group 2	7	71.4	28.6	85.7	14.3	0	0	63.7
Group 3	8	75.0	25.0	62.5	37.5	0	0	70.2
Group 4	8	100.0	0	75.0	25.0	0	0	70.6

Note. NSWD = Students without disabilities; SWD = Students with LD; AA = African American; C = Caucasian; H = Hispanic; O = Other. GPA calculated based on 0-100 scale.

Instructional Materials

Content Acquisition Podcasts (CAPs) for Vocabulary Instruction

Content Acquisition Podcasts (CAPs) are stand-alone multimedia-based instructional materials that can be used in teaching and learning. Each CAP delivers instruction for a specific topic or piece of information (e.g., one vocabulary term or concept). Traditionally, podcasts are audio recordings that can be uploaded to the Internet and synced to a simple syndication (RSS) feed. However, there are no explicit guidelines with respect to the length, topic, or quality for how to produce and use podcasts in learning (Heilson, 2010; Hew, 2009). A second kind of podcasts, enhanced podcasts, are also audio recordings, but they are synced in time with visuals (Kennedy, Hart, & Kellems, 2010). However, the basic definition of enhanced podcasts fails to describe guidelines for production that pay explicit attention to the cognitive learning needs of users (Heilson; Hew).

CAPs were designed to address this limitation of generic podcasts or enhanced podcasts by combining the ease of use of podcasts and enhanced podcasts with strong science related to cognitive learning and adherence to validated instructional design principles (Mayer, 2009). CAP contains a combination of narration and visuals (pictures and on-screen text) that delivers instruction on one specific topic. While there is not a precise requirement for length, to adhere to Mayer's segmenting and coherence principles (Mayer), it is important that only essential information be included within each CAP.

The CAP intervention is intended to be a theoretically sound framework for designing, packaging, and delivering an assortment of evidence-based practices that meet specific cognitive processing and academic needs of students with LD and, in turn, enable students with LD to respond to the rigorous demands of the curriculum relative to vocabulary understanding, learning, and application. As such, the CAP design framework embodies Mayer's cognitive theory of multimedia learning (CTML; 2009) and accompanying instructional design features (Mayer, 2008, 2009). Each of Mayer's instructional design principles has its own empirical record (Mayer, 2008) and functions as a roadmap for the constructing multimedia instructional materials that support the cognitive processing of learners (Kennedy & Deshler, 2010; Mayer, 2009).

Figure 4 presents this model as aligned with DeLeeuw and Mayer's (2008) triarchic model of cognitive load. As noted in Chapter 2, the triarchic model of cognitive load (DeLeeuw & Mayer) organizes the three goals of multimedia instruction (i.e., limit extraneous processing, manage essential processing, and foster generative processing) into a framework aligned with Mayer's multimedia instructional design principles (Mayer, 2001, 2005, 2008, 2009). In this study, Mayer's multimedia instructional design model was paired with evidence-based explicit and strategic vocabulary instruction to support the vocabulary learning of adolescents with LD who were enrolled in a high school world history course. An example of a CAP may be viewed at www.vimeo.com/19021764.

Construction of CAPs. The production steps for the CAPs used in this experiment were multi-faceted. For example, each CAP adheres to (a) generic production steps for creating CAPs using PowerPoint (e.g., Kennedy et al., 2010); (b) Mayer's CTML and accompanying instructional design features; and (c) specific methods for evidence-based vocabulary instruction that lend themselves to delivery using multimedia instruction.

Figure 4. Mayer's design principles as aligned with the triarchic model of cognitive load (Kennedy et al., 2010).

Triarchic Model of Cognitive Load (DeLeeuw & Mayer, 2008)	Research-Based Instructional Design Principles (Mayer, 2009)	Brief Description of Mayer's Instructional Design Principles (Mayer, 2009)
Limit Extraneous Processing	Coherence Principle	Learning is enhanced when irrelevant or extraneous information is excluded
	Signaling Principle	Learning is enhanced when explicit cues are provided that signal the beginning of major headings or elements of the material being covered
	Redundancy Principle	Learning is enhanced when extensive text (transcription) on screen along with spoken words and pictures is not used. Carefully selected words or short phrases, however, augment retention (Mayer & Johnson, 2008)
	Spatial Contiguity Principle	Learning is enhanced when on-screen text and pictures are presented in close proximity to one another to limit eye shifting during instructional presentations
	Temporal Contiguity Principle	Learning is enhanced when pictures and text correspond to the audio presentation
Manage Essential Processing	Modality Principle	Learning is enhanced when spoken words and pictures are used as part of instruction
	Segmenting Principle	Learning is enhanced when multimedia presentations are divided into short bursts (5-7 minutes) as opposed to longer modules
	Pretraining Principle	Learning is enhanced when instructional messages contain an orienting message to introduce the forthcoming content
Foster Generative Processing	Multimedia Principle	Learning is enhanced when pictures and spoken words are used instead of words alone
	Personalization, Voice, and Image Principles	Learning is enhanced when narration is presented in a conversational style instead of more formal audio presentations

Context-free production steps. Appendix A presents the context-free steps for creating a CAP using PowerPoint (Office 2011) and Apple's iMovie (iMovie '11) software. "Context-free" indicates that Mayer's instructional design principles are being used; however, the specific content being taught has not yet been specified. These steps have been used to create CAPs used in various research studies (Kennedy et al., 2010, in preparation a, in preparation b). The current iteration of these production steps reflects critical feedback received during a recent design experiment (Kennedy et al., in preparation c).

In the present study, the context-free steps for CAP production were combined with evidence-based practices for vocabulary instruction to create the final intervention tested in this study. A CAP on how to produce a CAP based on the context-free production steps is available at www.CAPInstructions.com.

Adherence to Mayer's model. Simple use of multimedia instructional materials does not inherently possess features that reflect best practice for learning (Heilson, 2010; Hew, 2009). Therefore, it was critical that the multimedia materials used in this study adhered to a theoretical model for high quality multimedia instruction. Figure 5 presents Mayer's CTML and instructional design features in the context of CAP production steps. It shows a broad framework for how each of Mayer's instructional design principles, as aligned with the triarchic model of cognitive load, guides production within each CAP as used in this experiment.

While Figure 5 provides a broad framework for CAP adherence to Mayer's model, a more precise guide was needed to ensure multimedia materials used in instruction adhered to this theoretical model. A rubric for CAP production based on Mayer's CTML and instructional design features (see Figure 6) was developed and used to ensure that all CAPs in this study adhered to this model.

Figure 5. Linkage of CAP production steps to Mayer's CTML and instructional design principles.

Triarchic Model of Cognitive Load (DeLeeuw & Mayer, 2008)	Research-Based Instructional Design Principles (Mayer, 2009)	Brief Description of Mayer's Instructional Design Principles (Mayer, 2009)
Limit Extraneous Processing	Coherence Principle	Each CAP only contains information relevant to the history term/concept being presented
	Signaling Principle	Each CAP contains recurring explicit cues to signal the beginning of a new section (e.g., definition, synonym, antonym, mnemonic)
	Redundancy Principle	Each CAP only contains carefully selected key text
	Spatial Contiguity Principle	The on-screen text and pictures in each CAP are presented in close proximity to one another
	Temporal Contiguity Principle	Pictures and text within each CAP correspond to the audio presentation
Manage Essential Processing	Modality Principle	CAPs are multimedia; therefore this principle is addressed
	Segmenting Principle	Each CAP is approximately 120 seconds in length; many are shorter
	Pretraining Principle	Each CAP begins with an explicit statement of purpose and an advance organizer for the term
Foster Generative Processing	Multimedia Principle	The CAPs are multimedia; therefore this principle is addressed
	Personalization, Voice, and Image Principles	The narration in each CAP is presented in a conversational style

CAPs and evidence-based vocabulary instruction. In this study, the CAP framework was teamed with various evidence-based instructional methods for vocabulary instruction to support adolescents as they engage voluminous vocabulary demands in high school history courses. Six specific instructional variables, grounded in the empirical literature on vocabulary instruction (see Chapter 2), were embedded into the instructional routine used with each CAP. These included (a) promoting word consciousness (e.g., pronunciation, spelling, syllables, prefix, suffix, root words); (b) providing direct instruction of word meanings; (c) providing guided practice and scaffolding; (d) providing awareness of closely related terms; (e) using the keyword mnemonic strategy; and (f) providing a statement of purpose/rationale for why the student needs to learn a given term or concept.

Figure 6. CAP production rubric based in Mayer's CTML and instructional design features.

Triarchic Model of Cognitive Load (DeLeeuw & Mayer, 2008)	Research-Based Instructional Design Principles (Mayer, 2009)	
Limit Extraneous Processing	Coherence Principle	1 - - - - - - - - - - - - - - - - - - 2 - - - - - - - - - - - - - - - - - - 3 Included excess irrelevant content / Some irrelevant content / Standard met
	Signaling Principle	1 - - - - - - - - - - - - - - - - - - 2 - - - - - - - - - - - - - - - - - - 3 Lacking Cues / Some cues provided / Standard met
	Redundancy Principle	1 - - - - - - - - - - - - - - - - - - 2 - - - - - - - - - - - - - - - - - - 3 Extensive Text / Too much text in some places / Standard met
	Spatial Contiguity Principle	1 - - - - - - - - - - - - - - - - - - 2 - - - - - - - - - - - - - - - - - - 3 Text and picture too broadly presented / Text and pictures too broad sometimes / Standard met
	Temporal Contiguity Principle	1 - - - - - - - - - - - - - - - - - - 2 - - - - - - - - - - - - - - - - - - 3 Audio & slides misaligned / Audio & slides misaligned some / Standard met
Manage Essential Processing	Modality Principle	1 - - - - - - - - - - - - - - - - - - 2 - - - - - - - - - - - - - - - - - - 3 No audio or pictures / Some audio &/or pictures / Standard met
	Segmenting Principle	1 - - - - - - - - - - - - - - - - - - 2 - - - - - - - - - - - - - - - - - - 3 Exceeds 7 minutes / Exceeds 5 minutes / Standard met
	Pretraining Principle	*1 - - - - - - - - - - - - - - - - - - 2 - - - - - - - - - - - - - - - - - - 3* No orientation occasionally / Orientation offered / Standard met
Foster Generative Processing	Multimedia Principle	*1 - - - - - - - - - - - - - - - - - - 2 - - - - - - - - - - - - - - - - - - 3*
	Personalization, Voice, and Image Principles	*1 - - - - - - - - - - - - - - - - - - 2 - - - - - - - - - - - - - - - - - - 3* Formal / Some formal/ Some conversational / Conversational

Appendix B is the CAP Vocabulary Instruction eWorksheet (VIeW) Checklist. The VIeW Checklist was used to plan the content of each CAP to ensure consistency between the videos and to create a script, which was used when creating each CAP. The researcher and the two participating teachers completed a VIeW for each vocabulary term/concept. A 100% agreement was reached regarding the content to be included for each individual CAP.

Independent review of CAPs. Each CAP used in the study was reviewed using the CAP production rubric (see Figure 3) and the CAP Adherence Worksheet (see Appendix C). The CAP Adherence Worksheet is similar to the VIeW described above (see Appendix B), but includes space for the designer and/or reviewer to note whether or not the various evidence-based practices for vocabulary instruction are included in the CAP.

Two reviewers with experience totaling approximately 20 hours each using the Production Rubric and Adherence Worksheet to score CAPs during a previous research study (Kennedy et al., in preparation c) independently scored each CAP. A third reviewer, a veteran teacher of adolescents with LD (i.e., 10 years experience; master's degree in special education), also used the production rubric and adherence worksheet to score the CAPs used in this study. Feedback from the three reviewers was pooled and used to make revisions to the CAPs prior to use in the study. Interscorer reliability across the three reviewers was 95%. The researcher made revisions based on the feedback received and then invited the reviewers to review the CAPs a second time. CAPs were not used in the study until all the reviewers' concerns were satisfied.

Measurement Instruments

Measurement Issues Related to Vocabulary Knowledge

Measuring knowledge of highly specific vocabulary terms/concepts from the various content areas has historically posed problems of reliability and validity (Baumann et al., 2003; Dale, 1965; Stahl & Bravo, 2010; Stahl & Fairbanks, 1986). Even when the instruments are reliable and valid for their intended use, many standardized measures (e.g., ITBS, PPVT-III) fail to provide reliable and valid measures of specialized academic vocabulary knowledge (Paris, 2005; Stahl & Bravo). In addition, standardized measures can be expensive, difficult to administer and score, and take up significant amounts of teacher and student time. Content-area courses are filled with discipline-specific terminology and concepts, which gives rise to a mismatch between the somewhat limited nature of standardized vocabulary assessments versus the terms/concepts actually taught during instruction (Stahl & Bravo).

Similarly, teacher- and/or researcher-created assessments of vocabulary knowledge (e.g., multiple choice, matching assessments) have been criticized for lack of adequate reliability and internal and external validity with respect to the information that can be gained through the use of instruments with multiple-choice options (Baumann et al., 2003). However, measuring whether students have learned the meaning of vocabulary terms or concepts in content areas is not a simple task (Nagy & Scott, 2000). In fact, there is controversy regarding what it even means to "know a word" (Paris, 2005; Stahl & Fairbanks, 1986; Stahl & Nagy, 2006). This controversy translates into challenges for measuring student knowledge. Nevertheless, it is possible for researchers and teachers to create reliable and valid instruments to measure student vocabulary knowledge (Stahl & Bravo, 2010).

In this study, two researcher-created instruments were created in an attempt to overcome the limitations of simple, "one-term, one-question" forced-choice measurement instruments. The instruments reflect the need to measure student knowledge of terms along a continuum of knowledge.

Pretest Instruments

The pretest for this research study was comprised of two instruments. Participants completed both instruments prior to the start of the study. Both instruments were intended to measure student knowledge regarding 30 world history terms/concepts taught using the CAP intervention.

Multiple-choice instrument. A multiple-choice instrument with 30 items was constructed to measure students' ability to use their knowledge to identify correct definitions for critical vocabulary terms and concepts from world history. The multiple-choice instrument included 30 items that correspond to the 30 vocabulary terms/concepts selected by the two participating history teachers for use in the study as being central to understanding and learning critical course content. The stem for each item simply included the term (e.g., Imperialism, Nationalism) and the appropriate article (e.g., Imperialism is, Nationalism is). The answer choices and distractors for each item were definitions from the textbook glossary. The exact definition that appeared in the glossary most often appeared in the text. Therefore, the decision to use glossary definitions as answer choices and distractors corresponds to a common reading requirement within most high school history courses (VanSledright, 2008). Answer choices were selected based on length (number of words), relevance to the correct answer (as distractors), and language density (ease of reading). (The multiple-choice instrument is available in Appendix D.)

The construction of this instrument reflects best practice for multiple-choice item construction as detailed by Haladyna, Downing, and Rodriguez (2002). Three experts in world history (one professor and two doctoral candidates) reviewed each of the multiple-choice items for difficulty, clarity, and errors in content or grammar, and provided comments for revision. The two partner teachers for the study also reviewed the items and provided comments for revision. Finally, a language specialist and expert in the field of learning disabilities reviewed each item for language consistency and appropriateness among the distractor items. Reviewers and the researcher held individual conversations regarding their critique and ideas for improvement. The reviewers confirmed that their concerns had been addressed through a review of the final instrument.

Students were told that by the researcher that they are invited to participate in a research study to help evaluate new methods for teaching vocabulary terms in history. “To accomplish this goal, it is necessary to take a pretest of knowledge to figure out which words students already know. The pretest contains 30 multiple-choice items, and 30 open-ended questions where you will be asked to provide a definition for each term, along with a synonym, antonym, and any other information you know about that term. You are not expected to know all of these terms, however, please do the very best that you can, there is no penalty for incorrect answers.” While the multiple-choice and open-ended instruments will be described separately here, during the experiment, the directions for both were given to students simultaneously.

Following the instructions, the multiple-choice pretest was given to students during a class period of their world history course. Students were given a test form and an answer sheet for recording responses. Students with LD were provided with an accommodation during all assessment activities. (The accommodation will be described below.)

All multiple-choice items were scored by the researcher and entered into a spreadsheet by research assistants (RA). RAs had a copy of the answer key and re-scored 10% of the researcher’s work to ensure fidelity. If mistakes were found, the researcher re-scored all the tests and resubmitted them for external review by the RA. Students were given a score of one for every correct answer, and a score of zero if the answer was incorrect. The researcher reviewed 10% of each assistant’s work to ensure accuracy. If any mistakes were found, the researcher reviewed 100% of that assistant’s work and fixed any errors.

Cronbach's alpha was calculated for the multiple-choice instrument following the pretest to determine the quality of internal consistency for this measure. The alpha level was .81. An alpha level of .70 or higher is typically considered acceptable in social science research (Cronbach, 1951). Regardless of quality, however, use of a researcher-created multiple-choice instrument alone would not provide sufficient evidence that students moved along Bravo and Cervetti's (2008) continuum from possession of no knowledge to passive knowledge of vocabulary terms/concepts (see Chapter 2). Passive knowledge requires a demonstration of knowledge that goes beyond identification of a simple definition. Therefore, a second assessment instrument was created in order to measure and corroborate student learning.

Open-ended instrument. The second pretest instrument was open-ended. Its purpose was to evaluate students' ability to produce a definition for the term in writing and also to probe deeper knowledge of terms (e.g., synonyms, antonyms) and any contextual understanding based on knowledge provided within each CAP. Specifically, the open-ended instrument asked students to "write what you know" about each of the 30 terms/concepts. To add structure, students were given space to write (a) the definition, (b) a synonym for the term, (c) an antonym for the term, and (d) any additional information they know about the concept. Thus, this instrument required much more than simple matching, a form of vocabulary assessment that has been widely criticized (Stahl & Bravo, 2010), as mentioned above. In addition, the open-ended instrument was intended to provide corroborating evidence of student movement on Bravo and Cervetti's (2008) continuum from no knowledge to passive knowledge of terms, and producing written responses is a typical requirement in high school coursework.

Again, students were encouraged to do the best that they could, despite the likelihood of not knowing the definition of all 30 terms. When taking the pretest, students completed the open-ended instrument first, teachers collected student papers, and then students completed the multiple-choice instrument. This step was built in to ensure students did not copy answers from the multiple-choice assessment onto the open-ended instrument. (The open-ended segment of the pretest is available in Appendix E.)

A rubric of correct and acceptable answers was constructed during discussion with the two teachers. The rubric is tied directly to the script used to create the narration for each CAP to ensure acceptable responses could be linked to instruction students received during the experiment. Students scored between zero and five points for each question on the open-ended instrument. A correct definition was worth two points, whereas students received one point each for naming a correct synonym and antonym. Students could earn a fifth point by providing an additional piece of information related to the term/concept that was provided within the CAP (e.g., if a student wrote "An example of an alliance is the Triple Alliance, which fought against the Triple Entente in WWI," they would receive 1 point).

The researcher and each of the two teachers independently scored student responses using a rubric of acceptable responses. Scores were compared between the researcher and each teacher for his own students. When scores did not match, 100% resolution for each item was achieved through conversation. Preliminary interscorer reliability was 93% with Teacher 1, and 95% with Teacher 2; final interscorer reliability with both teachers for all items was 100%.

Student scores from the multiple-choice and open-ended instruments were combined for the purpose of analysis. Students could score between 0-30 on the multiple-choice instrument (0-10 on each of the three segments) and between 0-150 on the open-ended instrument (0-50 on each of the three segments). Therefore, raw scores were converted to standardized *z*-scores and then averaged to produce the final score used in analyses. Raw scores from the pretest, posttest, and maintenance probes were all converted to standardized *z*-scores prior to analyses.

Cronbach's alpha was calculated for the open-ended items following the pretest to determine the quality of internal consistency for this measure. The alpha level was .84. An alpha level of .70 or higher is typically acceptable in social science research (Cronbach, 1951).

Posttest Instruments

The posttest contained the same multiple-choice and open-ended instruments used in the pretest. This was done to be able to measure gains in knowledge following exposure to the CAPs across Conditions 1-3 and the instruction in Condition 4. Based on feedback from the pilot study, and findings from Johnson et al. (1987) regarding efficiency of multimedia instruction, students watched five CAPs back-to-back and then took the posttest on the five terms/concepts.

Students again completed the open-ended instrument first, handed it in, and then completed the multiple-choice instrument to prevent copying from one instrument to the other. This process was completed a total of six times across three school days. Student responses on both instruments were scored using the same procedures described for the pretest.

Cronbach's alpha was calculated for the multiple-choice and the open-ended items following the posttest to determine the quality of internal consistency for each instrument. The alpha level for the multiple-choice instrument at posttest was .87. The alpha level for the open-ended instrument at posttest was .95. Both alpha levels provide strong evidence of the reliability of the measurement system used in this study.

Maintenance Probes

The maintenance probes contained the same instruments used in the pretest. The purpose of using the same instruments for the pretest, posttest, and maintenance probes was to measure gains and durability in knowledge following exposure to the CAPs across Conditions 1-3 and the instruction in Condition 4. Student responses were scored using the same procedures noted above.

For terms 1-10, the maintenance probe was given 24 days after the experiment. For terms 11-20, maintenance was given 22 days after the experiment, and for terms 21-30, the maintenance probe was given 19 days after the experiment. After the instructional phase of the study ended, the two teachers provided in-class instruction that incorporated the first 20 terms/concepts during their lectures and other learning activities throughout their unit on World War I. This instruction was not observed or evaluated. However, it could be assumed that maintenance data for these items reflects student performance influenced by a combination of learning from the CAPs and in class learning. Terms 21-30 were never mentioned during class instruction; therefore, maintenance scores for these items from both measurement instruments can be attributed to learning acquired during the CAPs and, therefore, were used in the final evaluation of the CAP intervention. Student responses were scored using the same methods as noted above.

Cronbach's alpha was calculated for the multiple-choice and the open-ended items following the posttest to determine the quality of internal consistency for this instrument. The alpha level for form A at posttest was .86. The alpha level for form B at posttest was .90.

Accommodations for students with LD. The students with LD (in the SWD group) in this study had specific and documented problems with reading. Although the researcher could not secure permission to report individual reading scores from standardized and other assessments, through conversations with the general education and the special education teachers, it was confirmed that students assigned to this group had a reading level of at least two years below their current grade. The teachers made this determination using recent psychological assessment evaluation information from each student's IEP and their professional judgment. Therefore, it was possible that the reading capacity of some students would result in inaccurate measurement when taking the multiple-choice assessments.

To help students with reading difficulties take assessments, several researchers (e.g., Dolan, Hall, Banerjee, Chun, & Strangman, 2005; Salend, 2009) have used screen reader technologies. The function of screen readers is to allow students to hear question stems and answer choices read aloud, and to see words highlighted in time with the audio. Many screen readers contain control button options including play, pause, stop, rewind, and fast-forward.

For this study, the screen reader software *Ghost Reader* (http://www.convenienceware.com/ghostreader.php) was selected, stemming from its similarity to software used in previous research (Dolan et al., 2005), compatibility with Apple computers, and the recommendation of a technology expert in the field of special education. Five copies of *Ghost Reader* were purchased and installed on laptops within the classrooms for use in the study.

During the experiment, all students in the study sat at laptop terminals with headphones on; therefore, there was no outward difference for students using the *Ghost Reader* software to complete assessments. *Ghost Reader* was used during the pretest, posttest, and maintenance probes. Before using *Ghost Reader* during the experiment, students practiced using sample multiple-choice items not included in the research study. Student questions and concerns were resolved through discussion.

Satisfaction Survey

A satisfaction survey was given to all participating students following completion of the maintenance probe. The survey took approximately 10 minutes to complete. Survey items were a blend of open-ended and Likert items. The scale for the Likert items was 1-10, with a score of 1 designating a response of "Strongly Disagree," and a score of 10 designating that the respondent "Strongly Agreed" with the statement or question. Students were free to select any score along the range from 1-10. This permits clearer differentiation of responses than is possible with typical five- or seven-choice Likert items (Fowler, 2009).

The survey was constructed based on three constructs relevant to this study's research questions: (a) ease and function of technology within the CAPs, (b) usefulness of CAPs for learning new vocabulary terms/concepts in world history, and (c) student preferences/plans for future use of the CAP tool. Some items were adapted from a survey used in a previous study of CAP use (Kennedy et al., in preparation c). Because students remained in the same experimental group throughout the study, they were asked to note which of the four groups they were in for the experiment. This allowed survey responses to be sorted by group, which permitted analyses of responses based on the version of the CAPs that were watched. (The survey may be found in Appendix F.) The survey was reviewed by three doctoral students, who were asked to provide feedback on wording of questions, order of questions, and overall quality of the instrument. Feedback was used to make updates to the survey. The reliability alpha for the open-ended instrument was .73.

Procedures

Recruitment of Teachers and Students

Permission to conduct research was secured from the University of Kansas Human Subject Committee and the district's research office. An email request to participate in this research was sent to all world history teachers in the targeted school district. Teachers who responded were asked to attend a meeting where the researcher introduced the CAP intervention and invited them to participate. A total of three world history teachers expressed interest, two serving in the same building.

A decision was made to constrain the study to one school because a sufficient number of overall students and students with LD were available. After securing permission from the teachers, the school's principal was informed and consent to conduct the study in the building was obtained. Students in both teachers' classes were invited to participate in the study. Informed consent forms were sent home with each student, and the teachers sent an email to parents explaining the purpose of the study and confirming the legitimacy of all research activities.

Selection of Vocabulary Terms/Concepts

Thirty vocabulary terms and/or concepts were selected from the course curriculum to be turned into CAPs. The researcher and both teachers collaboratively reviewed a list of all relevant vocabulary terms/concepts for the WWI unit based on a review of the course textbook, the district curriculum, and state standards. Twenty terms/concepts considered to be critical to understanding the unit were selected from a pool of more than 50 terms. The terms/concepts were also selected based on the teachers' respective course calendars to ensure the first in-class exposure to the terms/concepts would come through watching the experimental CAPs. Then, 10 additional vocabulary terms/concepts were selected from units in the curriculum that had not yet been taught (WWII, Cold War, etc.).

During the span of the WWI unit, teachers were scheduled to teach each of the selected 20 terms/concepts at some point following the experiment and posttest; therefore, any maintenance probe evaluating sustained learning would include effects from the teacher's instruction. Therefore, the additional 10 terms/concepts provided a clean opportunity to measure sustained learning based on the CAPs. (The list of terms/concepts is available in Appendix G.)

Student Procedures for Watching CAPs and Taking Assessments

Fidelity checklist. A fidelity checklist was created for use during the experiment (see Appendix H). Because the two participating teacher's sections (six sections per teacher) met simultaneously, it was not logistically possible for the researcher to personally give instructions to all students and be present during each trial of the experiment. All participating students with LD were taught by one of the two teachers; the researcher remained in that classroom to provide any needed support to those students.

The fidelity checklist provided teachers and the researcher with a script and steps to follow when giving directions and during the experiment to address any technical problems or student questions. The checklist was reviewed with both teachers prior to each day of the experiment. The researcher and teachers debriefed following each trial of the experiment to discuss and resolve any issues.

Students completed research activities during their regularly scheduled world history course. Students were provided a random ID number to protect their identity throughout the study. All assessments given during the experiment were untimed. Students who did not finish before the end of a given period were given hall passes that enabled them to stay and finish their work. All students used an Apple Macbook laptop computer for the experiments. Students were provided with a set of headphones if they did not have their own. All CAPs were uploaded to the two teachers' course management site (www.schoolloop.com) and sorted into online folders in groups of five. Online folders with the CAPs were only made available for the specific day and time of the experiment. Assessments were completed on paper.

Orientation CAP. On the first day of the experiment (Day 1 of 6), students were instructed to watch an orientation CAP on what to expect when participating in the instruction with a CAP. The Orientation CAP contained explanations of each major element of the major elements of each CAP: (a) pronunciation, spelling, syllables, prefix, suffix, root words; (b) direct instruction of word meanings; (c) guided practice and scaffolding; (d) awareness of closely related terms; (e) use of the keyword mnemonic strategy; and (f) a statement of purpose/rationale for why the student needs to learn the term or concept. Student questions were answered following completion of the Orientation CAP. (The Orientation CAP may be seen at http://vimeo.com/19153441.)

Experimental procedures. Students were instructed to watch five CAPs in succession during one class period. Depending on condition, each CAP was approximately 120 seconds long. The researcher and teacher circulated the room to ensure students were watching the CAPs and not navigating to other websites or programs. After finishing the fifth video, students were to raise their hand and close their laptop.

The researcher or teacher handed students the open-ended instrument, which asked students to (a) write the definition for each term/concept, (b) provide a synonym/antonym, and (c) provide any other related information for each term/concept. When students completed this instrument, they raised their hand; the researcher or teacher collected the paper and handed the students the multiple-choice assessment. After completing the multiple-choice items, students again raised their hand, the paper was collected, and students watched the next five CAPs. In sum, students watched 10 CAPs during each day of the experiment and completed the corresponding posttests. There were three total experiment days, for a sum of 30 CAPs.

Research Design and Data Analysis

An experimental, four-group pretest-posttest-maintenance design was used to determine the utility of CAPs for providing vocabulary instruction to adolescents with and without LD enrolled in a world history course. The content and narration within the CAPs for each of the four experimental conditions were the same. Further, all students completed the same pretest, posttest, and maintenance assessment.

Two repeated measures ANOVAs were conducted for each of the three sets of students, (a) students with LD (SWD; n = 30); (b) students without LD (NSWD; n = 249); and (c) all students (n = 279). Therefore, a total of six repeated-measures ANOVAs were conducted with two between-subjects variables, (a) group assignment (Group 1-4) and (b) grade point average (GPA), from the first semester of the world history course (scale of 0-100). There were also two within subject variables, (a) standardized scores on a pretest and posttest of vocabulary knowledge for all 30 world history terms; and (b) standardized scores on a pretest, posttest, and maintenance instrument for terms 21-30. Appropriate post-hoc analyses were completed after each of the six ANOVAs to further evaluate differences in group performance and/or impact of GPA.

When significant group differences were found in any of the analyses, post-hoc analyses were completed. A Bonferroni Correction was used to control for Type I errors during analyses of the six pairwise group comparisons (e.g., Group 1-Group 2, G1-G3, G1-G4, G2-G3, G2-G4, G3-G4; $\alpha = .05/(2x3) = .0083$). Tukey's test for post-hoc comparisons was used to conduct the analyses.

Finally, results from the Student Satisfaction Survey were analyzed using quantitative data for the Likert-items, and qualitative coding methods for the open-ended questions. For the Likert items and corresponding data, responses were organized by group assignment and were compared to one another for the purpose of evaluating differences and/or emerging trends that may be attributed to the different versions of the CAPs.

Along with the Likert items, students were also asked to answer three open-ended questions regarding their experience and overall satisfaction with the CAPs. A research assistant typed student responses into a spreadsheet organized by question (1-3) and group assignment (1-4). Based on an analysis of student responses, the researcher created codes within each of the three open-ended questions. For example, for question 1: Was there anything about the podcasts that really helped you learn about the vocabulary term (e.g., the pictures, the sound, the words on the screen, technology format)? Several students across all four groups noted that the use of pictures and text helped them learn. Therefore a code for 'Use of Multimedia Materials' was created. A tally was kept within each code for each of the four groups of students.

CHAPTER IV

RESULTS

Results for Students with LD, Students without LD, and All Students

Two hundred seventy nine urban adolescents were randomly assigned to one of four experimental conditions. Students in Group 1 watched Content Acquisition Podcasts (CAPs) containing both explicit instruction and the keyword mnemonic strategy. Students in Group 2 watched CAPs containing explicit vocabulary instruction. Students in Group 3 watched CAPs containing the keyword mnemonic strategy, and students in Group 4 watched instructional videos that did not adhere to Mayer's CTML (only text, no pictures), but did contain the same content as the other three CAPs. The information provided within each condition's CAPs was exactly the same. Although students were randomly assigned to conditions, independent *t*-tests of pretest scores confirmed there were no significant differences between any combinations of the four experimental groups prior to the intervention. Table 2 presents the results of the independent *t*-tests.

First, two repeated measures ANOVAs were conducted each for two sets of students, (a) students with LD (SWD) and (b) students without LD (NSWD). Therefore, a total of four repeated measures ANOVAs were conducted with two between-subjects variables, (a) Group Assignment (Group 1-4), and (b) Grade Point Average (GPA) from the first semester of the world history course (scale of 0-100). There were also two within subject variables (Time), (a) standardized scores on a pretest and posttest of vocabulary knowledge for 30 world history terms; and (b) standardized scores on a pretest, posttest, and maintenance instrument for the subset of terms 21-30. Appropriate post-hoc analyses were completed after each of the

ANOVAs to further evaluate differences in group performance and/or impact of GPA. Means and standard deviations for the Multiple-Choice and Open-Ended Instruments are presented in Tables 3 and 4.

Table 2

Results of independent t-tests for measurement of group differences at pretest

Group	*N*	*M*	*SD*	*p*
Group 1—Group 2				
Group 1	70	.079	2.21	.90
Group 2	66	.138	3.21	
Group 1—Group 3				
Group 1	70	.079	2.21	.34
Group 3	70	-.297	2.42	
Group 1—Group 4				
Group 1	70	.079	2.21	.93
Group 4	71	.115	2.63	
Group 2—Group 3				
Group 2	66	.138	3.21	.37
Group 3	70	-.297	2.42	
Group 2—Group 4				
Group 2	66	.138	3.21	.96
Group 4	71	.115	2.63	
Group 3—Group 4				
Group 3	70	-.297	2.42	.34
Group 4	71	.115	2.63	

Note. Mean score reflects the average of standardized scores for Multiple-Choice and Open-Ended instruments

Second, a series of repeated measures ANOVAs were conducted to compare the performance of students with learning disabilities in Groups 1-3 against the performance of students without LD in all four Groups. The purpose of these comparisons is to determine the extent to which the CAP intervention can provide specially designed instruction to help SWD close the performance gap for content-area vocabulary learning between SWD and NSWD. The same between and within subjects variables will be tested, and appropriate post-hoc analyses will be completed. The results section concludes with the results from a student satisfaction survey.

Table 3

Pretest and Posttest Mean Scores and Standard Deviations for Multiple-Choice and Open-Ended Instruments

	MC Pretest		OE Pretest		MC Posttest		OE Posttest	
	M	SD	M	SD	M	SD	M	SD
SWD Items 1-10								
Group 1 (n = 7)	4.0	2.23	3.3	3.99	8.1	2.48	12.0	1.06
Group 2 (n = 7)	4.0	1.82	3.0	2.82	7.3	2.14	11.9	2.19
Group 3 (n = 8)	4.3	2.31	2.5	2.20	7.1	1.64	7.1	1.64
Group 4 (n = 8)	4.4	.52	3.3	.92	7.3	1.28	7.3	1.28
NSWD Items 1-10								
Group 1 (n = 63)	5.3	2.03	4.2	4.11	8.3	1.68	17.0	7.44
Group 2 (n = 60)	4.7	2.62	4.1	4.06	7.9	1.96	14.8	6.34
Group 3 (n = 62)	4.8	2.62	3.3	3.46	8.1	2.05	13.6	4.60
Group 4 (n = 63)	5.2	2.52	3.8	4.26	6.8	2.16	10.9	5.27
SWD Items 11-20								
Group 1 (n = 7)	3.3	.95	.57	1.13	8.3	2.63	12.7	2.00
Group 2 (n = 7)	3.1	2.67	.29	.49	7.6	2.00	8.3	3.77
Group 3 (n = 8)	3.1	1.89	.50	.53	6.1	1.55	6.1	1.55
Group 4 (n = 8)	3.1	1.64	.50	.53	5.3	1.75	5.3	1.75
NSWD Items 11-20								
Group 1 (n = 63)	4.2	1.88	.97	1.63	8.6	1.35	20.4	12.8
Group 2 (n = 60)	4.6	2.64	1.3	2.36	7.2	2.16	16.3	10.26
Group 3 (n = 62)	4.0	2.10	.87	1.69	7.1	2.05	14.8	7.60
Group 4 (n = 63)	4.1	2.13	.81	1.35	5.8	2.01	11.3	8.90
SWD Items 21-30								
Group 1 (n = 7)	2.0	1.15	.43	1.13	8.1	1.57	8.7	1.11
Group 2 (n = 7)	2.9	1.68	.00	.00	5.7	2.36	5.6	2.03
Group 3 (n = 8)	1.9	1.45	.00	.00	6.4	.92	6.3	2.12
Group 4 (n = 8)	2.5	.93	.37	.52	4.1	2.10	3.3	3.32
NSWD Items 21-30								
Group 1 (n = 63)	2.8	1.79	.44	1.17	8.2	1.69	18.5	9.70
Group 2 (n = 60)	3.2	2.05	.28	.79	6.6	1.81	14.3	8.41
Group 3 (n = 62)	3.1	1.93	.67	1.43	6.5	1.72	11.9	6.26
Group 4 (n = 63)	2.7	1.74	.60	1.18	5.6	1.65	8.9	6.36

Note. *MC = Multiple-Choice Instrument; OE = Open-Ended Instrument. The MC Instrument has a score range of 0-10 (30 total); the OE Instrument has a score range of 0-50 (150 total). NSWD = Students without a learning disability; SWD = Students with LD.*

Table 3 (Continued)

Pretest and Posttest Mean Scores and Standard Deviations for Multiple-Choice and Open-Ended Instruments

	MC Pretest		OE Pretest		MC Posttest		OE Posttest	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
SWD Total								
Group 1 (n = 7)	9.3	2.69	4.3	5.59	24.6	6.10	33.4	6.99
Group 2 (n = 7)	10.0	4.65	3.3	3.15	20.6	4.61	25.7	6.6
Group 3 (n = 8)	9.3	2.05	3.0	2.33	19.6	3.33	23.8	5.65
Group 4 (n = 8)	10.0	2.13	4.1	.99	16.6	3.25	14.1	5.99
NSWD Total								
Group 1 (n = 63)	12.2	4.26	5.6	5.90	25.0	3.81	56.0	25.11
Group 2 (n = 60)	12.5	6.47	5.8	6.56	21.8	4.61	45.4	21.61
Group 3 (n = 62)	11.9	5.30	4.8	5.90	21.7	4.39	40.3	14.83
Group 4 (n = 63)	12.1	5.18	5.2	6.40	18.3	4.80	31.2	17.90

Note. MC = Multiple-Choice Instrument; OE = Open-Ended Instrument. The MC Instrument has a score range of 0-10 (30 total); the OE Instrument has a score range of 0-50 (150 total). NSWD = Students without a learning disability; SWD = Students with LD.

Table 4

Maintenance Mean Scores and Standard Deviations for Multiple-Choice and Open-Ended Instruments

	MC Instrument		OE Instrument	
	M	*SD*	*M*	*SD*
SWD Items 21-30				
Group 1 (n = 7)	6.6	1.90	7.7	2.87
Group 2 (n = 7)	3.4	1.40	4.0	1.15
Group 3 (n = 8)	4.5	1.41	4.1	1.55
Group 4 (n = 8)	2.2	1.67	1.4	1.51
NSWD Items 21-30				
Group 1 (n = 63)	6.3	2.14	11.7	9.40
Group 2 (n = 60)	4.8	2.08	7.6	6.77
Group 3 (n = 62)	4.5	1.99	7.1	5.80
Group 4 (n = 63)	3.1	1.72	4.4	3.81

Note. MC = Multiple-Choice Instrument; OE = Open-Ended Instrument. The MC Instrument has a score range of 0-10; the OE Instrument has a score range of 0-50. NSWD = Students without a learning disability; SWD = Students with LD.

Results for Students with Learning Disabilities

Pretest-posttest for students with LD on items 1-30. A repeated measures ANOVA with two within subjects variables and two between subjects factors was completed for students with learning disabilities (n = 30; SWD). The within subjects factors (Time) were standardized scores on the vocabulary pretest and posttest for 30 terms in world history. The between subjects factors were Group Assignment (Group) and Student GPA (GPA) from the first semester of their world history course. A maintenance probe could not be used for terms 1-20 because the teachers taught those terms during their regular instruction concurrent with this study's research activities. However, the first exposure to each term came from the CAPs, and students completed the posttest prior to in-class instruction.

Levene's test for equality of variances was not significant for either the pretest or posttest. The raw score means and standard deviations for the pretest and posttest instruments for students with LD (SWD) are listed in Tables 3 and 4. The results for the ANOVA indicated a significant effect between Time and Group, Wilks's Λ = .34, $F(3, 18) = 11.78$, $p < .000$, multivariate $\eta^2 = .66$. Partial eta-squared describes the "proportion of total variation attributable to the factor, partialling out (excluding) other factors from the total non-error variation" (Pierce, Block & Aguinis, 2004, p. 918). Therefore, 66% of the variance in this model can be attributed to the interaction between Time and Group. In addition, η^2 can be used in ANOVA as an estimate of effect size (Cohen, 1988). A η^2 measurement of .66 indicates a large effect size. Table 5 contains additional information relating to the ANOVA results.

Results were not significant for the interaction between Time and GPA: Wilks' Λ = .91, $F(3, 18) = .574$, $p < .64$, multivariate $\eta^2 = .09$, nor the interaction between Time, Group, and GPA: Wilks' Λ = .74, $F(5, 18) = 1.29$, $p < .31$, multivariate $\eta^2 = .26$. Thus, given the knowledge that there were no significant differences at pretest, performance on the posttest was significantly influenced by Group assignment, whereas GPA did not significantly influence results for SWD.

Table 5

One-way within-subjects ANOVA for Pretest-Posttest scores from Students with LD

Effect	Λ	*MS*	*F*	*df*	Error df	*p*	Partial η^2
Pretest-Posttest							
Time x Group (n =30)							
Wilks' Lambda	.34	20.83	11.78	3.000	18.000	.000	.66
Time x GPA (n = 30)							
Wilks' Lambda	.91	1.01	.574	3.000	18.000	.64	.09
Time x Group x GPA (n = 30)							
Wilks' Lambda	.74	2.29	1.29	5.000	18.000	.31	.26

To further investigate observed group differences and determine which groups (if any) significantly outperformed the others, a Bonferroni Correction was used to control for a Type I error during six pairwise group comparisons (e.g., Group 1-Group 2, G1-G3, G1-G4, G2-G3, G2-G4, G3-G4; α = .05/(2x3) = .0083). To conduct the pairwise comparisons, a one-way ANOVA was completed using Tukey post-hoc comparisons. Tukey post-hoc comparisons of the four groups' standardized scores indicate that students with LD in Group 1 (*M* = 1.45, 95% CI [-1.01, 3.91] scored significantly higher on the posttest than students with LD in Group 4 (*M* = -2.78, 95% CI [-4.00, -1.57], *p* = < .000. There were no other significant results. This finding suggests that students with LD in Group 1 who were taught 30 vocabulary terms using CAPs containing both explicit instruction and the keyword mnemonic strategy had significantly higher outcomes on this measure of vocabulary knowledge compared with students in Group 4 who received the same content instruction, but through multimedia-based modules that did not adhere to validated instructional principles.

Pretest-posttest-maintenance for students with LD on items 21-30. A repeated measures ANOVA was conducted for SWD (n = 30) with the between subjects factors being Group and GPA. The three within subjects variables were standardized scores on the pretest (Time 1), posttest (Time 2) and maintenance instrument (Time 3) for terms 21-30. The teachers did not explicitly teach terms 21-30 during this experiment as they were selected from units later in the semester; therefore, it is unlikely that the maintenance probe contained any contamination from the teachers. Levene's test for equality of variances was not significant for any of the three measures. The raw score means and standard deviations for pretest, posttest, and maintenance instruments are listed in Tables 3 and 4.

The results for the ANOVA indicated a significant time effect for group assignment, Wilks's $\Lambda = .18$, $F(6, 34) = 7.77$, $p < .000$, multivariate $\eta^2 = .58$. This result indicates that 58% of the variance is explained through the interaction of Time and Group assignment, and is a large effect size. The interaction between Time, Group, and GPA was also significant, Wilks's $\Lambda =$ $.25$, $F(10, 34) = 3.38$, $p < .004$, multivariate $\eta^2 = .50$, which indicates that half of the variance is explained through the interaction between Time, Group, and student GPA, and also represents a large effect size. The interaction between Time and GPA alone was not significant, Wilks's $\Lambda =$ $.60$, $F(6, 34) = 1.6.8$, $p < .16$, multivariate $\eta^2 = .23$. Based on these results, performance on the posttest and maintenance probes for students with LD was significantly and individually influenced by group assignment, and by the interaction of Time x Group Assignment x GPA, but not GPA alone. Table 6 contains additional information relating to the ANOVA results.

Table 6

One-way within-subjects ANOVA for Pretest-Posttest-Maintenance scores from Students with LD

Effect	Λ	*MS*	*F*	*df*	Error df	*p*	Partial η^2
Pretest-Posttest-Maintenance							
Time x Group (n =279)							
Wilks' Lambda	.18	6.33	7.77	6.000	34.000	.000	.58
Time x GPA (n = 279)							
Wilks' Lambda	.60	.724	1.68	6.000	34.000	.16	.23
Time x Group x GPA (n = 279)							
Wilks' Lambda	.25	1.46	3.38	10.000	34.000	.004	.50

To further investigate observed group differences and determine which groups (if any) significantly outperformed the others at maintenance, a Bonferroni Correction was used to control for Type I error during six pairwise group comparisons ($\alpha = .05/(2x3) = .0083$). To conduct the pairwise comparisons, a one-way ANOVA (Time x Group) and a MANOVA (Time x Group x GPA) were completed using Tukey post-hoc comparisons. First, Tukey post-hoc comparisons of the four groups' standardized scores indicate that students in Group 1 ($M = 1.06$, 95% CI [-.024, 2.15] scored significantly higher on the maintenance probe than students in Group 2 ($M = -.87$, CI [-1.56, -.175], $p = <.000$, and Group 4 ($M = -1.43$, 95% CI [-2.18, -.684], $p < .000$. There were no other significant results between the groups at maintenance. This finding suggests that students with LD in Group 1 statistically outperformed students in Groups 2 and 4 on the maintenance probe; thereby demonstrating stronger and more durable gains in learning based on Group 1's combination of vocabulary instruction and validated multimedia instructional design principles.

These results indicate that (a) vocabulary instruction delivered by CAPs that contain both explicit instruction and the keyword mnemonic strategy result in stronger and more durable performance for this sample of students than CAPs that provide explicit instruction alone; and (b) similar to the previous result, the use of CAPs that adhere to validated instructional design principles results in stronger and more durable gains versus similar students who received multimedia instruction that did not meet standards of validated design principles.

Second, Tukey post-hoc comparisons following a MANOVA of the interaction between Time, Group and GPA were completed. No significant interactions between the combined Time, Group and GPA were found. While several interactions were significant at the .05 levels (Group 1 vs. Groups 2-4, and Group 3 vs. Group 4) the alpha was set at .008, thus it must be concluded that the significant differences observed from the RM ANOVA were potentially due to a type I error.

Results for Students Without Disabilities

Pretest-posttest for students without LD on items 1-30. A repeated measures ANOVA with two within subjects variables and two between subjects factors was completed for students without learning disabilities ($n = 248$; NSWD). The within subjects factors (Time) were standardized scores on the vocabulary pretest and posttest for 30 terms in world history. The between subjects factors were Group assignment (Groups 1-4) and student GPA from world history. Levene's test for equality of variances was not significant. The raw score means and standard deviations for pretest and posttest instruments are listed in Tables 3 and 4.

The results for the ANOVA indicated a significant time effect, Wilks's $\Lambda = .86$, $F(3, 231) = 12.56$, $p < .000$, multivariate $\eta^2 = .14$. Therefore, only 14% of the variability in this model is explained by the interaction between Time and Group assignment; however, this is considered a large effect size (Cohen, 1988). The interaction for Time and GPA was also significant: Wilks's $\Lambda = .94$, $F(3, 231) = 5.02$, $p < .002$, multivariate $\eta^2 = .06$. Therefore, only 6% of the variability in this model is explained by the interaction between Time and GPA. The interaction between Time, Group, and GPA was not significant: Wilks's $\Lambda = .95$, $F(9, 231) = 1.33$, $p < .22$, multivariate $\eta^2 = .05$. This result indicates that group assignment and GPA individually had a significant impact on student performance on the posttest as compared to the pretest. Table 7 contains additional information relating to the ANOVA results.

Table 7

One-way within-subjects ANOVA for Pretest-Posttest scores from Students without LD

Effect	Λ	*MS*	*F*	*df*	Error df	*p*	Partial η^2
Pretest-Posttest							
Time x Group (n =248)							
Wilks' Lambda	.86	28.00	12.56	3.000	231.000	.000	.14
Time x GPA (n = 248)							
Wilks' Lambda	.94	11.19	5.02	3.000	231.000	.002	.06
Time x Group x GPA (n = 248)							
Wilks' Lambda	.95	2.96	1.33	9.000	231.000	.22	.05

To further investigate observed group differences and determine which groups (if any) significantly outperformed the others, a Bonferroni Correction was used to control for Type I error during six pairwise group comparisons ($\alpha = .05/(2x3) = .0083$). To conduct the pairwise comparisons, two one-way ANOVAs were completed using Tukey post-hoc comparisons. First, Tukey post-hoc comparisons of the four groups' standardized scores indicate that students in Group 1 (M = 1.83, 95% CI [1.22, 2.44] scored significantly higher on the posttest than students in Group 2 (M = .302, 95% CI [-.366, .971], p < .004, students in Group 3 (M = .098, 95% CI [-.484, .680], p < .001, and students in Group 4 (M = -1.71, 95% CI [-2.37, -1.05], p < .000. In addition, students in Groups 2 and 3 statistically outperformed students in Group 4 (p = < .000; p = < .000, respectively). There were no other significant results for the interaction between Time and Group.

These results demonstrate that students in Group 1 statistically outperformed students from every other group, which indicates the combination of validated instructional design principles and both explicit instruction and the keyword mnemonic strategy collectively provide stronger instruction than other iterations of this intervention. Furthermore, students in Groups 2 and 3 significantly outperformed students in Group 4, lending further evidence to the utility of the CAP framework for designing and delivering effective multimedia instruction compared to non-validated methods of multimedia instructional design.

Second, Tukey post-hoc comparisons of the interaction between Time and student GPA indicated that students with a GPA between 80-100% (scale of 0-100; n = 74, M = 2.01, 95% CI [1.57, 2.45]) statistically outperformed students with a GPA of 65-79% (n = 98, M = .024, 95% CI [-.476, .524], p = < .000), 51-64% (n = 60, M = -1.31, 95% CI [-2.02, -.594], p = < .000), and 0-50% (n = 16, M = -2.58, 95% CI [-3.75, -1.40], p = < .000) on the pretest. In addition, students with a GPA between 65-79% statistically outperformed students with a GPA of 51-64% (p = < .004), and 0-50 (p = < .000). There were no other significant results for the interaction between Time and GPA. This result indicates that students with higher GPAs scored statistically higher on the posttest than students with lower GPAs regardless of Group assignment. However, given that students in Group 1 statistically outperformed all other Groups on the posttest without a significant interaction from GPA, there is strong evidence that the CAP intervention is contributing to gains in performance.

Pretest-posttest-maintenance for students without LD on items 21-30. A repeated measures ANOVA was conducted for NSWD (n = 248) with the between subjects factors being group assignment and GPA. The within subjects variables were standardized scores on the pretest, posttest and maintenance instruments for items 21-30. Levene's test for equality of variances was not significant. The raw score means and standard deviations for pretest, posttest and maintenance instruments are listed in Tables 3 and 4.

The results for the ANOVA indicated a significant effect for Time x Group, Wilks's Λ = .87, $F(6, 460) = 5.33$, $p < .000$, multivariate $\eta^2 = .07$, for the interaction between Time x GPA, Wilks's Λ = .86, $F(6, 460) = 5.98$, $p < .000$, multivariate $\eta^2 = .07$, and the interaction for Time x Group x GPA, Wilks's Λ = .88, $F(18, 460) = .1.66$, $p < .04$, multivariate $\eta^2 = .06$. However, Mauchly's test indicated that the assumption of sphericity had been violated (χ^2= 80.44, p < .000); therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity (ε = 0.77). Results of the corrected analysis showed a significant time effect for Group, $F(4.63, 6.64) = 7.67$, p < .000, partial $\eta^2 = .09$, and Time x GPA, $F(4.63, 5.04) = 5.83$, p < .000, partial $\eta^2 = .07$. The corrected measure of the interaction between Time x Group x GPA was not significant, $F(1.48, 1.71) = 1.71$, $p < .051$, partial $\eta^2 = .06$. Therefore, group assignment and GPA individually had a significant influence on student performance on the posttest and maintenance probes. However, the measures of η^2 were small, therefore, most of the variability in this model is explained through error. Additional data relating to this ANOVA are presented in Table 8.

Table 8

One-way within-subjects ANOVA for Pretest-Posttest-Maintenance Scores from Students without LD

Effect	*MS*	*F*	*df*	*p*	Partial η^2	Greenhouse-Geisser
Pretest-Posttest-Maintenance						
Time x Group (n =248)						
Greenhouse-Geisser	6.64	7.67	4.63	.000	.09	.000
Time x GPA (n = 248)						
Greenhouse-Geisser	5.04	5.83	4.63	.000	.07	.000
Time x Group x GPA (n = 248)						
Greenhouse-Geisser	1.48	1.71	13.90	.51	.06	.051

To further investigate observed group differences, a Bonferroni Correction was used to control for Type I error during six pairwise group comparisons ($\alpha = .05/(2x3) = .0083$). To conduct the pairwise comparisons, two one-way ANOVAs (Time x Group, Time x GPA) were completed using Tukey post-hoc comparisons. First, Tukey post-hoc comparisons of the four groups' standardized scores indicate that students in Group 1 (M = 1.55, 95% CI [.661, 1.44] scored significantly higher on the maintenance probe than students in Groups 2 (M = .095, 95%

CI [-.253, .444], $p < .000$, Group 3 ($M = -.076$, 95% CI [-.397, .245], $p = < .000$, and Group 4 ($M = -.864$, 95% CI [-1.11, -.614] $p = < .000$. In addition, students in Groups 2 and 3 significantly outperformed students in Group 4 ($p = < .000$; $p = < .005$, respectively). There were no other significant results between the groups at maintenance. This result is a duplication of the first ANOVA for students without LD that evaluated differences between pretest and posttest.

Second, Tukey post-hoc comparisons of the four groups' standardized scores on the maintenance probe when controlling for student GPA indicated that students with a GPA between 80-100% ($N = 74$, $M = .052$, 95% CI [.319, 1.09] statistically outperformed students with a GPA between 65-79% ($N = 98$, $M = .704$, 95% CI [-.291, .234], $p = < .000$), 51-64% ($N = 60$, $M = -.344$, 95% CI [-.677, -.012], $p = < .000$), and 0-50% ($N = 16$, $M = -.989$, 95% CI [-1.26, -.618], $p = < .000$). This result indicates that students who have a high GPA (80% or above) statistically outperformed all other students regardless of group assignment.

Comparison of Performance Between Students with LD and Students without LD

The goal of special education is to provide specially designed instruction to help students gain the skills and knowledge necessary to succeed when accessing the general education curriculum. Therefore, a critical set of analyses within this study involves investigating to what extent students with LD from the various Groups achieved similarly to students without LD on the posttest and maintenance probes.

A series of repeated measures ANOVAs were conducted comparing all students without learning disabilities ($n = 248$) to students with learning disabilities ($n = 30$) with the between subjects factors being group assignment and GPA. For these comparisons, students with LD were separated from their original group, and four new groups were created (Students in Group 1 became Group 5, LD Group 2 = Group 6, LD Group 3 = Group 7, and LD Group 4= Group 8). The within subjects variables were standardized scores on the pretest and posttest for terms 1-30, and the maintenance probe for items 21-30. The raw score means and standard deviations for pretest, posttest and maintenance instruments are listed in Tables 3 and 4.

Results for students with LD in Group 5 (original Group 1). A total of eight repeated measures ANOVAs were completed to compare the performance of students with LD in Group 5 (original Group 1) against students without LD in Groups 1-4 for the pretest-posttest assessments and the pretest-posttest-maintenance probes when continuing to include the effect of student GPA on overall performance. Table 9 presents the results for these analyses. For the purpose of brevity and availability of all data in the Table, the focus here is on significant results. Results from the ANOVA comparing performance of students in Group 5 to students in Groups 2, 3 and 4 on the pretest and posttest indicated significant effects for Time x Group, Wilks's $\Lambda = .92$, $F(2, 59) = 17.31$, $p < .02$, multivariate $\eta^2 = .09$; Wilks's $\Lambda = .91$, $F(1, 62) = 15.01$, $p < .02$, multivariate $\eta^2 = .09$; and Wilks's $\Lambda = .67$, $F(1, 63) = 47.43$, $p < .000$, multivariate $\eta^2 = .33$, respectively. In addition, results from the ANOVA comparing performance of students in Groups 5 to students in Groups 2, 3 and 4 on the pretest, posttest and maintenance probes indicated a significant effect for Time x Group: Wilks's $\Lambda = .84$, $F(2, 58) = 6.83$, $p < .006$, multivariate $\eta^2 = .16$; Wilks's $\Lambda = .81$, $F(2, 61) = 9.38$, $p < .001$, multivariate $\eta^2 = .19$; and Wilks's $\Lambda = .68$, $F(2, 62) = 13.06$, $p < .000$, multivariate $\eta^2 = .32$, respectively. Interactions for Time and student GPA were not significant.

To further examine between-group differences, independent-sample *t* tests were completed separately for students without LD in Groups 2, 3, 4, and students with LD in Group 5 to compare mean scores on the pretest, posttest, and maintenance probes. A Bonferroni

Correction was used to control for Type I error ($p = .05/3 = .016$). Results indicated no statistically significant differences between students without LD in Group 2 and students with LD in Group 5 on the pretest: $t(64) = 1.11$, $p = .770$, posttest: $t(65) = -1.11$, $p < .273$, or maintenance $t(65) = -1.81$, $p = <.74$. Results also indicated no significant differences between students in Groups 3 and 5 at pretest: $t(67) = .967$, $p = .337$, posttest: $t(67) = -1.46$, $p < .150$, or maintenance $t(67) = -2.270$, $p = <.026$. Results were not significant between students in Groups 4 and 5 at pretest: $t(68) = 1.11$, $p = <.273$; however, results were significant for the posttest: $t(68) = -3.03$, $p = <.003$, and at maintenance: $t(68) = -4.78$, $p = <.000$. Standardized mean scores for Group 5 at posttest (*N = 7, M = 1.45,* 95% CI [-1.01, 3.91]) and maintenance (*N = 7, M =* 1.06, 95% CI [-.024, 2.15] demonstrate higher mean performance than students without LD in Group 4 at posttest (*N = 63, M* = -1.71, 95% CI [-2.37, -1.05] and maintenance (*N = 63, M = -.864,* 95% CI [-1.11, -.614]. In summary, students with LD in Group 5 made significant gains in vocabulary knowledge and demonstrated durability of learning compared to students without LD who received multimedia instruction that did not adhere to validated principles for instructional design in Group 4.

Despite the lack of significant gains versus all groups for the students with LD, each of these results is educationally significant. Evidence of educational significance is based on the closeness of mean scores for the students with LD as compared to the students without LD. To illustrate, on the posttest, only students without LD in Group 1 (*N = 63, M = 1.83,* 95% CI [1.223, 2.436]) scored higher than students with LD in Group 5: (*N = 7, M = 1.45,* 95% CI [-1.01, 3.91]). Students without LD in Groups 2 (*N = 60, M = .302*, 95% CI [-.366, .971]; and 3 (*N = 62, M = .098,* 95% CI [-.484, .680] had lower standardized mean scores on the posttest than students with LD from Group 5. Therefore, the CAP intervention that includes explicit

Table 9

One-way within-subjects ANOVA for Pretest-Posttest scores comparing performance of students with LD in Group 5 (Original Group 1) to students without LD in Groups 1-4

Effect	Λ	*MS*	*F*	*df*	Error *df*	*p*	Partial η2
Pretest-Posttest							
Time x Group							
Group 5 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.98	2.72	1.16	1.00	63.000	.29	.02
Group 5 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.92	17.31	5.51	1.000	59.000	.02	.09
Group 5 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	.91	15.01	6.19	1.000	62.000	.02	.09
Group 5 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.67	47.43	31.40	1.000	63.000	.00	.33
Time x GPA							
Group 5 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.91	3.51	5.01	3.000	63.00	.10	.09
Group 5 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.98	1.57	.50	3.000	59.000	.68	.03
Group 5 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	.99	.546	.225	3.000	62.000	.88	.01
Group 5 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.95	1.53	1.01	3.000	63.000	.39	.05
Time x Group x GPA							
Group 5 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.96	3.51	1.50	2.000	63.000	.23	.05
Group 5 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.99	1.37	.44	2.000	59.000	.65	.02
Group 5 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	.99	1.16	.477	2.000	62.000	.62	.02
Group 5 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.95	2.77	1.83	2.000	63.000	.17	.06

Table 9 (Continued)

Effect	Λ	MS	*F*	*df*	Error *df*	*p*	Partial η2
Pretest-Posttest-Maintenance							
Time x Group							
Group 5 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.98	.914	.651	2.00	62.000	.53	.02
Group 5 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.84	6.83	5.64	2.000	58.000	.006	.16
Group 5 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	.81	9.38	7.26	2.000	61.000	.001	.19
Group 5 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.68	13.06	14.39	2.000	62.000	.000	.32
Time x GPA							
Group 5 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.80	.914	2.42	6.000	124.00	.03	.11
Group 5 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.92	1.57	.663	6.000	116.000	.58	.04
Group 5 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	.95	.500	.483	6.000	122.000	.82	.02
Group 5 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.90	5.10	1.07	6.000	124.000	.39	.05
Time x Group x GPA							
Group 5 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.96	4.01	.648	4.000	124.000	.63	.02
Group 5 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.91	1.37	1.31	4.000	116.000	.26	.04
Group 5 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	.94	1.15	.943	4.000	122.000	.45	.03
Group 5 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.92	3.40	1.32	4.000	124.000	.26	.04

instruction and the keyword mnemonic strategy helped students with LD at a minimum keep pace with students without LD, and significantly outperform students who did not receive multimedia instruction based on validated design principles.

Results for students with LD in Groups 6-8. Results from 16 repeated measures ANOVAs indicated that there were no significant findings for students with LD in Groups 6 and 7 (original Groups 2 and 3) when performance between the pretest and posttest for terms 1-30 and the pretest, posttest and maintenance for terms 21-30 was compared to students without LD in Groups 2-4. However, the lack of significance is also educationally meaningful, as the students without LD in Groups 2, 3 and 4 did not significantly outperform students with LD in Groups 6 or 7 on any of the posttest or maintenance probes. Results for these ANOVAs can be found in Table 10.

Conversely, students with LD in Group 8 (original Group 4) were significantly outperformed by students in Groups 1-4 on the posttest: Wilks's $\Lambda = .60$, $F(1, 64) = 42.48$, $p < .000$, multivariate $\eta^2 = .40$; Wilks's $\Lambda = .80$, $F(1, 64) = 43.40$, $p < .000$, multivariate $\eta^2 = .20$; Wilks's $\Lambda = .74$, $F(1, 64) = 48.43$, $p < .000$, multivariate $\eta^2 = .26$; and Wilks's $\Lambda = .87$, $F(1, 64) = 12.05$, $p < .003$, multivariate $\eta^2 = .13$, respectively. Further data regarding these results are listed in Table 11.

To determine between-group differences, independent-sample *t* tests were completed separately for Groups 1, 2, 3, 4 and Group 8 to compare mean scores on the pretest, posttest, and maintenance probes. A Bonferroni Correction was used to control for Type I error ($p = .05/3 = .016$). Results indicated no statistically significant differences on the pretest between any of the groups: $t(69) = -.544$, $p = .588$; $t(65) = -.303$, $p = .763$; $t(68) = -.893$, $p = .375$; and $t(69) = -.621$, $p = .537$, respectively. However, results from the comparison of posttest between Groups 1, 2, and 3 and Group 8 were significant: $t(69)= 5.28$, $p < .000$; $t(66)= 3.29$, $p < .002$; and $t(68)= 3.45$, $p < .001$, respectively. Results were also significant between Groups 1, 2 and 3 and Group 8 at maintenance: $t(69) = 4.42$, $p = .000$; $t(66) = 3.29$, $p = .003$; and $t(68) = 2.94$, $p = .003$, respectively.

Table 10

One-way within-subjects ANOVA for Pretest-Posttest scores comparing performance of students with LD in Group 6 (Original Group 2) to students without LD in Groups 1-4

Effect	Λ	MS	*F*	*df*	Error *df*	*p*	Partial η2
Pretest-Posttest							
Time x Group							
Group 6 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.99	.153	.072	1.000	63.000	.789	.00
Group 6 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.98	2.75	.951	1.000	59.000	.333	.02
Group 6 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	1.00	.014	.006	1.000	62.000	.936	.00
Group 6 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.81	18.73	14.63	1.000	63.000	.000	.19
Time x GPA							
Group 6 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.92	3.71	1.76	3.000	63.000	.165	.08
Group 6 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.92	4.84	1.67	3.000	59.000	.183	.08
Group 6 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	.99	.502	.229	3.000	62.000	.876	.01
Group 6 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.83	5.63	4.40	3.000	63.000	.007	.17
Time x Group x GPA							
Group 6 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.97	2.42	1.14	2.000	63.000	.326	.04
Group 6 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.99	.499	.172	2.000	59.000	.842	.01
Group 6 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	.99	.157	.071	2.000	62.000	.931	.00
Group 6 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.98	.990	.773	2.000	63.000	.466	.02

Table 10 (Continued)

One-way within-subjects ANOVA for Pretest-Posttest scores comparing performance of students with LD in Group 7 (Original Group 3) to students without LD in Groups 1-4

Effect	Λ	MS	*F*	*df*	Error *df*	*p*	Partial η2
Pretest-Posttest							
Time x Group							
Group 7 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.91	14.66	6.62	1.000	64.000	.012	.14
Group 7 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.99	1.60	.535	1.000	60.000	.470	.01
Group 7 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	.98	2.46	1.07	1.000	63.000	.305	.02
Group 7 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.98	2.23	1.60	1.000	64.000	.211	.02
Time x GPA							
Group 7 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.89	6.15	2.78	3.000	64.000	.048	.12
Group 7 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.99	.887	.297	3.000	60.000	.828	.02
Group 7 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	.98	.823	.359	3.000	63.000	.783	.02
Group 7 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.95	1.48	1.06	3.000	64.000	.372	.05
Time x Group x GPA							
Group 7 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.97	2.14	.966	2.000	64.000	.386	.03
Group 7 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.97	2.35	.785	2.000	60.000	.461	.03
Group 7 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	.99	.635	.277	2.000	63.000	.759	.01
Group 7 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.94	2.81	2.02	2.000	64.000	.141	.06

Table 10 (Continued)

One-way within-subjects ANOVA for Pretest-Posttest-Maintenance scores comparing performance of students with LD in Group 6 (original Group 2) to students without LD in Groups 1-4

Effect	Λ	MS	*F*	*df*	Error *df*	*p*	Partial η2
Pretest-Posttest-Maintenance							
Time x Group							
Group 6 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.98	1.45	.780	2.00	62.000	.46	.03
Group 6 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.98	.321	.502	2.000	58.000	.61	.02
Group 6 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	.99	.129	.292	2.000	61.000	.75	.01
Group 6 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.98	.294	.545	2.000	62.000	.58	.02
Time x GPA							
Group 6 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.73	3.96	3.57	6.000	124.00	.003	.15
Group 6 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.76	1.43	2.90	6.000	116.000	.011	.13
Group 6 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	.92	.444	.863	6.000	122.000	.52	.04
Group 6 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.81	1.30	2.32	6.000	124.000	.04	.10
Time x Group x GPA							
Group 6 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.89	2.64	1.82	4.000	124.000	.13	.06
Group 6 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.93	.613	1.15	4.000	116.000	.34	.04
Group 6 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	.94	.560	.900	4.000	122.000	.47	.03
Group 6 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.94	.336	.903	4.000	124.000	.46	.03

Table 10 (Continued)

One-way within-subjects ANOVA for Pretest-Posttest-Maintenance scores comparing performance of students with LD in Group 7 (original Group 3) to students without LD in Groups 1-4

Effect	Λ	MS	*F*	*df*	Error *df*	*p*	Partial η2
Pretest-Posttest-Maintenance							
Time x Group							
Group 7 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.94	3.46	1.91	2.00	63.000	.16	.06
Group 7 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.99	.035	.063	2.000	59.000	.02	.09
Group 7 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	.99	.336	.274	2.000	62.000	.76	.01
Group 7 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.94	1.54	1.92	2.000	63.000	.16	.06
Time x GPA							
Group 7 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.83	3.94	2.05	6.000	126.00	.06	.09
Group 7 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.91	.977	.968	6.000	118.000	.45	.05
Group 7 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	.94	.791	.705	6.000	124.000	.65	.03
Group 7 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.89	.842	1.25	6.000	126.000	.28	.06
Time x Group x GPA							
Group 7 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.91	2.97	1.50	4.000	126.000	.21	.05
Group 7 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.93	.778	1.05	4.000	118.000	.38	.03
Group 7 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	.96	.559	.659	4.000	124.000	.62	.02
Group 7 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.93	.728	1.12	4.000	126.000	.35	.03

Table 11

One-way within-subjects ANOVA for Pretest-Posttest scores comparing performance of students with LD in Group 8 (Original Group 4) to students without LD in Groups 1-4

Effect	Λ	MS	*F*	*df*	Error *df*	*p*	Partial η2
Pretest-Posttest							
Time x Group							
Group 8 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.60	90.53	42.48	1.000	64.000	.000	.40
Group 8 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.80	43.40	14.97	1.000	64.000	.000	.20
Group 8 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	.74	48.43	21.88	1.000	63.000	.000	.26
Group 8 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.87	12.05	9.20	1.000	64.000	.003	.13
Time x GPA							
Group 8 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.80	11.11	5.21	3.000	64.000	.003	.20
Group 8 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.94	3.94	1.36	3.000	60.000	.264	.06
Group 8 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	.93	3.47	1.57	3.000	63.000	.205	.07
Group 8 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.94	5.78	4.41	3.000	64.000	.007	.17
Time x Group x GPA							
Group 8 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.97	2.09	.982	2.000	64.000	.38	.03
Group 8 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.94	5.41	1.87	2.000	60.000	.16	.06
Group 8 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	.95	3.87	1.75	2.000	63.000	.18	.05
Group 8 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.91	4.07	3.11	2.000	64.000	.051	.09

Table 11 (Continued)

One-way within-subjects ANOVA for Pretest-Posttest-Maintenance scores comparing performance of students with LD in Group 8 (Original Group 4) to students without LD in Groups 1-4

Effect	Λ	MS	*F*	*df*	Error *df*	*p*	Partial η2
Pretest-Posttest-Maintenance							
Time x Group							
Group 8 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.65	27.76	17.76	2.000	63.000	.000	.35
Group 8 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.75	7.86	9.71	2.000	59.000	.000	.25
Group 8 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	.83	5.24	6.22	2.000	62.000	.003	.17
Group 8 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.87	2.65	4.75	2.000	63.000	.012	.13
Time x GPA							
Group 8 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.71	5.06	3.85	6.000	126.00	.001	.16
Group 8 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.80	1.80	2.31	6.000	118.000	.038	.11
Group 8 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	.84	1.69	1.92	6.000	124.000	.082	.09
Group 8 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.81	1.62	2.34	6.000	126.000	.035	.10
Time x Group x GPA							
Group 8 v. Group 1 (SWD v. NSWD)							
Wilks' Lambda	.89	2.66	1.83	4.000	126.000	.038	.11
Group 8 v. Group 2 (SWD v. NSWD)							
Wilks' Lambda	.81	2.10	3.30	4.000	118.000	.013	.10
Group 8 v. Group 3 (SWD v. NSWD)							
Wilks' Lambda	.86	1.80	2.41	4.000	124.000	.052	.07
Group 8 v. Group 4 (SWD v. NSWD)							
Wilks' Lambda	.83	2.09	3.12	4.000	126.000	.017	.09

Student Satisfaction Survey

Students completed the SSS immediately following the maintenance probe; therefore, the return rate was 100% (N = 278). The Likert items on the SSS were tested for overall reliability. The reliability α = .73, indicating good overall reliability for the instrument. Means and standard deviations for the Student Satisfaction Survey (SSS) are presented in Table 12.

Based on the results of the SSS, few students reported having technical problems when watching the CAPs (M = .08, SD = .276). On average, students reported that the narrator was easy to understand (M = 8.59, SD = 1.78) and the CAPs looked good with respect to pictures and on-screen text (M = 8.2, SD = 1.95). Mean scores demonstrate that students tentatively agreed that the content of the CAPs was interesting (M = 6.32, SD = 2.16). On average, students reported that they do not have a difficult time learning new vocabulary terms in history (M = 4.97, SD = 2.56); however, students generally agreed that the CAPs helped them learn the meaning of the terms (M = 7.38, SD = 2.06) and the CAPs prepared them to do well on the posttest and maintenance probes (M = 6.91, SD = 2.16). Finally, students in Groups 1 and 3, on average, agreed that the keyword mnemonic strategy to be helpful in learning the meaning of vocabulary terms (M = 7.58, SD = 2.19). These findings from the SSS corroborate the results from the aforementioned experiment, as regardless of Group, mean scores for all students went up following exposure to their conditions' CAPs.

Post-hoc analyses of student survey responses were completed using a one-way ANOVA. A Bonferonni correction (.05/5 survey items) was used to set the alpha level for significance testing at .01. Tukey post-hoc comparisons of the four groups' survey responses for item 3 (The podcasts looked good) indicated that the students in Group 1 (N = 70, M = 8.53, 95% CI [8.11, 8.95]), Group 2 (N = 68, M = 8.41, 95% CI [7.96, 8.86]), and Group 3 (N = 70, M = 8.66, 95%

CI [8.31, 9.00]) all expressed significantly higher satisfaction with the visual elements of the CAPs that students in Group 4 (N = 70, M = 7.26, 95% CI [6.70, 7.81]), $p < .000$; $p < .002$; and $p < .000$, respectively. Additionally, students in Group 1 ($N = 69$, $M = 7.91$, 95% CI [7.42, 8.41] expressed significantly higher satisfaction on Question 6 (The podcasts helped me learn the meanings of the vocabulary terms) than students in Group 4 ($N = 6.77$, $M = 2.13$, 95% CI [6.26, 7.28], $p < .006$). Neither result is surprising given the differences in vocabulary performance between students in the four groups. Finally, students in Group 3 ($N = 70$, $M = 7.69$, 95% CI [7.26, 8.11]) expressed significantly higher satisfaction on Question 7 (After watching the podcasts I was ready to do well on the quizzes) than students in Group 4 ($N = 70$, $M = 6.17$, 95% CI [5.64, 6.69], $p < .000$). Students in Group 1 also felt more prepared to do well on the quizzes ($N = 70$, $M = 7.11$, 95% CI [6.59, 7.64]) that students in Group 4, but the difference was not significant at the .01 level ($p < .04$). In summary, mean score data and the noted significant differences indicate that students in Groups 1-3 have stronger positive feelings towards CAPs than students in Group 4.

Open-ended questions on the SSS. Along with the Likert items, students were also asked to answer three open-ended questions regarding their experience and overall satisfaction with the CAPs. A research assistant typed student responses into a spreadsheet organized by question (1-3) and group assignment (1-4). The researcher reviewed 10% of the assistant's work to ensure fidelity; no irregularities were found. Based on an analysis of student responses, the researcher created codes within each of the three open-ended questions. For example, for question 1: Was there anything about the podcasts that really helped you learn about the vocabulary term (e.g., the pictures, the sound, the words on the screen, technology format)?

Several students across all four groups noted that the use of pictures and text helped them learn.

Table 12

Student Satisfaction Survey Results

	Group 1			Group 2			Group 3			Group 4		
	M	SD	N	M	SD	N	M	SD	N	M	SD	N
Q1: Did you experience any technical problems when watching the podcasts?												
	.06	.00	70	.04	.207	67	.10	.302	70	.13	.337	70
Q2: The speaker on the podcast was easy to understand												
	8.9	1.36	70	8.3	2.24	68	9.0	1.32	70	8.1	1.90	70
Q3: The podcasts looked good (the pictures, words, etc.)												
	8.5	1.78	70	8.4	1.85	68	8.7	1.46	70	7.3	2.32	70
Q4: The information in the podcasts was interesting to me												
	6.5	2.16	70	5.9	2.58	67	6.8	1.89	70	6.0	1.88	69
Q5: Learning new vocabulary terms in world history is difficult for me												
	4.9	2.30	70	5.2	2.91	68	5.2	2.30	70	4.5	2.65	68
Q6: The podcasts helped me learn the meanings of the vocabulary terms												
	7.9	2.06	69	7.2	2.09	68	7.6	1.81	70	6.8	2.13	69
Q7: After watching the podcasts I was ready to do well on the quizzes												
	7.1	2.22	70	6.7	2.17	68	7.7	1.80	69	6.2	2.19	70
Q8: The keyword helped me remember the meaning of the term												
	7.4	2.18	70				7.7	2.20	68			
Grand Mean*	7.3	1.98	70	7.0	2.30	68	7.5	1.76	70	6.5	2.17	70

*Note. Item scores range from 1-10. * = Does not include item 8, which was only answered by students in Groups 1 and 3.*

Therefore, a code for 'Use of Multimedia Materials' was created. A tally was kept within each code for each of the four groups of students. A graduate student with extensive experience in qualitative research reviewed the student responses and the researcher's codes to augment the validity of this research activity. Following discussion, the final list of codes was agreed to with 100% reliability by the researcher and colleague.

Table 13 presents the codes and tally of student responses sorted by group assignment for open-ended question number 1: Was there anything about the podcasts that really helped you learn about the vocabulary term (e.g., the pictures, the sound, the words on the screen, technology format)? Table 14 presents the codes and tally of student responses sorted by Group assignment for open-ended question number 2: How would you improve the podcasts to support your learning? Table 15 presents the codes and tally of student responses sorted by group assignment for open-ended question number 3: If you could watch the podcasts whenever you wanted, how often, when, and why would you use them? A sample student response is provided for each code to demonstrate a common response that promoted creation of the code.

Trends from question 1. Students were asked in question 1 to provide feedback on the elements of the CAPs that best supported their learning. Percentages of student responses for each code were calculated for each of the four groups. For question 1, over 50% of the responses from students in Group 1 noted that the use of multimedia components (e.g., video, audio, on-screen text) helped them learn using the CAPs. Conversely, only 31% of responses in Group 4 mentioned multimedia components as a support for learning. This could be attributed to the lack of pictures and overabundance of text within Group 4's CAPs. By way of comparison, students in Groups 2 and 3, respectively, noted on 48.1% and 40.4% of their responses that multimedia components supported their learning.

Table 13

Tally of Responses for Codes Created Within Open-Ended Question #1 from Student Satisfaction Survey

Question 1. Was there anything about the Podcasts that really helped you learn about the vocabulary term (e.g. the pictures, the sound, the words on the screen, technology format)?

	N	*%*
Use of Multimedia Materials (e.g., I liked the use of pictures and text)		
Group 1	29	51.8%
Group 2	26	48.1%
Group 3	21	40.4%
Group 4	17	31.0%
Description of Synonyms/Antonyms (e.g., I liked how a synonym was provided for each term)		
Group 1	6	10.7%
Group 2	2	3.7%
Group 3	1	1.9%
Group 4	1	1.8%
Breaking Words Down (e.g., I like how each CAP helps me see the parts of words)		
Group 1	5	8.9%
Group 2	6	11.1%
Group 3	3	5.8%
Group 4	11	20.0%
General Positive Comments (e.g., I liked everything)		
Group 1	5	8.9%
Group 2	5	9.3%
Group 3	9	17.3%
Group 4	6	10.9%
Repetition of Definition (e.g., I like how the definition was repeated during the video)		
Group 1	3	5.4%
Group 2	2	3.7%
Group 3	5	9.6%
Group 4	10	18.2%
Did Not Learn from CAP (e.g., Not really, I already knew the terms)		
Group 1	4	7.1%
Group 2	6	11.1%
Group 3	3	5.8%
Group 4	7	12.7%
Use of Keywords (e.g., The keywords helped me remember the meaning)		
Group 1	3	5.4%
Group 2	0	0%
Group 3	10	19.2%
Group 4	0	0%
Use of Examples (e.g. I liked the use of examples in the videos)		
Group 1	1	1.8%
Group 2	3	5.6%
Group 3	0	0%
Group 4	3	5.5%

Trends from question 2. Question 2 asked students to provide ideas regarding ways to improve the CAPs. The highest percentage of responses for Groups 1-3 noted that the CAPs are good ‘as is’ (28.6%, 42.6%, 36.5%, respectively), and they could not think of a way to make improvements. 25.5% of the responses from Group 4 responded that CAPs could be improved through the addition of pictures. Another interesting finding is that students across all four groups noted (25.0%, 18.5, 13.5, and 16.4%, respectively) that they would like the CAPs to be ‘more interesting’. For students, this included requests to use more engaging photos, add movies and/or music, and change the narrator.

Trends from question 3. Question 3 asked students to report their plans for using CAPs in the future, given the opportunity. Students in Groups 1-3 again reported that they would use the CAPs frequently to support their learning (39.3%, 38.9%, 34.6%, respectively). Students in group 4 were not as enthusiastic about using the CAPs on a frequent basis in the future (25.5% of responses). Another common response for all students was their desire to use the CAPs in preparation for quizzes or tests (26.8%, 24.1%, 23.1%, 23.6%, respectively). This indicates that students see a specific utility for the intervention that had not explicitly been communicated to students. Finally, while no intervention is a perfect match for students’ learning preferences, 29.1% of responses from students in Group 4 noted they would not use the CAPs again. This was a higher percentage than any other group (16.1, 16.7%, 7.7%, respectively).

Table 14

Means and Standard Deviations for Open-Ended Question #2 from Student Satisfaction Survey

How would you improve the Podcasts to support your learning?

	N	*%*
Add More/Different Pictures (e.g., I would use more interesting pictures)		
Group 1	7	12.5%
Group 2	5	9.3%
Group 3	10	19.2%
Group 4	14	25.5%
CAPs are Good 'As Is' (e.g., I wouldn't change anything)		
Group 1	16	28.6%
Group 2	23	42.6%
Group 3	19	36.5%
Group 4	12	21.8%
Make CAPs More Interesting (e.g., Make it more appealing and interesting to young people)		
Group 1	14	25.0%
Group 2	10	18.5%
Group 3	7	13.5%
Group 4	9	16.4%
Make CAPs Longer (e.g., The CAPs could be a little bit longer)		
Group 1	2	2.5%
Group 2	0	0%
Group 3	5	9.6%
Group 4	0	0%
Give More Examples of Meaning (e.g., Give other examples of meaning)		
Group 1	2	2.5%
Group 2	2	3.7%
Group 3	5	9.6%
Group 4	4	7.3%
Make CAPs Shorter (e.g., They could be shorter)		
Group 1	3	5.4%
Group 2	2	3.7%
Group 3	0	0%
Group 4	6	10.9%
Use [More] Mnemonics (e.g., The keywords help me remember, use more)		
Group 1	2	2.5%
Group 2	3	5.6%
Group 3	4	7.7%
Group 4	0	0%
Adjust Speed of CAP (e.g., Slow the speed down to help me keep up)		
Group 1	2	2.5%
Group 2	2	3.7%
Group 3	3	5.8%
Group 4	2	3.6%
Simplify Language used in CAP (e.g., Don't use so many big words)		
Group 1	2	2.5%
Group 2	2	3.7%
Group 3	4	7.7%
Group 4	3	5.5%

Table 15

Means and Standard Deviations for Open-Ended Question #3 from Student Satisfaction Survey

If you could watch the Podcasts whenever you wanted, how often, when, and why would you use them?	*N*	*%*
Frequently (e.g., I would watch the videos all the time)		
Group 1	22	39.3%
Group 2	21	38.9%
Group 3	18	34.6%
Group 4	13	23.6%
Once in a While (e.g., I would watch the videos only when I needed to learn the meaning of a term)		
Group 1	8	14.3%
Group 2	6	11.1%
Group 3	12	23.1%
Group 4	14	25.5%
Study Before Tests/Quizzes (e.g., I would use the videos to study for a test)		
Group 1	15	26.8%
Group 2	13	24.1%
Group 3	12	23.1%
Group 4	13	23.6%
During Class (e.g., I would use the videos during class to learn the meaning of words)		
Group 1	5	8.9%
Group 2	2	3.7%
Group 3	3	5.8%
Group 4	2	3.6%
Would Not Watch Again (e.g., I would not watch these videos again)		
Group 1	9	16.1%
Group 2	9	16.7%
Group 3	4	7.7%
Group 4	16	29.1%

CHAPTER V

DISCUSSION

The purpose of this study was to evaluate the effects of a multimedia-based instructional intervention (CAPs) designed to deliver evidence-based vocabulary instruction to adolescents with and without learning disabilities. Specifically, the effects of CAPs as an instructional tool were measured with respect to growth between the pretest and (a) student performance on the Multiple-Choice and Open-Ended Instruments for terms 1-30 at posttest; (b) student performance on the Multiple-Choice and Open-Ended Instruments for terms 21-30 at maintenance; and (c) student feedback provided through the Student Satisfaction Survey. The study was needed given the overall poor performance of adolescents with LD on measures of literacy proficiency, and the limited number of studies investigating the effects of multimedia instruction on vocabulary performance of adolescents with and without LD.

Conclusions

Study results support the use of CAPs with both explicit instruction and the keyword mnemonic strategy as an effective instructional intervention for improving the vocabulary knowledge of adolescents with and without learning disabilities (LD) enrolled in a social studies course. Several conclusions can be drawn from this study with respect to: (a) the vocabulary performance of students with and without LD following multimedia-based instruction; (b) student satisfaction with CAPs as a learning tool; and (c) the advance of existing research and theory in this area.

Conclusions for Students with LD

The performance of students with learning disabilities (SWD) on the pretest, posttest, and maintenance probes was compared to that of other SWD and students without LD (NSWD).

Comparisons of performance were based on the type of multimedia instruction provided given each student's group assignment.

During the comparisons of SWD to other SWD across experimental groups, several important findings emerged. First, SWDs in Group 1 (CAP with explicit instruction and the keyword mnemonic strategy) statistically outperformed SWD in Group 4 (multimedia-based vocabulary instruction without adherence to validated instructional design principles) on the posttest for terms 1-30. The interaction between group assignment and performance on the pretest (Time 1) and posttest (Time 2) accounted for 66% of the variance in this model. This result was replicated at maintenance, when measuring the durability of learning for the meanings of terms 21-30. SWD in Group 1 significantly outperformed SWDs in Groups 2 (CAP with explicit instruction only) and Group 4 at maintenance. The interaction between group assignment and performance on the pretest, posttest, and the maintenance probe (Time 3) accounted for more than half of the variance in that model. The ability to account for such a large portion of variability in the respective examinations of group performance confers reliability to the significant findings. This result confirms Mayer's CTML (2001, 2005, 2009), and is a practical advance of his work into the field of vocabulary instruction. In addition, this result confirms and adds to the literature base for vocabulary instruction for adolescents with LD given the successful blend of various approaches to teaching word meanings (Bryant et al., 2003; Ebbers & Denton, 2008; Jitendra et al., 2004).

Further, although not significant, mean score differences for the posttest and maintenance probes were higher for students with LD in Groups 2 (CAP with explicit instruction only) and Group 3 (CAP with the keyword mnemonic strategy only) compared to students in Group 4. Given the small sample size of students with LD in the study (*n* = 30), it is possible that results would have been significant if observed trends were to have continued if more students had participated. In summary, emerging evidence supports the use of multimedia instructional materials created using Mayer's instructional design principles over multimedia materials that do not reflect validated methods for instructional design. This is an important finding given the limited amount of research in the field of multimedia-based vocabulary instruction for adolescents with LD. In addition, the introduction of Mayer's CTML and instructional design principles into the field of applied vocabulary instruction for adolescents with LD is a unique feature of this experiment.

Although improving the performance of SWD over other SWD is an important finding, a larger goal for this intervention study, and for the overall field of education, warrants further comparison and discussion. This goal is the need to provide SWD with specially designed instruction that meets individual skill and processing needs to help close performance gaps between SWD and NSWD across various indicators of learning. Therefore, the performance of SWD and NSWD was compared across the four experimental conditions to determine the extent to which the CAP intervention can provide specially designed instruction that "levels the playing field" for this population of students given a memory-based task such as vocabulary learning.

Results indicate that SWD in Group 1 (full CAP model including explicit and strategy instruction) significantly outperformed NSWD in Group 4 on the posttest and maintenance probes. Given the non-significant differences between groups at pretest, these significant findings at posttest and maintenance provide preliminary evidence that the full CAP intervention (Mayer's design principles plus explicit and strategy instruction for vocabulary learning) supports students' cognitive processing capacity to an extent not replicated by multimedia instruction that does not adhere to validated principles of instructional design. This finding transcends typical achievement barriers associated with LD for quickly learning and retaining new vocabulary terms, and points to the importance of providing all students with instruction that reflects validated instructional design principles.

Further evidence for this claim is provided through the non-significant group differences observed between students with LD in Groups 1-3 and NSWD in Groups 2-4. To illustrate, the performance of SWD is typically less efficient and less robust than that of NSWD on various academic tasks that require cognitive processing capacity to draw from and construct schemas within LTM to promote efficient and successful processing within WM (Swanson, 2001; Swanson & Hoskyn, 2003; Swanson et al., 2009). Thus, immediately following instruction, and during measures of durability of memory nearly three weeks later, it is reasonable to expect NSWD to perform higher on various academic tasks such as recall of new vocabulary terms and concepts. However, following vocabulary instruction using various iterations of CAPs (Mayer's design principles plus either explicit instruction, strategy instruction, or both), the SWD in this study were not significantly outperformed by NSWD with respect to performance at posttest and maintenance. While preliminary in nature, the educational significance of these results have the potential to be important for SWD and others who struggle with memory-related tasks such as vocabulary learning.

The sum of these results show that (a) vocabulary instruction delivered by CAPs that contained both explicit instruction and the keyword mnemonic strategy resulted in stronger and more durable performance for this sample of students than CAPs that provided explicit instruction or strategy instruction alone; and (b) the use of CAPs that adhered to validated instructional design principles resulted in stronger and more durable gains than multimedia instruction that did not meet standards of validated design principles.

These findings corroborate existing research in the field of vocabulary learning for students with LD (e.g., Bryant et al., 2003; Ebbers & Denton, 2008; Jitendra et al., 2004) in that combinations of instructional methods for teaching vocabulary (e.g., explicit and strategic instruction) are preferred over single methods for teaching word meanings. In addition, instruction provided using multimedia instruction (computer-aided instruction) can also help SWD improve their vocabulary knowledge (Horton et al., 1988; Johnson et al., 1987; Xin & Rieth, 2001). These results are very promising given the need for improvement for many adolescents with LD in the area of vocabulary knowledge and related skills and capacity. In addition, given the very limited number of studies using multimedia-based methods to provide vocabulary instruction, the implications of this study will hopefully function to spur ongoing scholarly investigations regarding opportunities to improve student vocabulary performance using instructional technology.

Conclusions for Students Without LD

Important empirical results emerged from this experiment with respect to gains made in vocabulary learning by students without learning disabilities (NSWD). First, the evidence supports the use of CAPs with both explicit instruction and the keyword mnemonic strategy to provide vocabulary instruction to urban adolescents with LD that results in powerful and durable learning. For example, students without LD in Group 1 significantly outperformed all other students on a posttest of knowledge for vocabulary terms 1-30. Nearly two thirds of the variance for these findings is accounted for within the interaction between Time and Group. Thus, the CAP intervention was a catalyst for these results. In addition, NSWD in Group 1 also statistically outperformed students in Groups 3 and 4 on the maintenance probe for items 21-30. These important findings demonstrate (a) the importance of multimedia-based instruction that adheres to validated instructional principles; and (b) that the most powerful and durable vocabulary instruction given the sample and conditions described in this study included both explicit and strategic instruction.

These findings extend Mayer's cognitive theory of multimedia learning (CTML, 2009) and instructional design principles to the field of vocabulary instruction for urban adolescents enrolled in history courses. Although the CTML and related design principles are well grounded in empirical research (Mayer, 2001, 2005, 2009), the bulk of this research has focused on learning gains made by undergraduates during introductory psychology courses. Additional research translating Mayer's principles into guiding principles for the design of instructional material for adolescents with and without disabilities is needed. As an applied model, the present investigation is the first known study in which Mayer's principles were directly applied to design, package, and deliver evidence-based vocabulary instruction to adolescents. Therefore, this study is an important innovation and extension of Mayer's work. Further applied research in this area is needed to corroborate this claim.

Conclusions Based on Student Feedback

Student feedback from the Student Satisfaction Survey (SSS) indicates positive palatability of the CAP intervention to support vocabulary learning. More specifically, students in Groups 1-3 indicated significantly higher positive dispositions towards the technical components of the CAPs (e.g., easy to understand and follow) than students in Group 4. Post-hoc statistical analyses of student responses also demonstrated significant differences in preference for the Group 1 version of CAPs compared to the videos used in Group 4. Students in Groups 1-3 also agreed that the CAPs were useful in learning the meaning of the terms, and students felt prepared for assessments after using CAPs to learn the terms. Written feedback from students on three open-ended questions indicated that a large number of students enjoyed the multimedia-learning format, and given the opportunity, most would use the CAPs on a frequent basis to prepare for assessments or to support their in-class learning.

Results from the SSS lend social validity to the findings of this study. If students do not enjoy multimedia-based instruction, they are unlikely to use or benefit from it during future organic learning opportunities. Thus, coupled with the empirical findings, the significant preference of students in Groups 1-3 over Group 4 on important variables tied to the theoretical framework for designing CAPs lends validity to the findings and the CAP intervention as a tool to be explored further.

Connections With Theory and Previous Research

The theoretical presuppositions in this study are directly tied to research in the fields of cognitive learning, multimedia learning, and vocabulary instruction, and sought to answer the research question: To what extent can multimedia-based instruction designed using validated instructional design features be packaged with evidence-based vocabulary instruction to support vocabulary learning of adolescents with and without learning disabilities?

The results of the study are similar to those of previous studies regarding (a) positive effects of multimedia-based instruction based on Mayer's CTML and instructional design principles (Mayer, 2001, 2005, 2008, 2009); (b) positive effects of instruction that specifically supports the limited cognitive processes of students when posed with challenging academic tasks (Swanson & Deshler, 2005; Swanson & Hoskyn 2003); (c) positive effects of multimedia-based instruction to support vocabulary learning of adolescents (Horton et al., 1988; Johnson et al., 1987; Xin & Rieth, 2001); (d) improved learning using the CAP intervention (Kennedy et al., 2010); and (e) augmented performance on measures of vocabulary learning for adolescents with

LD following use of a blend of explicit and strategic approaches (Bryant et al., 2003; Ebbers & Denton, 2008; Jitendra, 2004). As noted, the results from this study provide preliminary evidence that pushes existing theories and practices to new space in the name of augmenting academic skills and outcomes for all students.

Limitations

Several limitations or cautions apply to this study. First, although an experimental design was used, only 279 students participated. In addition, only 30 (9.3%) students with LD participated. While the percentage of students with LD within the study population constitutes an increase over the reported prevalence rate of 6% of individuals with LD in reading found nationally in schools (NRCLD, 2006), it limits the generalizability of the results with regard to that type of student. Additionally, while these are not small numbers in social science research, the students were enrolled in one high school; thus potentially representing a homogeneous group.

Second, the researcher was unable to receive permission from the participating district research office to acquire relevant standardized test scores and important student identification (e.g., IQ scores) for students in the study. While students' GPA from the first semester of the course were used to first stratify the sample during random assignment, and later to compare performance differences at posttest and maintenance, this metric is not as reliable as a standardized measure for evaluating student ability.

Third, the researcher created all of the CAPs used in the study. While the CAPs were created using the CAP Production Steps for the delivery of content (Appendix A), the CAP VIeW Checklist (Appendix B), and the CAP Adherence Worksheet (Appendix C), and were reviewed by experienced colleagues, important questions remain about the ability of other teachers or researchers to create effective CAPs. This is an important question to be answered by future research. Relatedly, instruction was provided using individually issued laptops and headphones to all students. The availability of laptops on a 1:1 ratio is unlikely in many schools; therefore, the controlled nature of this experiment does to some extent threaten its external validity. While individual laptops and headphones were necessary to establish a controlled method for evaluating student learning, this is not necessarily the intended use of CAPs.

Fourth, the researcher created the measures used in the study. Standardized measures of vocabulary knowledge for specific content areas (e.g., world history) do not exist, and other standardized vocabulary measures were not appropriate for use in the study given the research questions. Furthermore, given the limited scope of this experiment with respect to terms that were taught as well as the duration of the study (approximately three weeks), growth on a standardized measure would likely be impossible. A related limitation was that only 30 vocabulary terms were selected for use in the study. This was a practical limitation in that the teachers were unwilling to give away additional class time to accommodate CAPs and accompanying assessments for more terms.

Implications for Future Research

This study has important implications for research and practice. With respect to research, future studies should attempt to leverage Mayer's CTML and instructional design principles to create multimedia-based instructional materials for a wide assortment of content areas. For example, this study was restricted to vocabulary terms and students enrolled in a world history course. Future explorations should be expanded to other courses within social studies (e.g., U.S. history) as well as other subject areas that require substantial vocabulary knowledge (e.g., science, mathematics, foreign languages). In addition, in this study, the primary objective was to promote vocabulary learning among students with LD; however, other students with disabilities may also benefit from multimedia instruction designed using validated instructional design principles. Future research should explore the extent to which CAPs can improve learning outcomes for students with a range of disabilities. Finally, although CAPs have already been shown to be effective during delivery of course content to undergraduate teacher candidates (Kennedy et al., 2010), more research in this area should be conducted. A wide range of applications for the CAP intervention is possible in the field of teacher preparation. Of note are studies that will help students prepare for success during in-class case-based learning activities, practicum experiences, and in full-time teaching.

With respect to practice, a clinical approach was used in this first study of the utility of CAPs to augment vocabulary knowledge. Future research should explore more socially valid and organic methods for using CAPs to deliver vocabulary instruction. This may include teachers using CAPs during large-group lectures, assigning students to watch CAPs at home, or during other study times in and out of school. Relatedly, studies in which other researchers or teachers create CAPs and evaluate their impact on student learning should be conducted. Success in this area will greatly expand the validity of this intervention as tool for supporting the learning of students with and without disabilities. Another interesting opportunity to extend the validity of the intervention is for students to participate in the production of CAPs. Comparison of student performance on CAPs created by teachers, researchers, and students is an important empirical question to be addressed by future research.

Summary

The CAP intervention is an effective tool for improving the vocabulary knowledge of adolescents with and without LD. Intervention research such as this study is important for the field of special education by adding to our collective knowledge base for designing and delivering specially designed instruction to students. Despite the effectiveness of the CAP intervention in this study, for it to be adopted by practitioners, additional research using this tool needs to be conducted by other researchers and educators who create their own CAPs and test their results under similar experimental settings.

Given the goal of improving vocabulary instruction for both students with and without learning disabilities, this study was a success. Convincing general education teachers to use new interventions during instruction must possess utility to influence the learning of all students. In this study, nearly all students who received instruction using CAPs made gains in vocabulary knowledge and, therefore, this promising practice should move to a new round of implementation and experimental testing.

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Appendix A

CAP Production Steps for Delivery of Content

Mayer's Instructional Design Principles (2009)	CAP [Content Acquisition Podcast] Production Steps For Delivery of Content
Preparation	
- Coherence - Segmenting	**Step 1.0**: **Identify a clearly defined and coherent topic of interest.** 1.1 Select only the most critical content to include in the CAP.
- Coherence - Segmenting - Signaling - Pretraining	**Step 2.0: Create 'standard' PowerPoint slides (heading and bulleted supporting points) for critical content.** **2.1** Create a clear PowerPoint title page slide **2.2** Separate critical content so each slide presents only one piece of discrete information and key descriptors. **2.3** Eliminate extraneous content from slides and planned comments. **2.4** Determine and implement a logical numbering or hierarchical ordering system for key ideas throughout slides when presenting multifaceted concepts **2.5** Make PowerPoint speaker notes as appropriate; print a copy of slides for reference when recording podcast narration.
Production	
- Multimedia - Spatial Contiguity - Redundancy - Coherence	**Step 3.0 Replace 'standard' text-heavy slides one-by one with images that represent the content as closely as possible. For example: A slide that introduces reading comprehension strategies might include a photo of a puzzled-looking child holding a book.** **3.1** Select one eye-catching image per key idea. Use google.com/images, bing.com/images or another internet search engine to find copyright-free photos or other images. **3.2** Select large images that fill most of the available slide space without losing clear visual resolution **3.3** Avoid cluttered images with embedded text or distracting details. **3.4** For slides where you plan to insert text to emphasize key terms or ideas, make three copies of the appropriate slide and keep them in order in your presentation.

- Redundancy - Spatial Contiguity - Coherence	**Step 4.0: Insert text over images by using 'insert text box' on the second of the three slides. The first and third slide should be free of text.** **4.1** Select one word or a short phrase (3-4 words) to highlight the topic of the slide to be typed into the text box. Using full sentences is not advised. Use clear and concise verbiage. **4.2 Use** 40 point or larger font size and widely-used type styles; select text color that is easily readable given the contrast with the background images and colors. [NOTE: The text box "fill color" tool make be used to ensure good contrast between images and text.] **4.3:** Centrally locate text boxes either in the middle of the slide or near a major image element. **4.4** Limit viewers' need to move their eyes across the podcast screen or to multiple locations on any given slide; use the same principle when selecting appropriate pictures.
- Modality - Temporal Contiguity - Coherence - Multimedia - Redundancy	**Step 5.0: Prepare and time your slide narration so it coincides with the appropriate on-screen text. For example**, *when recording a presentation about making pizza:* **5.1** Create three identical slides that adhere to the aforementioned steps. Insert a text box (See Steps 3.0-4.4 above) in the second of three identical slides that has the words "add cheese". **5.2** Begin narrating these slides (See Step 6.0). With Slide 1 of 3 on the screen say, "The next step in making pizza is…", then hit "Enter" to advance to the second slide already prepared with the text box and say, "add cheese," (narration will match text on the screen) hit "Enter," and finish narration on this element of making a pizza while slide 3 (without any text, but same picture) is on screen. **5.3** Repeat this process for every key CAP term/concept to be addressed in the presentation. Not every picture representing a concept or piece of information needs additional text—reserve use of text for the most essential concepts/pieces of information within your CAP.
- Multimedia - Coherence - Modality -Personalization, Voice, and Image - Segmenting	**Step 6.0: Finalize slides and familiarize yourself with the written narrative before recording narration. Save your file.** **6.1** Under PowerPoint pull-down menu, click 'Slide Show', and then, 'Rehearse Timings." **6.2** Rehearse narration; hit enter to advance through the slides. Note the total length of your narration when done. **6.3** PowerPoint will ask if you want it to automatically link the amount of time you spent on each slide for later use. **CLICK YES.** **6.4** Practice recording podcast several times until comfortable and confident with the flow of the CAP. If it is longer than 3-5 minutes (shorter is fine), or if more than three-five concepts are presented, divide the CAP content into two or more podcasts (e.g., Learning Strategies [LS] Part I, LS Part II). **6.5** Save the file as a movie. Select the quality of playback (highest quality is recommended)

<table>
<tr><td>- Personalization, Voice, and Image

- Multimedia

- Modality</td><td>Step 7.0: Import saved .ppt movie file into your choice of iMovie (MAC) or Windows MovieMaker (PC).
7.1 There are several options for recording narration and linking to your movie—there is no ‘correct’ way. Recording narration within PowerPoint is possible, but is frequently unreliable (based on experience with Office 2008 or previous versions). An easy way for novices to record narration following the preceding steps is Apple’s iMovie or Window’s Movie Maker programs.
7.2 Drag the file into the video production timeline (at bottom of screen in both iMovie and Movie Maker).
7.3 Ensure your computer’s built in microphone or external mic is functioning properly and at an appropriate volume. Record a test statement to confirm audio level prior to narration.
7.4 Record narration in a room free from background noise or other distractions. Preview your recording. If sound is distorted or otherwise imperfect, diagnose the problem (you were too close to microphone, etc.) and re-record.
7.5 Speak in a clear, engaging voice; record in front of a mirror or with another person to create a more natural-sounding recording. Use good posture, smiling, and hand gestures can also improve the quality of vocal recordings.
7.6 Listen to your recording for unnecessary pauses (um’s or other dead air). If they are noticeable/distracting, re-record your Pre-CAP.
7.7 Save/Export your finished video as a quicktime or windows media file.</td></tr>
<tr><td colspan="2" align="center">Publishing</td></tr>
<tr><td></td><td>Step 8.0 Upload your saved video to the web
8.1 Upload your CAP to course management websites (e.g., BlackBoard) or other file-sharing sites (e.g., www.vimeo.com; www.youtube.com).</td></tr>
</table>

Appendix B

The CAP Vocabulary Instruction eWorksheet (VIeW) Checklist

CAP Vocabulary Instruction eWorksheet (VIeW) Checklist

Phase I. Explicit Instruction

1.0 Provide a Statement of Purpose/Rationale for the student

This is the pre-CAP to learn about ________. ______ is a very important and common concept in [subject area].

Yes ____________ No ____________

2.0 Promote Word Consciousness (pronunciation, spelling, syllables, root word, prefix/suffix)

2.1 The term ______ is pronounced _____

2.2 The term ______ is spelled _____

2.3 The term ______ has _____ syllables.

2.4 The term ______ has the root word _____. A(n) _____ is _____

2.5 The term ______ does or does not have a prefix. The term ______ has the prefix_____. _____ means _____

2.6 The term ______ does or does not have a suffix. The term ______ has the suffix _____. A(n) _____ means _____

3.0 Provide Direct Instruction in Word Meaning

3.1 The term ______ means _____ *(definition should reflect what ALL Students need to know)*

4.0 Guided Practice with Scaffolding

4.1 Select [or write] a Passage from the textbook that defines the term:

4.2 Select [or write] a passage of text that uses the term in context without defining it:

5.0 Provide Awareness and Instruction of Closely Related Terms/Concepts

5.1 Provide a closely related example of the term

A term [synonym or closely related concept] you will often hear associated with ______ is ______. This is because …

5.2 Provide a Non-Example

5.3 Introduce variation of the term caused by different suffix

Another form of the word ______ is ______. The small change in suffix from ______ to ______ is important.

The term ______ has the suffix ______. The suffix ______ means _____

5.4 Define the new term and relate to the original term

Therefore, the term _____ means _____. This is similar to the term ____

5.5 Give an example of the term with the new suffix

Phase II: Strategy Instruction

6.0 Use the Keyword Mnemonic Strategy

6.1 State the term and provide a definition

6.2 Select an acoustically similar keyword to take the place of the term you are teaching. The keyword must be a term the students will understand.

The keyword for ______ is ______.

6.3 Describe the keyword interacting with the definition of the original term.

6.4 Find or draw a picture that graphically depicts the keyword interacting with the definition of the original term.

Appendix C

CAP Adherence Worksheet

Name ___________________________________ CAP Title _____________________________

1.0 Provide a Statement of Purpose/Rationale

a. Statement of purpose/rationale is provided: Yes _____ No _____ Mayer _____

2.0 Promote Word Consciousness (pronunciation, spelling, syllables, root word, prefix/suffix)

Menu of Evidence-Based Practices for promoting word consciousness:

a. Term is pronounced: Yes _____ No _____ Mayer _____

b. Term is broken into syllables: Yes _____ No _____ Mayer _____

c. Root word is identified/defined: Yes _____ No _____ N/A _____ Mayer _____

d. Prefix is identified/defined: Yes _____ No _____ N/A _____ Mayer _____

e. Suffix is identified/defined: Yes _____ No _____ N/A _____ Mayer _____

3.0 Provide Direct Instruction in Word Meaning

a. An explicit statement of the term or concept's meaning is provided :

Yes _____ No _____ Mayer _____

b. Essential supporting details are provided: Yes _____ No _____ Mayer _____

4.0 Guided Practice & Scaffolding

a. A passage from the textbook that explicitly defines the term is provided & read:

Yes _____ No _____ Mayer _____

b. A passage is provided & read where the term is used in context without definition:

Yes _____ No _____ Mayer _____

c. A passage is provided that uses the term in context. Students are instructed to read the sentence; time is given to read the sentence. After ample wait time, the narrator asks did you read… then read the passage (modeling of good fluency):

Yes _____ No _____ Mayer _____

5.0 Provide Awareness and Instruction of Closely Related Terms/Concepts

a. Synonym is provided: Yes _____ No _____ N/A _____ Mayer _____

b. Antonym is provided: Yes _____ No _____ N/A _____ Mayer _____

c. Closely related term is presented and defined: Yes _____ No _____ N/A _____ Mayer ___

d. Non-example term or concept it presented and defined:

Yes _____ No _____ N/A _____ Mayer _____

6.0 Use the Keyword Mnemonic Strategy

a. The keyword mnemonic strategy is used: Yes _____ No _____

b. Instruction is provided for why the keyword mnemonic strategy is important for learning:

Yes _____ No _____ Mayer _____

d. The keyword is an easily recognizable term: Yes _____ No _____ Mayer _____

e. The keyword is shown visually interacting with the original term definition:

Yes _____ No _____ Mayer _____

Appendix D

Multiple-Choice Instrument

1. An alliance is:

a) A policy of refusing to participate in international affairs

b) A formal agreement between two or more nations or powers to cooperate and come to one another's defense

c) A style or art composed of lines, colors, and shapes, sometimes with no recognizable subject matter at all

d) A policy of giving in to an aggressor's demands in order to keep the peace

2. Nationalism is:

a) Domination by one country of the political, economic, or cultural life of another country or region

b) Glorification of a nation's military

c) A strong feeling of pride and devotion to one's country

d) Takeover of property or resources by the government

3. An entente is:

a) A nonbinding agreement to follow common policies

b) A formal agreement between two or more nations or powers to cooperate and come to one another's defense

c) A branch of biology dealing with variations among plants and animals

d) Free trade between countries without tariffs or other restrictions

4. Industrialization is:

a) An economic cycle that involves a rapid rise in prices linked to an increase in the amount of money available

b) A process by which national economies, politics, cultures, and societies become integrated with those of other nations around the world

c) An intellectual movement in the early 18th century that focused on education and the classics

d) An introduction to new machine-based business and development capacity into an area on a large scale

5. Militarism is:

a) A deliberate attempt to destroy an entire religious or ethnic group

b) The use of military power to take control over another nation

c) The glorification of a nation's armed forces

d) A policy of supporting neither side in a war

6. An ultimatum is:

a) A list of demands that are negotiable

b) A final set of demands

c) The process of fixing up the poor areas of a city

d) The ability to meet the needs of the present without compromising the needs of future generations

7. A diplomat is:

a) A person appointed by a national government to conduct official negotiations with other countries

b) A ruler with absolute authority over the government and lives of the people he or she governs

c) A branch of biology dealing with heredity and variations among plants and animals

d) The common currency used by member nations of the European Union

8. Neutrality is:

a) A policy of joining the stronger side in a war

b) The American policy of discouraging European intervention in the Western Hemisphere

c) A policy of supporting neither side in a war

d) A policy allowing business to operate with little or no government interference

9. A stalemate is:

a) The forced separation by race, sex, religion or ethnicity

b) A deadlock in which neither side is able to defeat the other

c) An agreement that ends a war

d) A person who moves from place to place in search of a permanent home

10. Casualties are:

a) Members of the armed services who are killed in action

b) Conflicts between two groups of people in the same nation

c) Groups of nations acting together in support of one another

d) Members of the armed forces lost through death, wounds, sickness, capture, or because they are missing in action

11. Convoys are:

a) A group of merchant ships protected by warships

b) Special economic rights given to a foreign power

c) A group of countries who agree to protect one another

d) Gaps between what a government spends and what it takes in through taxes and other sources

12. Morale is:

a) Complete control of a product or business by one person or group

b) Preparation for war

c) The degree of mental confidence of a person or group; can be positive or negative

d) A person who assumes financial risk in the hope of making a profit

13. A pandemic is:

a) A severe shortage of food in which large numbers of people starve

b) An event having to do with worldly, rather than religious beliefs

c) A government in which ruling power belongs to a few people

d) The spread of a disease across a large area, country, continent, or the entire world

14. Reparations are:

a) Spreading of ideas to promote a cause or to damage an opposing cause

b) Payment for war damage, or damage caused by imprisonment

c) Taxes placed on goods being brought into a country

d) Repairs made to a country after a natural disaster

15. Conscription is:

a) Special economic rights given to a foreign power

b) Written laws for a country

c) "The draft," which requires all young men to be ready for military or other service

d) An agreement among people

16. Contraband is:

a) The forced joining together or workers and property into collectives

b) The military supplies and raw materials needed to make weapons and other tools for war

c) A group of guerrillas who fought the Sandinistas in Nicaragua

d) The money or wealth used to invest in business or enterprise

17. Atrocities are:

a) People who do not believe in God

b) Skilled craftspeople

c) Horrible acts committed against innocent people

d) Drugs that prevent pain during surgery

18. An armistice is:

a) An agreement to end fighting in a war

b) A fleet of ships ready for war

c) When a king or queen gives up their throne

d) When a country adds territory taken from another country

19. Containment is:

a) An agreement in which each side makes concessions; an acceptable middle ground

b) The killing or forcible removal of people of different ethnicities from an area by aggressors so that only the ethnic group of the aggressors remains

c) The strategy of keeping communism within its existing boundaries and preventing its further expansion

d) The spread of ideas, customs, and technologies from one people to another

20. Suburbanization is:

a) A multistory building broken into several apartments

b) The movement to build up areas outside of central cities

c) A nation stronger than other powerful nations

d) The ability to meet the needs of the present without compromising the needs of future generations

21. Collectivization is:

a) The forced joining together of workers and property

b) The middle class

c) A branch of mathematics in which calculations are made using special symbolic notations

d) When a nation adds territory taken from another nation

22. Subsidize is:

a. A final list of demands

b. The movement of people from rural areas to cities

c. The idea that the goal of society should be to bring about the greatest happiness for the greatest number of people

d. Support provided through government spending

23. Nonalignment is:

a) A policy of nonparticipation in or withdrawal from international affairs

b) A formal agreement between two or more nations or powers to cooperate and come to one another's defense

c) A political and diplomatic independence from both Cold War powers

d) The reduction of a nation's nuclear arsenal

24. Theocracy is:

a) A system in which the people as a whole rather than private individuals own all property and operate all businesses

b) A government headed by a privileged minority or upper class

c) A government run by religious leaders

d) A government in which the people hold the ruling power

25. Apartheid is:

a) The killing or forcible removal of people of different ethnicities from an area by aggressors so that only the ethnic group of the aggressors remains

b) A policy of rigid segregation of non-white people in the Republic of South Africa

c) The union of Germany and Austria

d) A group of countries led by Germany, Japan,
and Italy that fought the Allies in WWII

26. Proliferate is:

a) The spreading of ideas to promote or cause damage to an opposing cause

b) A ban on the manufacture and sale of alcoholic beverages in the United States from 1920-1933

c) To multiply rapidly

d) A country with its own government but under the control of an outside power

27. Surrealism is:

a) The deliberate use of random violence, especially against civilians, to achieve political goals

b) An artistic movement that attempts to portray the workings of the unconscious mind

c) The personal, elegant style of art and architecture made popular during the mid-1700's that featured designs with the shapes of leaves, shells, and flowers

d) To step down from a position of power

28. Fascism is:

a) A government in which the people hold the ruling power

b) A form of socialism advocated by Karl Marx; According to Marx, class struggle was inevitable and would lead to the creation of classless society in which all wealth and property would be owned by the community as a whole

c) Any centralized, authoritarian government system that is not communist whose policies glorify the state over the individual and are destructive to basic human rights

d) A system in which the people as a whole rather than private individuals own all property and operate all businesses

29. An appeasement is:

a) A distribution of military and economic power that prevents any one nation from becoming too strong

b) An agreement to end fighting in a war

c) A horrible act committed against innocent people

d) A policy of giving in to an aggressor's demands in order to keep the peace

30. Pacifism is:

a) The largest ocean on Earth

b) The opposition to all war

c) To step down from a position of power

d) Someone who wants to abolish all government

Appendix E

Open-Ended Instrument

Part A: Please write the definition, synonym, antonym, and any other information you know for each term

1. Alliance -

Synonym:
Antonym:
Anything Else:

2. Nationalism -

Synonym:
Antonym:
Anything Else:

3. Entente -

Synonym:
Antonym:
Anything Else:

4. Industrialization -

Synonym:
Antonym:
Anything Else:

5. Militarism -

Synonym:
Antonym:
Anything Else:

6. Ultimatum -

Synonym:
Antonym:
Anything Else:

7. Diplomat -

Synonym:
Antonym:
Anything Else:

8. Neutrality -

Synonym:
Antonym:
Anything Else:

9. Stalemate -

Synonym:
Antonym:
Anything Else:

10. Casualties -

Synonym:
Antonym:
Anything Else:

11. Convoys -

Synonym:
Antonym:
Anything Else:

12. Morale -

Synonym:
Antonym:
Anything Else:

13. Pandemic -

Synonym:
Antonym:
Anything Else:

14. Reparations -

Synonym:
Antonym:
Anything Else:

15. Conscription -

Synonym:
Antonym:

16. Contraband -

Synonym:
Antonym:
Anything Else:

17. Atrocities -

Synonym:
Antonym:
Anything Else:

18. Armistice -

Synonym:
Antonym:
Anything Else:

19. Containment -

Synonym:
Antonym:
Anything Else:

20. Suburbanization -

Synonym:
Antonym:
Anything Else:

21. Collectivization -

Synonym:
Antonym:
Anything Else:

22. Subsidize -

Synonym:
Antonym:
Anything Else:

23. Nonalignment -

Synonym:
Antonym:

24. Theocracy -

Synonym:
Antonym:
Anything Else:

25. Apartheid -

Synonym:
Antonym:
Anything Else:

26. Proliferate -

Synonym:
Antonym:
Anything Else:

27. Surrealism -

Synonym:
Antonym:
Anything Else:

28. Fascism -

Synonym:
Antonym:
Anything Else:

29. Appeasement -

Synonym:
Antonym:
Anything Else:

30. Pacifism -

Synonym:
Antonym:
Anything Else:

Appendix F

Student Satisfaction Survey

Student Questionnaire—Podcasts

Directions: Circle the appropriate response, or provide a short answer in the space provided.

1. Did you experience any technical problems when watching the Podcasts?

a. Yes

b. No

2. If you answered yes to Question #1, which caused you problems? (circle all that apply)

a. Finding and loading Podcasts using School Loop

b. Speed of the Podcasts

c. Audio of the Podcasts

d. Other____

3. Was there anything about the Podcasts that helped you learn about the vocabulary term (e.g. the pictures, the sound, the words on the screen, technology format)?

____

____

4. The speaker on the Podcasts was easy to understand

Strongly Disagree								**Strongly Agree**	
1	2	3	4	5	6	7	8	9	10

5. The Podcasts looked good (the pictures, words, etc.)

1	2	3	4	5	6	7	8	9	10

7. The information in the Podcasts was interesting to me

Strongly Disagree									**Strongly Agree**
1	2	3	4	5	6	7	8	9	10

8. Learning new vocabulary in world history is hard for me

1 2 3 4 5 6 7 8 9 10

9. The Podcasts helped me learn the meanings of the vocabulary terms

1 2 3 4 5 6 7 8 9 10

10. The Podcasts helped me to do well on the quizzes

1 2 3 4 5 6 7 8 9 10

11. The keyword in the Podcasts helped me remember the definition

1 2 3 4 5 6 7 8 9 10

12. How would you improve the Podcasts to support your learning?

____

____

13. If you could watch the Podcasts whenever you wanted, how often, when, and why would you use them?

____

____

15. I was in Group # _____

Appendix G

Vocabulary Terms Used in Experiment

1. Alliance
2. Nationalism
3. Entente
4. Industrialization
5. Militarism
6. Ultimatum
7. Diplomat
8. Neutrality
9. Stalemate
10. Casualties
11. Convoys
12. Morale
13. Pandemic
14. Reparations
15. Conscription
16. Contraband
17. Atrocities
18. Armistice
19. Containment
20. Suburbanization
21. Collectivization
22. Unremitting
23. Nonalignment
24. Theocracy
25. Apartheid
26. Proliferate
27. Surrealism
28. Fascism
29. Appeasement
30. Pacifism

Appendix H

Fidelity Checklist

Directions for Experiment Days: Today we are conducting a test of how well you can learn vocabulary terms in World History using instruction over the computer. Each of you will watch a total of 10 short videos that give information about important terms from World History. After watching the videos you will take a short quiz so we can figure out how well you learned.

1. Log in to Mr. X's or Mr. Y's School Loop page for World History

Complete _________

2. You are assigned to Group 1(A), 2(B), 3(C) or 4(D). Write your group and student ID number on your folder. Only click on your group—you cannot change groups. If you are not sure which group you are in, please ask. This is very important. We will walk around to ensure you have accessed the correct group's podcasts.

Complete _________

3. Click on the folder that says "World War I Podcasts"

Complete _________

4. Everyone will watch a podcast that explains what you can expect in the videos. This video will help you prepare for watching the Podcasts. Click on "Orientation Video"

Complete _________

5. There are a total of 10 podcasts for you to watch today, however you will only watch 5 at a time. Please put on your headphones to watch the videos. Some videos have pictures and text on the screen, pay careful attention to each. Do not take notes when watching the videos.

Complete _________

6. There are questions that go along with the information presented in each podcast. When you finish watching podcasts 1-5, raise your hand and close your computer. You will answer questions about those 5 podcasts.

Complete _________

7. There are two different sheets of questions for each podcast. The first sheet will ask you to write a definition for each term, a synonym and antonym, and any other information you know. The second sheet is multiple-choice items. When you finish raise your hand. Write your student ID number on both sheets, do not write your name.

Complete _________

8. When you finish then watch podcasts 6-10 and answer questions 6-10 (repeat)

Complete _________

Testing Irregularities: