The Effects of Computer-Based Graphic Organizers and Instructional Technology for Students with High-Incidence Disabilities

by

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Abstract

This study investigated the effects of an instructional technology, a computerized graphic organizer, on vocabulary acquisition skills of students with high-incidence disabilities. Specifically, this study focused on the computerized *Real-World Connections Vocabulary* graphic organizer which was published by Dr. Edwin Ellis in 2015 and is part of the Differentiated Visual Tools Model (Ellis, Deschler, Lenz, Schumaker, Clark, 1991; Ellis, Willis, & Deshler, 2011). Although graphic organizers have been studied since they were first identified by Dr. David Ausubel in the 1960's, there is very little research regarding the effectiveness of computer-based graphic organizers and their effectiveness when used with students with high-incidence or mild disabilities and their benefit acquiring college entrance exam vocabulary knowledge, specifically the ACT exam. The purpose of this study was to examine the effects of this instructional technology tool by means of a single-subject, multiple probe across participants design. This study examined the existence of a functional relation between the computerized graphic organizer, *The Real-World Connections Vocabulary* tool (Ellis, 2015), and vocabulary acquisition. After this study, it was demonstrated that a functional relation did exist for each participant. In addition to this, a social validity survey was completed after the study which also rendered positive results regarding the use of the tool. Implication for the practice and future research are also discussed.

Dedication

This project is dedicated to my family first and foremost, beginning with my awe-inspiring, strong-willed, God-fearing mother, Cathryn Carroll Clark, for her continuous love, support, and belief in me. Without her confidence and encouragement, I would have never ventured down this path. To my equally supportive son, Tyler, and my sister, Terry, who are more alike than they are different, for always encouraging me, and making sure I never traveled too far off the mark or lost sight of my goal. This work is dedicated, again, to my sister, and brother-in-law, Mark, who made sure I took a break every now and then to help keep me sane and a little more human. Specifically, to my son Tyler, I wish you all the happiness in your future adventures, wherever they take you. You are smarter than I will ever be, as strong willed and tenacious as all of us Carroll's are, and loved beyond the measures of this Earth.

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Chapter I: Statement of the Problem

As most would agree, the importance of reading comprehension cannot be underestimated. According to Rasinski, Padak, and Newton (2017), its significance was first identified more than seventy years ago when research indicated that reading comprehension skills were strongly connected to one's knowledge of vocabulary. This theory holds true today. Many might argue that of all the skills taught in the public education classroom, a student's ability to read and comprehend text is of the upmost concern (Davis, 1944; Kim, Vaughn, Wanzek, & Wei, 2004; Kuder, 2017; Schloss, Smith, & Schloss, 2007). Even though reading involves many different processes, it can be concentrated into two key components: the ability to decode or recognize words and the ability to understand their meaning, with comprehension being the, "all-important end" (Schloss et al., 2007, p. 234).

This concern for student's reading comprehension has continued over the last several decades. For example, *A Nation at Risk*, a 1983 report from the National Commission on Excellence in Education, emphasized the belief that public education systems were not preparing students for the present-day workforce. One of the major assertions of this report was that approximately 40% of secondary high school students were unable to construct simple inferences from reading material. Among other statistics, this landmark report also stated that secondary high school students were scoring significantly lower than previous years. Specifically, in relation to the topic of reading comprehension, this report stated the average score on the verbal section of the Scholastic Assessment Test (SAT), had dropped more than 50 points between 1963 and 1980 (Kuder, 2017; National Commission on Excellence in Education, 1983).

A Nation at Risk led to the ultimate creation of the National Assessment of Educational Progress, a website funded by the Commissioner of Educational Statistics, head of the National

Center for Education Statistics (NCES) within the U.S. Department of Education. This site continually assesses student performance in the academic areas of reading, math, science, social studies, writing, and technology/engineering literacy. According to the most recent information available on the National Assessment of Educational Progress website, in the areas of reading vocabulary, scores for students in both the 4th and 8th grade levels have demonstrated improvement, but high school aged students' scores have demonstrated no significant change in this area between 2009 and 2011 (NCES, 2013).

Traditionally, students with disabilities score poorer than their non-disabled peers on vocabulary and reading comprehension measures (Vaughn et al., 2015). As recently as 2015, based on findings from the NCES, *Average Scale Score for Reading* in which reading scale scores range from 0-500, students without disabilities averaged a 269-scaled score while students with disabilities average score was a 226. More specifically, in the isolated area of vocabulary, scale scores range from 0-500, students without disabilities have demonstrated improvements by increasing their vocabulary knowledge scores from 222-224 between 2009 and 2013; whereas scores for students with disabilities have decreased from 187 to 184 during the same time frame. This evidence demonstrates that despite educators' best efforts, there is a continued need to target vocabulary meaning and reading comprehension instruction, especially at the secondary level (Bryant, Goodwin, Bryant, & Higgins, 2003). In fact, Kuder (2017) most recently states that a review of the current literature shows that of the five most common types of intervention, (fluency, word study, vocabulary, comprehension, multi-component methods), vocabulary instruction produces the largest effect size (1.62) thus indicating improvement in this isolated skill continues to be of the upmost concern.

With the evolution of new technology occurring at lightning-fast speed, an ever-shrinking world has become more difficult for students as their standards and expectations have increased substantially. This complexity is described in the Common Core State Standards which outline the need for more rigorous text complexity, variations in the structure in which text is presented, and the deepening of students' content knowledge by encouraging them to use higher-order thinking skills (Kim, McKenna, & Park, 2017).

Vaughn et al. (2015) states that as students' age, reading difficulties become compounded. In a study of 9th grade students, Lang et al. (2009) found that these students require greater support and interventions to improve their deficits in both background knowledge and vocabulary for meaning to occur. Vaughn et al. (2015) also completed a meta-analysis of the number of reading interventions available for students with reading disabilities; they found there were twice as many reading interventions available for elementary students than for secondary students. The overwhelming consensus from this information indicates that remediating students with reading deficits, especially secondary students, remains a challenge and warrants continued research (Boon, Fore, & Spencer, 2007; Bryant et al., 2003; Kennedy, Thomas, Meyer, Alves, & Lloyd, 2014).

There is a heightened sense of need as educational instruction and student performance, now more than ever, are being evaluated, analyzed and reported transparently by both state and federal agencies; additionally, this information is being shared publicly via social media. Many teachers report feeling pressured to ensure meaningful outcomes for all students, regardless of a student's disability, academic, or behavioral need (Basham, Israel, Graden, Poth, & Winston, 2010). As a result, both teachers and administrators are looking outside the proverbial box for more effective means of closing the gap and improving student performance. Consequentially, as

the 21st century marches on and assistive technology – more specifically, instructional technology – becomes more abundant, it begins to take a greater stance on the educational stage.

This, combined with students' seemingly innate enthusiasm for electronic devices and computerized gadgets have caused educators to rush and create more modern high-tech versions of traditional evidence-based strategies such as graphic organizers and other direct instruction techniques, but little evidence exists to measure their effectiveness (Kennedy et al., 2014). Research takes time, and with the rapid speed at which technology is evolving, it is difficult for researchers to keep up with the demand for their sound knowledge.

Background of the Study

Despite this shortcoming, educators continue to search for research-based, effective tools to overcome students' ongoing academic difficulties while also taking advantage of technology available to them in their current, modern classrooms. One such tool, the graphic organizer, was first identified in 1963 by Dr. David Ausubel as a means of increasing students' knowledge by building on their current understanding and presenting new information through well-organized, visual models (Kim et al., 2004). These models allow students to better understand content which, therefore, make them highly effective in improving the reading comprehension of students with disabilities (Watson, Gable, Geer, & Hughes, 2012). As students enter secondary grades, learning becomes more dependent upon their ability to grasp information-driven text that contains subject-specific, technical vocabulary which, as already established, can be a challenge for students with disabilities (Kim et al., 2004). The use of graphic organizers can aide instructors as they motivate students to forge through this oft-times, muddy content.

A second concept, differentiated instruction, became vitally important between the passage of the No Child Left Behind Act (2002) and the reauthorization of the Individuals with

Disabilities Education Improvement Act (2004) in which federal mandates re-emphasized the importance of including all students in the general education classroom to the greatest extent possible. The use of differentiated instruction implies one responds to a student's individual needs while considering their learning style to help ensure learning is accessible to the student (Tomlinson, 1999). But as Stanford and Reeves (2009) posit, one single teaching approach will not accommodate every student. Therefore, teachers must be diligent in their attempt to vary instruction via effective differentiated instruction techniques to meet the needs of all their students, which invariably will support the overall growth of their students most effectively.

Along similar lines, the Universal Design for Learning (UDL) Framework outlines that teachers should be proactive in their approach to teaching and learning by purposely structuring instruction to provide successful opportunities for all learners (Kennedy et al., 2014; Meyer & Rose, 2011; Stanford & Reeves, 2009). Teachers who choose this approach plan for success via various and diverse modalities instead of attempting to fix problems and redirect student error after these habits they have been established.

Another approach, Assistive Technology (AT), has proven to be very successful when employing both differentiated instruction and UDL strategies (Basham, et al., 2010; Elder-Hinshaw, Manset-Williamson, Nelson, & Dunn, 2006; Kennedy et al., 2014; Meyer & Rose, 2011; Tomlinson, 1999). Assistive technology may be a significant part of a student's success in the 21st century. This concept, as defined by the Individuals with Disabilities Education Improvement Act (2004), states that it includes any item that can be used to improve the educational performance of a student with a disability. Although it is widely accepted that assistive technology is to focus on the needs of an individual student, it also encourages educators to evaluate the appropriateness of technology to support student performance (Basham

et al., 2010). The notion of *instructional technology* is an extension of this concept, in that assistive technology advocates for educators to consider technologically-enhanced programs that purposely support the diverse needs of students including those that expressly address instruction (Basham, et al., 2010; Puckett, Judge, & Broso, 2009). The progression of instructional technology in recent years, has led to a barrage of educational tools, but concernedly their benefits and usefulness has been debated and under-utilized at best (Johnson, Dudgeon, & Kuehn, 2007; Johnston & St. Evans, 2005; Smith & Okolo, 2010).

Statement of the Research Problem

There is limited research on high school students with mild/high-incidence disabilities regarding the acquisition of vocabulary that centers on college entrance and career readiness exams; specifically, in the content area of reading and using instructional technology in the form of a computerized graphic organizer. Targeted instruction of academic vocabulary promotes content-area knowledge (Fisher & Frey, 2014; Horton, Lovitt, & Christensen, 1991; Shanahan & Shanahan, 2008; Vaughn et al., 2015). Graphic organizers, albeit not electronic in nature, have been proven to promote this cause (Ae-Hwa, Vaughn, Wanzek, & Wei, 2004; Ausubel, 1963; Boon, Fore, Ayres, & Spencer, 2005; Hall & Strangman, 2002; Ives, 2007; Kim et al., 2004; McMackin & Witherell, 2005; Singleton & Filce, 2015). With the emphasis of rigor in education and, thus, the cognitive demand placed upon students steadily increasing, the challenge placed before students is accumulating (Kim et al., 2017; Vaughn et al., 2015). To this end, teaching vocabulary is not only vital, but is a key component in the success of students with disabilities at the secondary level (Vaughn et al., 2015; Watson et al., 2012). The use of technology to teach vocabulary through an evidence-based approach such as graphic organizers makes sense, and is a

need within the educational community, but needs to be researched to determine its effectiveness; therein lies the basis for this study.

Purpose of the Study

The purpose of this study is to determine the effectiveness of a computerized graphic organizer on improving reading comprehension with high school students. The study specifically examined the effectiveness of a graphic organizer, *Real-World Connections Vocabulary* (Ellis, Deschler, Lenz, Schumaker, & Clark, 1991; Ellis, 2015), on the improvement of American College Testing (ACT) vocabulary word knowledge, which is a test presently given to all 11th grade students in the state of Alabama, thus indicating its relevancy. This study evaluated students' performance on pre- and post-test measures related to ACT vocabulary terminology and their definitions, as well as pre- and post-test scores on the *Woodcock Reading Mastery Test: WRMT-III* (Woodcock, 2011); specifically, the *WRMT-III* subtest area of Reading Comprehension which focused on synonyms, antonyms, and analogies. Finally, this study also examined students' perception of the ease-of-use of the computerized graphic organizer, the vocabulary's perceived usefulness to them, and the program's effectiveness.

Significance of the Study

Even though the Every Student Succeeds Act of 2015 and the Individuals with Disabilities Education Improvement Act of 2004 both mandate improving efforts for students with disabilities as well as the consideration and appropriate inclusions of effective use of technology, there is very little research to support this combined effort (Kennedy et al., 2014; Kuder, 2017). According to a recent meta-analysis of the literature on this topic by Ciullo and Reutebuch (2013), twelve studies met both criteria and of those, and only eight of the twelve centered on students eligible for services under the category of specific learning disabilities in

secondary schools (grades 6-12) albeit, these eight did render positive results. In each case, their positive results were contingent upon the principles of explicit instruction (Ciullo & Reutebuch, 2013), but again, only eight focused on secondary students with learning disabilities.

Although there is one specific study that rendered positive results regarding the effectiveness of the overall Differentiated Visual Tools (DVT) Model (Ellis, Willis & Deshler, 2011), there are no studies regarding the effectiveness of the specific DVT graphic organizer used in this study, the *Real-World Connections Vocabulary* visual tool (Ellis, 2015) and its impact on students with disabilities. Several researchers do establish the need for the use of computerized graphic organizers in order to and many researchers support the need to provide students with visual tools that support instruction and scaffold learning (Ellis & Rock, 2001; Lawrence-Brown, 2004; Rock, Gregg, Ellis, & Gable, 2008: Tomlinson, 2001)

Overall, research is limited as to the effectiveness of computerized graphic organizers. Results from this study provide validation regarding the use of instructional technology, specifically computerized graphic organizers, to improve vocabulary acquisition, which is an integral component of reading comprehension for secondary students with high-incidence disabilities educated in the 21st century.

Research Question

Considering (1) the importance of vocabulary knowledge to strengthen reading comprehension skills, as well as (2) the use of technology in this modern era to support this achievement, and (3) the lack of information in these combined two fields, specifically (4) concerning secondary students with high-incidence disabilities, the research question involved in this study is: What are the effects of a computer-based graphic organizer strategy on increasing the ACT vocabulary knowledge of secondary students with high-incidence disabilities?

Considerable evidence exists regarding the effectiveness of traditional, paper-pencil graphic organizers (Ausubel, 1960; Ciullo & Reutebuch, 2013; Hall & Strangman, 2002; Kim et al., 2004; Meyer & Rose, 1998; Rose, Meyer, & Hitchcock, 2005; Smith & Okolo, 2010; Vaughn & Edmonds, 2006). This researcher hypothesized that computerized graphic organizers would also be effective in improving the vocabulary acquisition of students with high-incidence disabilities.

The research design was a single-subject, multiple probe across participants design (Horner & Baer, 1978). Single-subject research entails the selection of independent variables that are both socially relevant and functionally related to change effects upon a dependent variable (Baer, Wolf, & Risley, 1968). When choosing this method, it was decided that this topic contained the seven components that Baer et al. (1968) determined to be vital components of single-subject research among which include that the independent variable was applied, behavioral, and generalizable. Because of the importance of determining social validity, in addition to identifying the magnitude of change, the researcher conducted a survey at the conclusion of the study as well to ensure its social relevance (Baer et al., 1968; Horner et al., 2005).

In single-subject research, the subject serves as their own control within a study and thusly, is administered all of the conditions within the experiment, and then conditions are re-measured (Horner et al., 2005). In multiple-probe design, the conditions are re-measured across participants. Single-subject, multiple probe design was chosen because the skill being acquired is a skill that a student cannot unlearn, thus rendering ABAB (baseline/treatment/baseline/treatment) or withdrawal design inappropriate (O'Neill, McDonnell, Billingsley, & Jenson, 2011). This particular design, multiple probe, varies only slightly from the

multiple baseline design in that conditions are observed and recorded intermittently as opposed to continuously (Horner & Baer, 1978). The benefits of this design are that it can eliminate the difficulties associated with multiple baseline which include extended baseline and intervention phases (O'Neill et al., 2011). To demonstrate experimental control, Horner et al. (2005) states that a study must establish that it can be replicated at a minimum of three different points. In a multiple baseline study, this can be demonstrated by changes to setting, behaviors, or participants. In this study, there were three participants who agreed to take part in this study. All three participants in this study have been identified with a high-incidence disability; two students have been identified with a specific learning disability, and one is identified as *'Other Health Impaired'* (OHI) resulting from mental health issues. All three students were students in the 10th grade and demonstrated a need for the identified instruction.

The intervention tool used was a computer-generated vocabulary graphic organizer, entitled the *Real-World Connections Vocabulary* published by Dr. Edwin Ellis from his Differentiated Visual Tools Model (2015). The researcher created probes and the graphic organizers were completed by the students. These probes targeted key vocabulary words encountered on the ACT exam presently required for all sophomores and juniors. The test taken by all sophomores in Alabama is called the *ACT Aspire* and is a pre-ACT exam. This exam renders a score that is to be purported to predict a student's performance on the 11th grade ACT exam if a student proceeds at the normal rate of expected learning. In addition, all juniors in the state of Alabama are required to take the ACT college entrance exam.

All three students who participated in this study benefited from the vocabulary instruction received. The vocabulary words encountered in this study benefited each student in the general education classroom, as well as on the ACT test they will take as juniors in Alabama schools.

Additionally, each student made progress on their pre/posttests, and their standard scores on the *WRMT-III* (Woodcock, 2011) in reading comprehension subtest areas of synonyms, antonyms, and analogies. Despite this, some limitations do exist.

Limitations

The first limitation is that the researcher conducted the study during the summer months when students did not have any outside academic pressure to perform. Thus, their performance might not be indicative of that obtained during the typical school year. A second limitation is that the researcher conducted this study on a one-to-one basis with each student receiving individual instruction. As a result, generalization to a small group setting cannot be assumed. The students in this study have been diagnosed with either a learning disability or the label of OHI. Therefore, a generalization to other disabilities cannot be assumed. The students within this study were fifteen or sixteen years old, therefore generalization to other age groups cannot be made. This researcher provided the entirety of instruction; therefore, one cannot assume instruction by another classroom teacher would produce the same outcome.

Definitions

- Assistive technology: "any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of a child with a disability. Assistive technology includes devices and services such as alternative and augmentative communication devices, low-vision aids, positioning and mobility devices, and adaptive toys and games (Assistive Technology Act, 2004).
- Baseline phase: The phase in which behavior is observed without any intervention or treatment applied.

- Differentiated instruction: Instruction that varies from student to student based upon individual students (or identified groups) needs. Differentiated instruction is founded on the belief that students acquire information better when it plays to their strengths in learning style.
- High-incidence disability: Disabilities that are the most prevalent in public education classroom. Currently, according to the National Center for Educational Statistics (2013) those are students with specific learning disabilities, mild intellectual disabilities, emotional disorders, and other health impairment.
- Intervention phase: The phase in which there is clear evidence of experimental control by the independent variable.
- Maintenance phase: Demonstrates a consistent measurement over time or between groups.
- Multiple-probe across participants design: Type of research design in which a relation is established between an intervention (independent variable) and the dependent variable (in this case, a behavior). In this type of study, the researcher collects data intermittently across all conditions. Once baseline has been established in the first condition, the intervention phase can be implemented while the other two conditions continue in baseline. Once mastery has been obtained within the first condition, the intervention phase can then begin with the second condition while maintenance data is collected intermittently on the first condition. Once mastery has been met with the second condition, the intervention phase can begin with the third condition while maintenance data is collected on the second condition, and so on in this pattern.

- Other Health Impaired disability: A student who exhibits limited strength, vitality, or alertness within the public education classroom. This impairment is due to specific medical or emotional disabilities that impact and must adversely affect the students' educational performance. (Individuals with Disabilities Education Improvement Act, 2004).
- Probe: A measure intended to establish the quality of one's performance.
- Single-Subject Research: Subjects serve as their own control. This can be demonstrated across participants, across behaviors or across settings.
- Social Validity: The determination of whether an intervention's outcome was socially important to those who participated in the intervention. Social validity, and thereby determining a study's social relevance, is widely accepted as the key indicator of quality single case research (Horner et al., 2005; Kazdin, 1977; Wolf, 1978).
- Specific learning disability: A disability in one or more of the basic psychological process involved in understanding. These can be manifested in a disability in using language, either spoken or written, and causes an imperfect ability to listen, think, speak, read, write, spell, or complete mathematical problems (Individuals with Disabilities Education Improvement Act, 2004).
- Targeted behavior: Operationally defining the behavior that will be identified as the dependent variable in a study. This behavior must be objective, clear, and complete (O'Neill et al., 2011).
- Universal Design for Learning: A framework within education that is based on research that has identified how students learn. Universal Design for Learning is

based on the concept that flexible learning environments will accommodate for student's varying learning differences.

Summary

Reading comprehension is arguably the underlying component of all literacy-based coursework completed in school today. Despite this, many students struggle significantly in this area. Fortunately, in the 21st century, instructional technology has become an aid to teachers nationwide, however its effectiveness is uncertain. Research is beginning to emerge in this area but continues to be needed to determine which tools are most effective for which students. To this point, very little evidence exists to support the use of computerized graphic organizers for students with high-incidence disabilities. Albeit traditionally effective, one cannot assume the same results once they are transposed electronically. Given the lack of research in this area, the focus of this study is to determine the effectiveness of a computer-generated graphic organizer on the improvement of vocabulary skills for students with high-incidence disabilities.

Chapter II: The Literature

The passage of the Education for All Handicapped Children Act of 1975 brought an increasing emphasis on the instruction of students with disabilities. This federal mandate required states to develop and implement policies that, among other requirements, assured all students with disabilities a free and appropriate public education. In recent years, specifically with the passage of the No Child Left Behind Act of 2001 and the 2004 reauthorization of the Individual with Disabilities Education Improvement Act, there is an even greater requirement for accountability of students' performance (Puckett et al., 2009). These mandates emphasize the importance of addressing transition issues and helping students' access the general education curriculum through the use of evidenced-based practices (Elder-Hinshaw et al., 2006).

Legislators, educators, and laypeople have called for accountability of student performance and this is the focus of current education-related legislation. As a result of this push, a great deal of research has been conducted in an attempt to determine ways teachers can improve their instruction to make it more effective for all students (Elder-Hinshaw et al., 2006). The concept of 'effective instruction' has changed radically throughout the years, but the quest continues for the most appropriate way to educate students in the public-school system. The following section will describe the changes in federal law as they have evolved over the past sixty years and the impact they have had on the education of students with disabilities.

Federal Laws

Prior to the 1960s, it was not uncommon for Americans with disabilities to be treated unfairly; they were often under-educated, or not respected by society (Martin, 2001). Many times, people with disabilities were segregated or denied fair access to educational opportunities

as well as many other facets of life (Rothstein & McGinley, 2010). But in the 1970s, after a decade of exposés recounting the mistreatment occurring within institutions and students with disabilities exclusion from education as well as from society, legal changes began to develop that afforded individuals with disabilities access to opportunities previously not available to them (Martin, 2001).

One of the first federal changes regarding the treatment of individuals with disabilities was the passage of the Developmental Disabilities Services and Construction Act of 1970 (Martin, 2001). This act coined the term, 'developmental disability' and specifically addressed and included those individuals with "mental retardation, epilepsy, and cerebral palsy" (Martin, 2001, p. 98). The definition stated a development disability was one in which, "onset of the development disability was to have occurred at birth or prior to age 18 and have imposed severe limitation in the child's or person's ability to function," (Martin, 2001, p. 98).

Shortly thereafter, the Rehabilitation Act of 1973 was initiated. Rothstein and McGinley (2010) stated this act prohibited federal government, federal contractors, and recipients of federal financial assistance from discriminating against individuals solely on the basis of their disability. They also stated that one of the key points of this act is in Section 504 of the Rehabilitation Act of 1973 which extends civil liberties to people with disabilities (Rothstein & McGinley, 2010). This includes reasonable accommodations for both children and adults with disabilities in education, employment, as well as other areas of life such as caring for one's self, performing manual tasks, walking, seeing, hearing, speaking, etc. (US Department of Health and Human Services, 2006). This terminology in turn, directly applied to students in the classroom and their access to education. As a result of this legislation, students with disabilities were given the right to reasonable accommodations in the classroom, and this continues to be true today.

In 1975, Congress extended tenets of the Rehabilitation Act through the Education of All Handicapped Children Act, when they determined that all public schools that receive federal funding must provide equal access to education for all children with disabilities (Yell, 1998). The Education of All Handicapped Children Act of 1975 is often referred to as Public Law (PL) 94-142 as well. (Yell, 1998). There were several vital new pieces included in this legislation that exist today in present legislation. One of the more important issues addressed in this act was the concept of 'zero reject' meaning that no student could be discriminated upon based on the nature or severity of their disability. This act also included the right to a 'nondiscriminatory evaluation' of a student's possible disability. It required that schools use multiple, non-biased measures in a child's native language to determine if a disability is present. It also specifically stated that one single testing measure could not determine placement. From this legislation the phrase 'free and appropriate public education' (FAPE) was created. Included in this act, it was also determined that all children with disabilities should receive an education without any charge to their parents or guardians. Additionally, this act stated that individuals with disabilities are entitled to an 'individualized education plan' (IEP) that meets their unique needs. It also stated that students should be educated in the 'least restrictive environment' (LRE) possible to the maximum extent possible, and procedural safeguards should be in place to protect the rights of these students and ensure this is occurring (Turnbull, Turnbull, Shank, & Lean, 1995).

In 1990, the Education for All Handicapped Children Act of 1975 was amended and reauthorized. During this reenactment, the name was amended as well; the word 'children' was changed to 'individuals' and the word 'handicapped' was changed to the phrase 'with disabilities.' As a result, the act was renamed the Individuals with Disabilities Education Act of 1990 (IDEA) and with it there were several additional modifications. The first was a significant

change in the perception of individuals with disabilities which focused on putting the person before the disability, instead of stating someone's disability first (e.g. a student with a learning disability versus a learning-disabled student). This is now referred to as 'person-first language' (Halmari, 2011). In addition to this, several categories were added to the list of covered disabilities; both autism and traumatic brain injury are now included. This new legislation also mandated that transition services be provided to individuals with disabilities. Because of this, legislation was adjusted to include a directive that each student with an individualized education plan must have a transition plan in place no later than the age of 16. This purpose of a transition plan, which is still in use today, is to encourage the individualized education plan team to consider the needs of a student with a disability upon exiting from high school. Examples of possible transition goals might include steps towards a student's desire to attend college, gain employment, or attend a supported employment facility after graduation. Individualized education plan teams must consider the desires of a student, gain input from all the members of the team, and determine the most appropriate outcome for a student. They are then expected to work with the student to help them reach that goal. The Individuals with Disabilities Act of 1990 also redefined related services to include rehabilitation counselors and social work services when deemed necessary by the individualized education plan team (Individuals with Disabilities Act, 1990). Related services were also required and were determined to be items such as hearing aids, wheelchairs, glasses, or education-related electronic devices that today would be considered technology.

The Individuals with Disabilities Act was amended again in 1997. Important changes and adjustments to legislation were made at that time. Some of the areas emphasized were to improve access to the general education curriculum, increase participation in assessments, and strengthen

the role of the parent (Individuals with Disabilities Education Act, 2004). Additional provisions include an increased attention to racial, ethnic, and linguistic diversity to prevent over-identification and mislabeling of students, and adequate training for paraprofessionals in the classroom (Individuals with Disabilities Education Act, 2004). These changes were precursors to future legislation such as No Child Left Behind of 2001 and the Individuals with Disabilities Education Improvement Act of 2004.

The Americans with Disabilities Act (ADA) was enacted by Congress in 1990 and was later amended in 2009. The Americans with Disabilities Act prohibits private employers, the government, and labor unions from discriminating against individuals with disabilities in all aspects of employment including hiring, firing, training, promotions, and salary (Rothstein & McGinley, 2010). This applies to any business that employs 15 people or more and includes both physical and mental impairments. The Americans with Disabilities Act states that a qualified employee cannot be discriminated against and reasonable accommodations must be made for that person unless it would pose an undue hardship on the employer (Rothstein & McGinley, 2010).

Additionally, in 2001, Congress amended the 1965 Elementary and Secondary Education Act enacted by Lyndon B. Johnson's War on Poverty and renamed it The No Child Left Behind Act of 2001. The goal of this legislation was to improve achievement of all students, targeting specifically children from low-income families. As part of this act, Congress declared that the ultimate goal of the No Child Left Behind Act was that all children would be functioning on grade level in both reading and math by the year 2014. The No Child Left Behind Act of 2001 introduced the term 'highly-qualified' (HQ) when it stated that all students would be taught by highly qualified teachers using scientifically-based instructional programs.

Finally, in 2004, the Individuals with Disabilities Education Act was again reauthorized and given the name the Individuals with Disabilities Education Improvement Act (IDEIA). There were several changes including requiring schools to analyze their at-risk population and take proactive steps towards improving their performance with the ultimate goal of decreasing drop-out rates. The Individuals with Disabilities Education Improvement Act of 2004 mandated that schools implement a 'response to intervention' (RtI) program that uses scientifically-based instruction and implement this program in the general education classrooms for a considerable length of time prior to referring a student to special education. Response to intervention provides a tiered framework for schools to follow that address both the academic and behavioral needs of students. This legislation stated that students' progress must be measured in reasonable, timely intervals through repeated measures (progress-based monitoring). It also requires that students be taught by highly qualified teachers, which mirrors the No Child Left Behind Act of 2001 (Individuals with Disabilities Education Improvement Act, 2004). These above-mentioned acts address the changes in legislation as related to individuals with disabilities; the next section will specifically address the chronological, legislative development in the area of assistive technology legislation.

Table 1

Summary of Federal Laws related to Students with Disabilities

Title	Year Enacted	Key Contribution(s)
Developmental Disabilities Services and Construction Act	1970	Provided definition of "Developmental Disability"
Rehabilitation Act	1973	Key Points: • Federal government or entities cannot discriminate against individuals solely on the basis of their disability • Section 504 provided students with the right to reasonable accommodations in the classroom
Education of All Handicapped Children ACT (EAHCA) Also known as: PI 94-142	1975	Mandated that all public schools that receive federal funding must provide equal access to education for all children with disabilities. Key terminology introduced: • zero reject • nondiscriminatory evaluation • free and appropriate education • individual education plan • least restrictive environment • multiple measures to determine placement • procedural safeguards
Individuals with Disabilities Education Act	1990; Amended in 1997	Reauthorized EAHCA Key changes: • the word "children" changed to "individuals" • person-first language • expanded categories to include traumatic brain injury and autism • mandated transition services
Americans with Disabilities Act (ADA)	1990; Amended in 2009	Prohibits private employers, governments, and labor unions from discriminating against individuals with disabilities in all aspects of employment including hiring, firing, training, promotions, and salary.
No Child Left Behind Act (NCLB)	2001	Goal is to improve achievement of all students, especially those from low-income families Key points include: • all children would be functioning on grade level in reading and math by 2014 • all students will be taught by highly qualified teachers • teachers will use scientifically-based instructional programs
Individuals with Disabilities Education Improvement Act (IDEIA)	2004	Key changes in this legislation: • response to intervention (RtI) • using scientifically-based instruction • implemented in the general education classroom • for an appropriate length of time • measure progress in reasonable intervals through repeated measures • reiterated high qualified teachers

Adapted from, "Individuals with Disabilities Education Act 20 U.S.C. § 1432(1) (2004)" and "Significant Disability: Issues Affecting People with Significant Disabilities from a Historical, Policy, Leadership, and Systems Perspective," by E. D. Martin, 2001, Springfield, Il: Charles C. Thomas Publisher, LTD and "No Child Left Behind Act PL 101-110 (2001)" and "Disability Law: Cases, Materials, Problems," L. F. Rothstein & A.C. McGinley, 2010, New Providence, NJ: LexisNexis: Michael Bender & Company, Inc. and "The Legal Basis of Inclusion, M. Yell, 1998, Educational Leadership, 56(2), 70-73.

Assistive Technology in Legislation

The first-time technology to assist students with disabilities, or assistive technology, was addressed in legislation was in the Education of All Handicapped Children Act of 1975. In this act technology was mentioned in the section that addresses instruction materials. The act stated that children should be afforded the right to necessary educational assistive technology, as well as the use of educational technology in the school setting. Specifically, Turnbull et al. (1995) state that the Education of All Handicapped Children Act of 1975 defined assistive technology and related services as those that "restore lost capacities or improve impaired capacities" (p. 52).

The second time and most thorough definition of assistive technology was described in the creation of the Assistive Technology Act originally passed in 1988. It has since been reauthorized in 1994, 1998, and 2004; it is often referred to as *The Tech Act*. It defined assistive technology as:

> any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of a student with a disability. Assistive technology includes devices and services such as alternative and augmentative communication devices, low-vision aids, positioning and mobility devices, and adaptive toys and games (Assistive Technology Act, 2004).

The purpose of this act is to promote access to assistive technology devices and services to help individuals with disabilities of all ages to meet their goal to participate to the greatest extent possible in all aspects of life including education, employment, leisure, and activities of daily living skills (Assistive Technology Act, 2004). This act includes assistance in the form of low-, medium- or high-tech items. Therefore, support may include a low-tech device such as

highlighters to emphasize key vocabulary, to high-tech devices such as amplified voice magnifiers or power-driven wheelchairs; all types of assistive technology are included.

Access for individuals with disabilities to the same opportunities as those without disabilities was noted also in another civil rights legislation. The Individuals with Disabilities Education Improvement Act of 2004 adopted the definition of assistive technology as defined in the Assistive Technology Act of 1998. It also included the concept of Universal Design for Learning, or UDL. The term UDL was applied to education to be more consistent with the Assistive Technology Act of 2004 by establishing a set of principles for developing curricular that give all individuals the opportunity to learn. Universal Design for Learning provides a method for creating goals, materials and assessment tools that work for all students but is flexible enough so that it can be customized and adjusted to meet students' individual needs (King-Sears, 2014). A large component of this model is the use of assistive technology to differentiate instruction and motivate learners and both will be discussed further in later sections.

All of the above acts have had a sweeping impact on individuals with disabilities, particularly in the area of education and equal access. From the beginning mandate of zero reject, special educators have made great progress in learning how to effectively teach students with disabilities and students have obtained greater academic achievements as a result. In addition to these acts enacted by Congress, there have been several landmark lawsuits that have also spurred progress in this area.

Landmark Court Cases

Legislation is not the only legal avenue that has had a positive impact on services for students with disabilities. As noted above, there are many federal laws and court cases that now substantiate the inclusion of students with disabilities in education. The first major court case,

Brown versus the Board of Education of Topeka, Kansas took place in 1954. While this case did not specifically address students with disabilities, it did become a basis for a later argument regarding the rights of students with disabilities in public schools (Rothstein & McGinley, 2010). In the Brown case, the U.S. Supreme Court cited the Fourteenth Amendment of the US Constitution and stated that education must be made available to all students on equal terms (Rothstein & McGinley, 2010). This landmark case became the foundation for equal protection and access for students with disabilities in the United States.

In 1972, the Pennsylvania Association for Retarded Children (PARC) went to court versus the Commonwealth of Pennsylvania. This significant case established the notion that appeared later in The Education for All Handicapped Children Act of 1975 in which it was determined that all children are entitled to a free and appropriate public education, regardless of the severity of their disability. It also established that the general education classroom is preferable to a separate classroom setting (Yell & Katsiyannis, 2001).

A similar case to PARC was the hallmark lawsuit *Mills versus the Board of Education of the District of Columbia* (1972) (Yell & Katsiyannis, 2001). This case also established the rights of students to have access to public education (Yell & Katsiyannis, 2001). It provided due process protection, as well as established that all students must receive special education services regardless of a school system's financial capabilities, again reiterated in The Education for All Handicapped Children Act of 1975. Both made very similar decisions; PARC related to a severely intellectually handicapped student, whereas Mills related to a student with severe behavior problems.

Polk versus Central Susquehanna Intermediate (1988) was a case in which it was determined that a student's individual education plans must produce meaningful progress, not

regression or insignificant educational advancement (Rothstein & McGinley, 2010). In this case a student's physical therapy services were shifted from direct therapy to consultative therapy, but unfortunately, his progress diminished because of this transition. The court determined that students are entitled to an education that offers meaningful progress and this should have been evaluated by the individual education plan team and readjusted.

Some landmark court cases found for the school systems. One such example of this is the *Board of Education of Hendrick Hudson School District versus Rowley* (1982). In this case, Amy Rowley was a deaf student who could read lips fluently. Despite this, her parents sought a full-time interpreter to assist her in her classes. In this case, the US Supreme Court determined that Rowley was receiving an appropriate education without the need for a sign interpreter. Because of this case, it was determined that schools must provide an 'appropriate' education, not necessarily the best education or one that can 'maximize' a student's potential (Martin, 2001). The Rowley case is considered a landmark case as it provided the first and lasting definition of an 'appropriate education as educational benefit' (Yell & Katsiyannis, 2001). Amy Rowley's court case, which requested a sign interpreter, was also considered a case that centered on assistive technology. This was the beginning of several cases that involve the use of assistive technology for students with disabilities and will be discussed in the next section.

In a 1984 Supreme Court case, *Irving Independent School District versus Amber Tatro*, the Supreme Court determined that a medical treatment, in this case a clean intermittent catheterization was considered a related service which was necessary for this particular student's education and without this service she was unable to attend school. The Supreme Court ruled that this student was entitled to a free and appropriate public education, and consequently the school system was required to provide the medical service (Yell & Katsiyannis, 2001).

There are two other Supreme Court cases that have had a historical influence on legislation and services for students with disabilities. The first case was *Honig versus Doe* in 1988 which involved the acceptable parameters for disciplining a student with disabilities. In this case, a middle school aged student was identified as having an emotional disability (Yell & Katsiyannis, 2001). The student began displaying verbally hostile and aggressive behaviors in school including stealing and making inappropriate sexual comments to female classmates. The school attempted to change the placement of this student without parental agreement. The parent sued regarding the school's unwarranted change of placement. In this case, the Supreme Court refused to create an exception to the *stay-put* provision of the Education for All Handicapped Children Act of 1975. This stay-put clause states that without parental permission, a student must remain in their current educational placement while a due process petition is pending (Yell & Katsiyannis, 2001). The school system felt there should be an exception in cases in which a student's behavior is considered dangerous. However, the Supreme Court disagreed and stated that if the behavior was a manifestation of a student's disability, then a change in placement without parental permission or due process is inappropriate (Yell & Katsiyannis, 2001).

The final legislative case related to special education was the 1989 case of *Daniel R.R. versus the State Board of Education of El Paso Independent School District* in which it was determined that inclusion is not always in the best interest of the students. In this case the 5th Court of Appeals determined that schools must consider four factors when addressing the least restrictive environment (Yell & Katsiyannis, 2001). These factors are the academic and non-academic benefit to the student, as well as the effect on other students and the financial burden placed on the school district versus a more segregated placement. Since this time, there have been many other court cases, as lawsuits are waged in an attempt to protect students from being

discriminated against. The outcomes may vary, but the main focus should be on the best interest of the child. A focus on litigation related specifically to assistive technology is provided in the next section.

Table 2

Summary of Landmark Court Cases

Court Case	Year	Outcome
Brown v. Board of Education of Topeka, Kansas	1954	Education must be available to all children on equal terms.
PARC v. Commonwealth of Pennsylvania	1972	All children are entitled to a free and appropriate public education regardless of the severity of their disability. Additionally, it determined that the general education setting is preferable to a separate classroom.
Mills v. Board of Education of District of Columbia	1972	Provided access to public education, due process protection, and established that all students must receive special education services regardless of the system's financial capabilities.
Polk v. Central Susquehanna Intermediate	1988	A student's IEP plan must produce progress, not regression or insignificant educational advancement
Board of Education of Hendrick Hudson School District v. Rowley	1982	Schools must provide an appropriate education, not necessarily the 'best' education or one that can 'maximize' a student's potential.
Irving Independent School District v. Amber Tatro	1984	If a medical treatment is necessary to the student's education, then it is considered a related service and must be provided.
Honig, California Superintendent of Public Instruction v. Doe et al.	1988	If a student's behavior is a manifestation of their disability, then a change in placement without the parent's permission or due process is inappropriate. They must remain in their current educational placement while a due process petition is pending.
Daniel RR v. State Board of Education of El Paso Independent School District	1989	Prior to changing a student's placement, schools must consider the academic and non-academic needs of the student, how it affects other children, as well as the financial burden it places on the school district versus a more segregated placement.

Note: Adapted from, "Disability Law: Cases, Materials, Problems," by L.F. Rothstein & A.C. McGinley, 2010, New Providence, NJ: LexisNexis: Michael Bender & Company, Inc. and "Legal Issues, Promises and Challenges in Education Law: 25 Years of Legal Developments," by M. Yell & A. Katsiyannis, 2001, *Preventing School Failure, 45*(2), 82-88.

Court Cases Related to Assistive Technology

In addition to the cases mentioned above, there have been several state court cases surrounding a student's right to assistive technology. The first was *Student versus Glendora*

Unified School District in California (2007). In this case, the district failed to offer a program called Communication Access Real-Time Translation (CART) to a student with above average intelligence who had a significant hearing 'impairment' (Student v. Glendora, 2007*).* The school district stated the CART program violated their state's code which prohibited the use of electronic recording devices in the classroom without prior consent. They instead offered a sign language interpreter, but the parents felt this was an unsatisfactory alternative when the assistive technology device would have allowed the student to function more independently. The California court sided with the parents stating that the use of assistive technology is clearly permissible under The Individuals with Disabilities Education Improvement Act of 2004 and did not violate the state's restriction on electronic devices as consent was requested and granted prior to its use (Student v. Glendora, 2007).

A second case related to assistive technology was *Kevin T. versus Elmhurst Community School District No. 205*. In this 2002 case, Kevin was a 19-year-old student with a severe learning disability, ADHD, and bipolar disorder. He had been a student in the same school system beginning at the age of six years old. Over the course of a ten-year span, his IQ dropped from a 101 to an 83 and his performance on academic achievement tests decreased significantly as well. At sixteen his reading, math, and writing skills were reported to only be between a 3rd and 5th grade level. When he was a senior, his grades dropped to F's. Finally, as a result of his parent's insistence, the school transferred Kevin to a therapeutic day school that specialized in students with severe learning disabilities and they reported Kevin made three year's growth in reading, math and writing in just one school year. In this case, the court found in favor of the parents and stated, among other points, the school did not provide free and appropriate public education when they failed to complete an assistive technology assessment or provide Kevin

with assistive technology despite the fact that two teachers testified that Kevin would have benefitted from assistive technology devices (Kevin T. v. Elmhurst, 2002). Specifically, one teacher testified that Kevin would have profited from visual software or AT and a second teacher testified that Kevin would have benefitted from vocabulary building software (Kevin T. v. Elmhurst, 2002).

Several other cases exist similar to *Kevin T. versus Elmhurst* with findings that are comparable as well. For example, in the case entitled, *City of Chicago School District 299*, a hearing officer determined that an 8th grade student with a learning disability who could not read or write was denied free and appropriate public education when the district completed an untimely and limited assistive technology evaluation (Chapman, 2012). As a result of the school's failure to assess this student's assistive technology needs, the parents sought an independent assistive technology evaluation which indicated the student needed assistive technology to read and write. Despite reviewing the evaluation, the school system did not adjust this student's individual education plan goals or pay for the independent agency to provide the deemed services. Because of this failure to complete an assistive technology evaluation or make necessary adjustments, the hearing officer ruled in the parent's favor (Chapman, 2012).

Another case, *K.I. versus Montgomery Public Schools* (2011), determined that the Montgomery school district failed to conduct both a cognitive assessment and an AT evaluation which resulted in a failure to determine the student's IQ or to develop appropriate academic or AT goals (K.I. v. Montgomery Public School, 2011). In this case, the student was a child with multiple physical and unknown mental impairments as a result of having severe communication issues related to her medical diagnoses of Arthrogryposis, Restrictive Lung Disease, and Muscular Dystrophy. Because of these, in addition to other medical issues, she had limited

movements of her body, was fed through a gastronomy tube, required her airways be suctioned regularly, and was completely non-verbal It was not debated by either parties that she required constant nursing services. As a result, she was educated for several years in a self-contained school for students who were medically fragile to address both her medical and educational needs. The parents did not want their child to continue in this setting; in fact, they wanted the student to be mainstreamed into general education classes (K.I. v. Montgomery Public School, 2011). The school district replied that their recommended alternative to a self-contained setting was for the student to receive homebound services. The parents temporarily agreed, and K.I. was in fact homebound for one school year where she received the necessary medical services along with speech therapy, physical therapy and special education services, but after one year, the parents again requested she be placed in her neighborhood school and mainstreamed to the greatest extent possible. The school system refused to provide these services (K.I. v. Montgomery Public School, 2011).

Testimony from an outside augmentative communication specialist found that to determine the student's appropriate AT needs, K.I. must undergo an intensive, comprehensive evaluation and the school district was unable to provide this service. In addition to this, testimony from an outside Speech and Language Pathologist found that she believed the child was not significantly, cognitively impaired. She felt K.I. could master academic content with the provision of appropriate assistive technology and intensive speech and language instruction. Both people who testified felt the staff in the school district were not qualified to meet the unique needs of this student. The court's findings in this case were divided. The decision regarding AT were that the school district had failed to provide FAPE because they had never completed a cognitive evaluation or an assistive technology evaluation and therefore the student was not

receiving the appropriate AT services and as a result, her academic progress was greatly minimized. But in addition to this, the court found that she was being educated in the appropriate setting (K.I. v. Montgomery Public School, 2011).

The Assistive Technology Act, No Child Left Behind Act, the Individuals with Disabilities Education Improvement Act, and the landmark court cases described above demonstrate the importance of accommodations, modifications, and AT evaluations for students when deemed appropriate. Despite issues related to compliance with legal requirements, over time, and with legislative and legal direction, schools have begun to more appropriately best meet the needs of students with disabilities. As the development of new technological devices become available every day, its integration in the classroom is becoming more and more important. The next section will discuss the use of technology in the classroom to support students' learning.

Table 3

Summary of Court Cases related to Assistive Technology

Court Case	Year	Outcome
Student v. Glendora Unified School District of California	2007	The use of AT is clearly permissible under IDEIA.
Kevin T. V. Elmhurst Community School District No. 205	2002	School system must provide FAPE which includes reviewing and changing a student's IEP goals if not making progress as well as providing an assistive technology assessment and AT device when warranted.
K.I. v. Montgomery Public Schools	2009	Must complete an AT evaluate to determine student appropriate goals.
City of Chicago School District 299,57 IDELR 29	2011	Must complete a timely and complete AT evaluation

Note: Adapted from "Student versus Glendora Unified School District, 2007," and "Kevin T. versus Elmhurst Community School District, 2002," and "K.I. v. Montgomery Public School, 2011 and "Randy Chapman's Ability Law Blog," by R. Chapman, 2012.

Technology in the Classroom to Support Instruction

Over the past twenty years, technology in the classroom to support teacher instruction has become an approach that has continually evolved (Jeffs, Morrison, Messenheimer, Rizza, & Banister, 2003). Politically, its use has been encouraged through various important key pieces of legislation. Two very influential changes in the field of special education have emerged from the reauthorization of the Assistive Technology Act in 2004 and the enactment of the Individuals with Disabilities Education Improvement Act of 2004. Both of these important pieces of legislation dictate that states provide access to technology, both adaptive and otherwise, that will improve access to the general curriculum for students with disabilities (Lee & Templeton, 2008).

When technology was originally introduced, there was a notable difference in the way in which it was used with students with disabilities. Originally, assistive technology was used primarily with students who had more severe disabilities. Technology generally focused upon adaptive ways to assist students with communication, mobility, and then academics, in that order. The goal of assistive technology for these students was, and still is, to help improve, minimize, or maintain one's functioning level using an adaptive device (Elder-Hinshaw et al., 2006). For decades, the use of adaptive technology as a means of AT has been beneficial for students with low incidence disabilities (Elder-Hinshaw et al., 2006).

Over time, AT has become more prevalent to assist students with higher functioning abilities as well. Assistive technology with students with high-incidence disabilities is used primarily to support their academic learning in the self-contained, resource, or general education classroom, whether it is using low-, medium- or high-technology tools (Jeffs et al., 2003). With each passing day, there becomes available a multitude of ways AT can be used to improve

instruction and make it more meaningful for all students with disabilities regardless of their severity.

Despite these technological breakthroughs and shifts in usage, assistive devices continue to not be used as often with older, secondary students with high-incidence disabilities (Lee & Templeton, 2008). These students are often expected to perform similar to their same aged peers without any assistive technology devices (Elder-Hinshaw et al., 2006). Youth with disabilities face many challenges when trying to overcome their weaknesses and master the more difficult, secondary content necessary to be successful within the general education curriculum. However, with the current changes in legislation, teachers are now required to consider the use of assistive technology with all students, regardless of their functioning level, as a way to support students' learning (Puckett et al., 2009). This legislation also supports the use of technology and the principles of UDL as a resource to increase student achievement and can easily be adapted to address meeting the needs of secondary students with mild disabilities (Puckett et al., 2009). Universal Design for Learning is a resource and a guide to assist teachers to make these adaptations and will be discussed in the next section.

Classroom Technology and the Universal Design for Learning

Universal Design for Learning originated from the 1950s architectural movement, called Universal Design, which referred to the goal of architects to design homes while taking into consideration the needs of all potential users (Dolan, Hall, Banerjee, Chun, & Strangman, 2005). The main purpose of UDL, which began in the 1990s, was to ensure that all learners are successful, by providing instruction through various modalities as opposed to more traditional means. The definition of universal design is defined in the Assistive Technology Act (2004) as "a concept or philosophy for designing and delivering products and services that are usable by

people with the widest possible range of functional capabilities" (p. 1). Despite the fact that the term was originally intended for architectural improvements for people with disabilities (i.e. automatic doors, curb cutouts, and closed captioning services) the Center for Applied Special Technology (CAST) expanded this concept to include student learning, as well as the previously existing notion that universal designs for learning should support as many students as possible (Schaaf, 2013). Over time, UDL has developed essential guidelines to help teachers design effective curriculum that provides students who may have otherwise been marginalized or left out of the successful educational equation with equal opportunity and access to instruction (Elder-Hinshaw et al., 2006). The framework of UDL consists of three basic fundamental principles that are based on the way in which students neurologically acquire knowledge. The first principle is called the 'Recognition Network'. This network has to do with what we learn in regard to how we gather information and sort what we see, hear or read (Meyer & Rose, 1998). The second principle is called the 'Strategic Network' and is considered the how of learning. This network, which originates in a different neurological area of the brain, is responsible for how we organize and express our ideas as well as plan and carry out tasks (Meyer & Rose, 1998). The third network is called the 'Affective Network'. This part of the brain has to do with the why of learning and focuses on what motivates learners and how to engage students effectively (Meyer & Rose, 1998).

With each principle or network, there are specific, identified ways to best meet the needs of students who in the past have been under-served, or at-risk students in these three categories. The first is called Multiple Means of Representations. Within this principle are three guidelines aimed at changing the way information is presented. This principle calls for teachers to vary the way students perceive information, as well as provide alternatives when presenting auditory or

visual information. If a student is having difficulty perceiving a teacher's information, UDL encourages teachers to present information to their students using different formats or modalities. Examples of this might include the use of large text, changing their volume or rate of speech, or the use of colored paper to highlighted information for emphasis (Lee & Templeton, 2008). Within this principle is also the guideline to provide options for language, mathematical expression, or symbols for students who struggle in this area. Teachers are encouraged to clarify difficult vocabulary or symbols, teach decoding skills, and possibly use multiple media to present information (Meyer & Rose, 2011). The final guideline in this principle is to provide options for comprehension. If students are having difficulty with comprehension, teachers are encouraged to activate or supply background knowledge, highlight patterns or relationships for students if they do not understand the big picture, and guide information processing to help students generalize information taught (Lee & Templeton, 2008).

The second principle in UDL is Multiple Means of Action and Expression. This principle has three guidelines as well which focus on differentiating the way students express their knowledge. The three guidelines are to (1) provide options for physical action, (2) expression and communication, and (3) executive functions. This principle encourages the use of assistive technology devices and/or educational technology when necessary to support a student's weaknesses or needs. For example, a student with physical disabilities or blindness might benefit from the use of voice activated switches or a student with difficulty expressing their knowledge might benefit from the use of graphic organizers, text-to-speech software, or word prediction software. (Meyer & Rose, 2011)

The third principle is Multiple Means of Engagement. The three guidelines in this principle are to provide options for (1) holding student's interest, (2) sustaining effort and

persistence, and (3) providing options for self-monitoring. Examples of these guidelines include providing students with choices and encouraging their autonomy, encouraging collaboration and communication and having students self-assess their own learning (Meyer & Rose, 2011).

This comprehensive framework encourages teachers to incorporate flexible objectives, devices, resources, and assessments into their curriculum in order to address the needs of all of their diverse learners (Rao, Dowrick, Yuen, & Boisvert, 2009). Instructional technology is a very useful tool in this model. As a result of UDL and federal mandates that support it, more teachers are searching for ways to incorporate innovations as well as supportive, instructional technology into their curriculum (Puckett et al., 2009).

Table 4

Summary of Universal Design of Learning Principles and Descriptions

Principles of UDL	**Guideline within the Principle**	**Description**	**Examples**
Recognition Network	Multiple Means of Representation	Present information and content using multiple formats	Larger text, change the volume or rate of speech, use of colored paper overlays to highlight information, teach decoding skills, use multimedia, and highlight patterns to show relationships
Strategic Network	Multiple Means of Action and Expression	When asking students to express what they know, allow for differentiation	Voice activated switches, graphic organizers, text-to-speech software, and word prediction software.
Affective Network	Multiple Means of Engagement	Encourage interest and motivation	Provides lecture outlines, break assignments into chunks and provide feedback often, encourage discussions, offer choices with assignments.

Adapted from, "Universal Design for Learning Guidelines," by CAST, 2011, Wakefield, MA: Author.

Universal Design for Learning and Assistive Technology

Assistive technology (AT) alone is simply the provision of necessary adaptations students need to accommodate for their disability. The inclusion of UDL along with AT, slightly changes the focus of the provision of AT services. It is a given that students should be provided with the necessary services to support their instruction, this is provided in Individuals with Disabilities Education Improvement Act of 2004 as well as the Assistive Technology Act of 1988. The use of AT in conjunction with UDL is an instructional approach that involves designing instruction in a proactive way in which instructors anticipate their students' needs and support their differences (Campbell-Whatley & Lyons, 2013). Simply providing a student or a group of students with a device does not necessarily maximize the benefits of its usage. But through careful research and planning then choosing an appropriate device for the education of an individual student to accommodate for their unique needs, this is when its usage will make the greatest difference (Schaaf, 2013).

Universal Design for Learning dictates that AT should be considered during the planning phase of a student's education. And to consider appropriate needs of students, teachers should consider low-, medium-, and high-tech devices that might help their student. The definition of low tech items are those that do not require a great deal of instruction, are not very expensive and do not contain complex mechanical features (http://www.gatfl.org/assistive.php). These tools are very easy to assemble, and often require rudimentary items that are located within a typical school setting. Medium technology would be considered such items which electronic but not as expensive as high-tech devices are (Schaaf, 2013). These items may have some features which are more complex than low tech items. They may be electronic or require training to use but are generally less expensive than high-tech devices (Schaaf, 2013). High-tech devices are those

which are considered digital, electronic, or computerized. They more often require training to learn how to use and are often costly (http://www.gatfl.org/assistive.php). Then, depending on a student's needs they may require assistive technology devices that assist them in the educational areas of daily living, employment, community living, and/or communication (http://www.gatfl.org/assistive.php). Pre-planning is vital and should be considered for use when reflecting on the best way to present material (Multiple Means of Representation), allowing students to express their learning (Multiple Means of Expression), and in educating students on the best way to self-assess their work (Multiple Means of Engagement). The following three paragraphs will present examples of low, medium, and high technology during each of these three phases.

Multiple means of representation. Examples of low technology tools instructors may choose to use when determining ways to support students in the presentation of material might include items such as grippers to help a student hold a pencil correctly, colored paper or specialty paper overlays, highlighting pens, planners for presented material, or cut-out paper that eliminates extraneous information on a page so that a student can focus on the key content. Examples of medium tech tools to represent material may include the use of web-based books or books on CD, talking calculators or electronic spell checkers. High tech materials during this phase might include the use of hands-free headsets, electronic aids, or hearing aids to assist with them hearing the material presented (http://www.gatfl.org/assistive.php).

Multiple means of expression. When determining the best way to support student's expression of the material they have learned, classroom teachers might choose to use low tech tools such as allowing a student to use paper or pencil to demonstrate mastery instead of orally, the use of electronic pens to record and produce information, providing students with a varied

test format or the opportunity to respond orally. They might decide that medium tech tools are more appropriate and decide to allow the student to use items such as talking spell checkers, alternate mouse or keyboards for them, or electronic, interactive graphic organizers. Finally, the teacher may determine that high tech tools would best meet the students' needs and determine that the best way a student could showcase their work is through the use of computers with specialized software, communication devices with voice output, or recognition or magnification software (http://www.gatfl.org/assistive.php).

Multiple means of engagement. Finally, when teachers are determining the best way a teacher can engage students in the reflection and assessment phase of their assignments, they should consider first the use of low tech tools, which might include items such as journals with overlays, extra time to complete assignments, or graphic organizers. If they feel medium tech tools are more appropriate they may choose to allow students to use electronic self-assessment websites, or computerized graphic organizers to organize their thoughts. Finally, if they decide students could best reflect on their performance using high tech tools, they may choose to use computers with specialized software that focuses of self-reflection or assessment (http://www.gatfl.org/assistive.php).

Table 5

UDL and Examples of Level Variations of Assistive Technology

Type of Technology	Example of Technology
Principle 1: Multiple Means of Representation	
Low	Pencil grippers, color overlays, highlighting pens, planners, response cards, cut-outs
Medium	Web-based books or those on CD
High	Closed caption TVs, digital hands-free headsets, electronic aids for daily living skills, or hearing aids
Principle 2: Multiple Means of Expression	
Low	Handheld magnifiers, using paper and pen to communicate, reachers/grabbers, specialized electronic pens, permit oral exams, vary test format, extra time to complete assignments
Medium	Talking spell checkers, alternate mouse or keyboards, electronic organizers
High	Computers with specialized software
Principle 3: Multiple Means of Engagement	
Low	Journals with overlays to minimize distractions, specialty paper, graphic organizers to organize thoughts, extra time to organize thoughts
Medium	Electronic self-assessment tools, computerized interactive graphic organizers, or journals, amplifiers
High	Computers with specialized software focused on self-reflection or assessment

Adapted from "Tools for Life: Georgia's Assistive Technology Act Program" (http://www.gatfl.org/assistive.php)

Despite the development of many instructional, technological tools, and the guidelines on possible adaptations for students, the question remains, how do instructors choose which tools to use and are they effective? If teachers do not support their usage or fail to use them correctly, then they are not very effective. It is important to begin with how to sift through the plethora of possible adaptations and make wise choices.

Efficacy of Instructional Technology with Students with Disabilities

It is well established that one area of instruction that students with disabilities struggle with is reading, especially as the content begins to deepen and students' progress through their education (Kennedy & Deshler, 2010). As they get older, students are asked to complete more

difficult higher order thinking skills that requires them to analyze the material being taught and to form an interconnection of their thoughts in order to showcase their understanding of the material being mastered (Gentry, 2008). This is often very difficult for students with disabilities to overcome. Kennedy and Deshler (2010) studied the National Longitudinal Transition Study II which documents the progression and development of approximately 11,000 students nationwide between the ages of 13 and 16 between the years 2000 and 2009. Kennedy & Deschler (2010) report that 21% of students with learning disabilities are five or more grade levels behind their peers in reading; this is a significant deficit. In addition to this, the report found that on average, 31% of students with learning disabilities drop out of school compared to 9.4% of their non-disabled peers. Armed with this information and other similar local data, schools can target these students, special education teachers can work with them though literacy instruction and the use of technological tools to help provide them with the support they need to close those gaps, and possibly keep them from dropping out from school. Kennedy and Deshler (2010) make several recommendations for educators on how this can be accomplished. Their first recommendation is to choose technological tools that "logically extend existing pedagogy" (p. 295) and helps students scaffold learning to meet their goals. Their second recommendation is to ensure that the vessel chosen is not laden with too much extraneous material, so as to overwhelm or distract the learner. Thirdly, they suggest ensuring that the necessary standards are addressed in the tool(s) chosen. In light of these recommendations, one can see how UDL principles can also be applied to instructional technology to help teachers meet these three recommendations.

One example of this successful combination between UDL and instructional technology is a study conducted by Hall, Cohen, Vue, and Ganley (2015). Using a program called *Strategic Reader*, which was created by CAST, Meyer & Rose (1998) and is a combination of both UDL

and Curriculum Based Measurements (CBMs), a digital learning environment was created to evaluate technology's effectiveness on reading. Researchers compared progress made by students both online and offline. Of note, this study focused exclusively on students with disabilities. Data were evaluated using both qualitative and quantitative measures. Quantitatively, the results found that the online version was significantly more effective than the offline version. Qualitatively, students also reported they enjoyed the online version more than the alternative (Hall et al., 2015).

Stetter and Hughes (2011) evaluated the usefulness of computer-assisted instruction in a study that used a single-subject, multiple baseline design. The study involved nine 9th grade students with learning disabilities and was geared towards improving reading comprehension. The standardized testing instrument used was the Gates-MacGinitie comprehensive subtest and students' performance was measured both at the beginning and end of the eight-week intervention period. The materials used throughout the study were from a program called *The Reader as Detective* (Goodman, 1994) which was a book of narrative stories and comprehension questions that accompanied the stories. Student progress was measured through computerized daily quizzes, computer-generated story maps, and the Gates-MacGinitie. An additional component to this study was the evaluation of students' perceptions regarding the computer-assisted instruction. The results showed improvement on the reading comprehension post-test when compared to the pre-test for seven out of the nine students evaluated (Stetter & Hughes, 2011). In addition to this, the students indicated they preferred computer assisted instruction over teacher-led instruction (Stetter & Hughes, 2011).

Teachers are constantly looking for ways to adapt or differentiate their instruction to best meet the needs of their students. Differentiating may involve the use of assistive technology or

instructional technology. The following section will discuss UDL in combination with a teachers' need to adapt instruction or differentiate it, to best meet the needs of their students.

Universal Design for Learning and differentiated instruction. All too often, students are taught in classrooms in which instruction is not adapted to meet their unique needs. The instructor teachers and evaluates student performance using traditional, summative means with little concern for ways in which to accommodate their instruction (Meo, 2008). This causes a great deal of difficulty for students who are not typical learners. Meyer and Rose (1998) state that research indicates students learn in a multitude of ways (e.g. visual, auditory, kinesthetic, etc.) and that each class contains a vast array of individual student needs which are often overlooked when instructors do not take these issues into consideration. Meo (2008) states that by simply dividing students into two groups, general education students and special education students, oversimplifies the problem.

Differentiation is a term that was coined by Tomlinson in 1999 to explain the importance of responding to students' individual needs and learning styles thus making learning accessible for all students. When teachers differentiate instruction, they are actively and positively responding to a student's unique need whether that need is to probe more deeply into a topic or provide scaffold support with a reading passage (Tomlinson, 1999). The goal of differentiated instruction is to provide flexibility while demonstrating mastery to maximize student's growth regardless of what level at which they are functioning (Tomlinson, 1999). A key term in understanding differentiated instruction is that each learner is unique (Tomlinson, 1999). In order to provide students with optimum opportunities for advancement, teachers must understand their students, recognize their strengths and weaknesses, and search for ways to adapt their traditional

instruction. The provision of alternatives will allow them to differentiate instruction and best meet their needs as quickly as possible (Tomlinson, 1999).

The Universal Design for Learning, which is based on the neuroscience principle that declares that each person's brain learns information differently, encourages teachers to deliver instruction through the provision of multiple means of representation, action, and expression (National Center on Universal Design for Learning, at CAST [NCUDL-CAST], 2013). When this transpires, learner variability occurs; in UDL the keyword is *variable* (Meyer & Rose, 2011). Universal Design for Learning provides a framework developed by CAST that allows teachers to analyze the way in which they present their curricula in order anticipate the needs of their learners to reach the largest number of students from the outset of a lesson. It also provides a theoretical shift from fixing the student, to adjusting the content to support the student and guide them to meet the same, high-stakes goals set in place for all students (Hall et al., 2014).

> To meet the needs of all students, both direct instruction (DI) and UDL recognize that cornerstones to learning include personal interest (DI) or engagement (UDL), experience (DI) or representation (UDL), and culturally shaped ways of seeing the world (DI) or strategies for action and expression (UDL). (NCUDL-CAST, 2013, p.1)

The National Center on Universal Design for Learning, at CAST (2013) also states that UDL focuses on the positive design of one's environment, which includes the curricula a teacher chooses, while direct instruction focuses on meeting a student's individual needs. When combined, they "provide a powerful combination of strategies to reach the needs of all students as they work to successfully reach the goal of instruction" (NCUDL-CAST, 2013, p.1). As both No Child Left Behind and Individuals with Disabilities Education Improvement Act focus on continuing to improve student outcomes, differentiated instruction merged with UDL provides

teachers with a model to address the diversity of the learners in a teacher's classroom while still maintaining high standards for all students (Strangman, Hall, & Meyer, 2003). The intersections of these two concepts combine the notion of uniqueness and variability (NCUDL-CAST, 2013).

UDL and instructional technology. The use of instructional technology to support learning in the 21st century naturally lends itself to the underlying principles of UDL as well as the notion of differentiated instruction (Ciullo & Reutebuch, 2013; Meo, 2008). Through its usage, teachers are able to support and scaffold their instruction as well as provide students with challenges that engage all levels of student learners. Technology has permeated all aspects of our lives, and education is no different. With it, we can differentiate instruction as well as plan more creatively and resourcefully which will ultimately make learning more meaningful for students. It is important to note that the use of technology in isolation does not necessarily enhance learning and does not put UDL into practice. Only when it is carefully planned to supplement instruction with the purpose of meeting a student's specific need, does it become effective (Kame'enui & Simmons, 1999).

Several national studies have been conducted to examine the effectiveness of UDL, computerized testing, and student assessment scores, specifically the technological tool of 'a read-aloud.' In a study by Brown and Augustine (2000), the reading skills of students during the social studies and science portion of the National Assessment of Educational Progress was evaluated with high school seniors who were provided with a computerized read-aloud component of the examination; it was determined that technology was useful for poor readers on this assessment. In addition to this, Calhoon, Fuchs, and Hamlett (2000) found when high school students were given a mathematics assessment with computer read-aloud capabilities (both with video and without), their scores improved significantly. A third study by Hollenbeck, Rozek-

Tedesco, Tindal, and Glasgow (2000) noted similar significant improvements on mathematics assessment with computer read-aloud capabilities that were self-paced. Finally, Burk (1999) found significant improvement when students were given large print material with extra spacing and read to them by a recorded human voice. This method was compared to traditional paper-pencil methods. These results were verified again when Dolan et al. (2005) conducted a pilot study with ten students to examine the effects of computerized, read-aloud United States History and Civics assessments. The findings indicated that the students' improvement using this method was statistically significant; in addition, when interviewed qualitatively, students stated they preferred the computer-based format. In each study, the researchers provided statistical and qualitative evidence that computer technology can be effective when analyzing student performance.

Within the last ten years, many websites have been created to supplement and offer an alternative to classroom instruction. There are also innumerable computer programs that have been created to do the same tasks. Many teachers feel these newer, alternative forms of instruction offer a way to "equalize" the playing field for struggling learners because it provides a means in which teachers can meet the needs of their students they did not possess before (Smith & Okolo, 2010). Innovations in instructional technology allow teachers the opportunity to expand the methods in which they present information to students with disabilities (Elder-Hinshaw et al., 2006). But are these innovations effective and are they more or less effective than the traditional means of instruction?

Today, as the broadening realm of technology continues to develop, so does the manner in which it is used. Technology can be used to help a student with a disability overcome many more limitations than ever before. The biggest challenges have been deciding which type of

support should be given, how much support, to what degree, and in which manner to best meet the needs of the individual. Naraian and Surabian (2014) posit that assistive technology is not implemented enough in the classroom. They state that the Individuals with Disabilities Education Improvement Act's requirement for Individual Education plan teams to consider technology does not provide a specific enough framework for its inclusion and therefore lacks resourcefulness needed for its usage. They feel teachers are inadequately trained or prepared for this booming area and need education and a viable model for determining best practices. They point out that current practices involve analyzing data and looking at standardized test scores. They note this is relevant but falls short of understanding the whole child. They state that a great deal of information can be gathered about a student by studying their journal writing and interviewing the student and their families to understand their strengths, weaknesses, and interests (Naraian & Surabian, 2014). Graphic organizers are one solution to this problem. They provide a specific model missing from legislation for teachers who lack the knowledge and training to meaningfully accommodate instruction. They also allow the teacher to use graphic organizers as formative assessment tools to help look at the whole child and determine their overall understanding of the content.

Graphic organizers are not new inventions; in fact, they were originally designed by Ausubel in 1960 as a way to improve general education students' retention rates of unfamiliar scientific material. As a psychologist, he felt that if material was confusing and disorganized, learners would struggle trying to master and retain the information taught. Therefore, he sought to provide structure to newly presented information (Ausubel, 1960). Since the late 1980s, graphic organizers have increasingly been created and utilized by classroom teachers as a means of providing sensibility to their content (Hall & Strangman, 2002). In light of constantly

changing technology, the way in which graphic organizers are used is evolving (Smith & Okolo, 2010). Combined with the increasing ease of access to technology, and the rise in web-based interventions available for use, a paradigm shift has occurred, and this changing technological access is influencing instruction.

Nevertheless, the fundamental basics of traditional instruction are not changing. Students continue to need teachers to scaffold instruction, fill in the gaps, provide multiple examples, and synthesize and desegregate material in a way that makes it understandable for students with special needs. The facts remain, the research behind traditional paper-based graphic organizers has proven that they have a moderate to high effect size for both vocabulary and content learning when researcher-developed measures are used (Ciullo & Reutebuch, 2013). Despite this, very few systemic reviews of the literature have been conducted to analyze the effectiveness of technology-based graphic organizers across all subjects (Ciullo & Reutenbuch, 2013). According to Ciullo and Reutenbuch (2013) practitioners have published articles regarding their use, but the articles did not produce effect sizes for either group designs or single-subject research. This indicates further research and analysis are needed, and as a result the authors were able to locate and coded twelve current studies to examine the effectiveness of computer-generated, graphic organizers on improved student academic outcomes. In their study, the authors found that teachers can use computer-based graphic organizers with confidence to improve comprehension, when combined with effective, explicit instruction, as their coding results yielded large effect sizes for their use in these situations (Ciullo & Reutebuch, 2013). The key to these positive results were the use of effective, explicit instruction in conjunction with the computer-based graphic organizers. In addition to this, the authors also found high effect sizes in several studies

in which researchers compared computer-based graphic to paper-based graphic organizers (Ciullo & Reutebuch, 2013).

Computer software has become increasingly affordable and accessible to both teachers and students. As a result of this ease of access and increased reliance on these tools, additional research is needed to evaluate the effectiveness of technology-based graphic organizers (Ciullo & Reutebuch, 2013). Moreover, teachers need to become more aware of their existence as well as when and how to use them.

Graphic Organizers as a UDL: Means of Accessibility

Graphic organizers, when used correctly, meet the requirements of UDL and Direction Instruction by taking traditional, educational content and displaying the information in a more meaningful framework that is variable as well as flexible (Rose et al., 2005). The goal of graphic organizers is to show the relation between key concepts through visual representations that ultimately increase students' understanding of the material (Kim et al., 2004). They accomplish this through the use of various spatial arrangements. This assists students by providing them with an alternative, engaging way to comprehend the text being taught (Kim, et al., 2004). Graphic organizers assist students in organizing their prior knowledge and reflecting upon the material they have learned while maintaining the integrity of the content so that they are ready for the next phase of learning. Using these tools allows students the ability to see connections between ideas and concepts, thus improving their overall comprehension and ensuring readiness for continued learning (Vaughn & Edmonds, 2006).

Oftentimes students with disabilities are faced with the challenge of understanding reading material that is written on their particular grade-level but is significantly above their ability to comprehend. This can be a result of many causes, but the effect is that they often have

difficulty reading their grade-level content for mastery as well as prioritizing the information provided within the text (McCoy & Ketterlin-Geller, 2004). In addition to this, as students' progress in school, reading classroom material becomes increasingly more difficult. In later grades, it involves lengthy expository text which is more challenging to comprehend than earlier material. Expository text is information driven, contains difficult vocabulary, and more technical terminology. Often times this material is also organized poorly (Kim et al., 2004). This places a significant burden on their teachers to reduce the content without compromising the integrity of the standards being taught. Graphic organizers are one way to organize this information for students. They allow teachers or students to isolate the critical information and focus solely on the information that is necessary. Graphic organizers help to identify these essential concepts for a topic by displaying the essential elements in a visually explicit manner through the use of arrows, lines, and spatial arrangements (Kim et al., 2004).

Specifically, students with learning disabilities habitually struggle with all components of reading (Gajria, Jitendra, Sood, & Sacks, 2007). This makes the comprehension of expository text especially laborious for these students since it usually contains unfamiliar vocabulary and covers both complex and abstract concepts. Despite being able to decode the words in the text, students with learning disabilities often have severe problems understanding the meaning behind or various levels of the material (Gajria et al., 2007).

Key components of a graphic organizer are the structure and organization of the information being displayed. The organizer should help a student connect their prior knowledge to the new topic by constructing a visual display of the relevant material. The ultimate goal is to deepen their understanding of the material through this tool (McCoy & Ketterlin-Geller, 2004).

Generally, when creating a graphic organizer, one begins by identifying the main focus of the instruction; then, identifies the associated components and how they relate to the main concept. Third, a visual representation is constructed to link the concept with its components. McCoy and Ketterlin-Geller (2004) feel the last step in this process involves a place for students to identify examples and non-examples of the concept being addressed. The authors' state when using this design, students are able to identify important information from the text and discern what is not. McCoy and Ketterlin-Geller (2004) also point out that through the explicit identification of the main idea, in conjunction with the visual image of a graphic organizer, instructors are able to clearly measure students' mastery of the content. The authors realize this is very fact-oriented approach but points out that higher-order thinking skills can be assessed once key concepts are understood by the student. There are many websites that offer downloadable graphic organizers. One example of this is the Interactive Graphic Organizer this site provides many different alternatives to graphic organizer designs for reading instruction (Houghton Mifflin Harcourt, 2018b).

UDL and Graphic Organizers in Reading

Arguably, one of the most important academic skills at the secondary level is reading comprehension. Adams (1990) states that reading comprehension is the key to not only a student's success, but to society's success as a whole. This skill encompasses many different elements (e.g. both phonics and comprehension) but is the foundation to achievement in all content areas (Adams, 1990). In order to progress in reading, students need to be able to obtain meaning from the text they read. There are many reasons students may have difficulty understanding the material. These reasons may be problems related to phonics, vocabulary, lack of prior knowledge, or lack of comprehension strategies (Vaughn & Edmonds, 2006). But most

importantly, teachers must continually work towards teaching all students to read at their highest level achievable (Coyne, Kame'enue, & Simmons, 2004).

Kame'enue and Simmons (1999) point out the drastic changes the typical classrooms have undergone throughout the years, and despite the changing dynamics of public classrooms, teachers must address the needs of all of their students. The authors outline six principles necessary to consider when making changes to curriculum design as in the case of creating graphic organizers. Curricular design is the way in which one chooses, sequences, and organizes instruction (Kame'enue & Simmons, 1999). The first principle is to determine what is most vital for students to learn and ensuring that the curriculum chosen addresses these components. The second principle involves outlining clear, explicit steps to assist students to learn a chosen strategy or skill. The third principle involves scaffolding learning when students have difficulty following the steps outlined in principle two. The fourth principle involves combining what a student already knows with the new material presented. This increases the likeliness that a student with remember the material, make connections to the new material, and better understand it. The fifth principle dictates that one uses a review process to reinforce the previously taught information to ensure that the fundamental principles of the process were mastered. Through repeated presentation of material, students are more likely to retain the information taught (Kame'enue & Simmons, 1999). The sixth and final step involves carefully determining a student's background knowledge and ensuring that their knowledge is correct. This can be accomplished by discussion or a pretest, but if a student does not possess the necessary background knowledge, then it should be taught prior to teaching new curriculum (Kame'enue & Simmons, 1999).

Table 6

Steps to Making Changes in Curriculum Design

Principle	Title	Features
1	Big Idea	Identify what is most critical, determine appropriate sequence, and decide which concepts will require more time than others
2	Conspicuous Strategies	Clearly identify the steps to perform the strategy or complete the task at hand, ensure that the material is taught purposefully and explicitly. Most important when introducing a new skill.
3	Mediated Scaffolding	Teach skills independent of each other, present information in logical sequence, be prepared to support instruction with examples, eliminate extraneous information when necessary, sequence tasks
4	Strategic Integration	Combine instruction with material one already knows, this will produce a deeper understanding of a topic as well as links the big ideas across multiple concepts
5	Judicious Review	Provide multiple opportunities for recall or review, make sure opportunities are offered over time and are cumulative
6	Primed Background Knowledge	Tie new instruction with a student's background knowledge. If they are lacking the necessary background knowledge, then this must be taught; preferably not within the same timeframe to preempt confusion

Adapted from, "Toward Successful Inclusion of Students with Disabilities: The Architecture of Instruction," by E. J. Kame'enui, & D. C. Simmons, 1999, *Adapting Curricular Materials Series: Volume 1: An Overview of Materials Adaptations. ERIC/OSEP Mini-Library, pp.* 1-51.

In the secondary classroom the focus is also on the acquisition of higher-order thinking skills. This can be a source of even greater difficulty for students with disabilities. In these instances, students are expected to come to class with some level of background knowledge on a subject, and then acquire new information that they are then expected to analyze and evaluate (Lenz & Shumaker1999). Higher-order thinking skills are difficult to master for students with

disabilities who do not possess the same background and prior knowledge that their same aged peers possess. These same students also may have difficulty satisfactorily processing new information independently and the critical skills to evaluate and synthesize the information (Lenz & Shumaker, 1999).

Lenz and Shumaker (1999) provide nine steps to use as a guideline when adapting material which might include the development of a graphic organizer. The first is to develop a plan for adapting the material. This involves determining who will be responsible for which part of the adapted material (e.g. special education teachers or general education teacher). This also includes any necessary notification of change in curriculum to parents and/or administration. The second step is to identify and evaluate individual students' needs. This provides the teacher with the necessary information to develop a tool to better help the student. The third step is to decide how it will be addressed. For example, will the adaptation alone be successful, or will the student need intensive instruction in the content or correct way to use the strategy. Fourth, teachers should ensure that the strategy is effective in demonstrating mastery of the standard being taught. The authors point out that there are times academic material cannot be changed or adapted. In these instances, tools can be created to ensure mastery of the information, but concern should be taken to safeguard that vital information is not eliminated. Step five involves identifying the information that needs to be adapted while step six is to determine what adaptation will meet the student's needs. Step seven is to inform the student and possibly the parent about the accommodation. Step eight is to implement, evaluate, and adjust the adaptation as necessary. Finally, the last step is to fade the adaptations when possible. This is a very vital component when using tools to accommodate instruction. At some point, the goal is for students to be as independent as possible. When appropriate, teachers need to evaluate if those tools can be faded

out and the student can then take more ownership of their learning without the need of tools (Lenz & Shumaker, 1999).

Table 7

Guidelines to Adapting Material

Steps	Description
1	Create a Plan for Adapting Material
2	Identify and Evaluate the Demands That Students Are Not Meeting
3	Develop Goals for Teaching Strategies and Making Adaptations
4	Determine the Need for Content Adaptions versus Formal Adaptions
5	Identify the Features of the Material That Need to be Adapted
6	Determine the Type of Adaptation That Will Enable the Student to Meet the Demand
7	Inform Students and Parents About the Adaptation
8	Implement, Evaluate, and Adjust the Adaptation
9	Fade the Adaptation When Possible

Adapted from, "Adapting Language Arts, Social Studies, and Science Materials for the Inclusive Classroom," by K. Lenz, & J. Schumaker, 1999, *Adapting Curricular Material Series: Volume 3: An Overview of Materials Adaptations. ERIC/OSEP Mini-Library* pp. 1-117.

Kame'enue and Simmons (1999) remind the reader that often times pre-canned curriculum are provided to classroom teachers and may contain support items for struggling students. Teachers should not be misled into thinking that simply by using the materials provided with the curriculum that they are employing the concept of UDL. Universal Design for Leanring is a process which dictates that great care should be taken prior to using a tool in order to ensure that it is appropriate for the needs of a particular student or group of students, rather than adding it after the fact or simply using it because it is available. Kame'enue and Simmons (1999) state that an instructor should consider UDL and other technological tools in addition to the graphic organizers that are provided within a curriculum's kit. For example, the author points out that a history curriculum might include graphic organizers along with its program; but the use of a text-to-talk software program might be more appropriate for a student who struggles with reading as

it would allow them to follow along with the text. After the student has listened to the text, the teacher might then choose to use the program's graphic organizers to help the student organize their thoughts. In this case, the teacher considered the whole child, addressed their disability, and provided support in a way that was most effective for the student (Kame'enue & Simmons, 1999).

Graphic organizers are useful tools for adapting material and can easily fit in the model listed above. They allow students to acquire knowledge and critical thinking skills within a provided framework and can be faded when appropriate. Some of the tools that are appropriate for subjects related to reading are reading logs, semantic mapping, concept diagrams, tiered, and partial graphic organizers.

Reading learning logs. A Reading Learning Log (RLL) allows students to answer questions about the text they are reading. Specifically, when using the RLL, students answer explicit questions posed by the teacher at three points during the reading passage. Before reading, questions are asked to preview the upcoming text. During the reading, questions are answered at various points during the passage in order to assess their understanding of the material they have read. After the reading, questions are asked to assess their overall comprehension. This log helps students answer questions that address the three key concepts, vocabulary, background knowledge, and comprehension (Vaughn & Edmonds, 2006). One website that offers sample learning logs as well as explanations for their use is the West Virginia Department of Education (http://wvde.state.wv.us/strategybank/LearningLogs.html). This site offers a definition of learning log, explanation of their purpose, and example learning logs that can be modified for individual student use.

Topic or Text Read:

_____

Before Reading:

What do I already know about this topic:

What do I think I will learn about this topic?

During Reading: 1st Stop

What words do I not know?

Main idea:

During Reading: 2nd Stop

What words do I not know?

Main idea:

After reading: Wrap Up

What is an easy question and answer?

What is a hard question and answer?

Figure 1. Reading Learning Log (RLL) used to improve reading comprehension. Adapted from, Vaughn & Edmonds, 2006.

Semantic maps. Semantic maps are simple graphic organizers that are helpful in the reading classroom. They allow students to explore key vocabulary terms and concepts related to the text they are reading. Semantic maps show relationships and similarities of the concept being covered in the text. Most maps begin with a key vocabulary word in the center of the page; then the student draw lines to written words that help clarify the meaning of the topic. This provides a visual cue to show the student the connection between unfamiliar vocabulary and its meaning (Vaughn & Edmonds, 2006). One very useful website for mapping is called *Bubbl.Us* (https://bubbl.us/). This is a free site that is very user friendly and easy for students to create, collaborate, manipulate, download, and print sematic maps.

An area that is often overlooked by classroom teachers is the importance of analytical skills. For example, when reading for information, the ability to consider the whole picture or both sides of an argument is a very important lifelong learning skill. For comprehension

purposes, students need to understand an issue thoroughly and also recognize that there is more than one side to an argument. Grasping the content being taught, as well as weighing the alternatives through a specially designed graph, e.g., a semantic map is a very effective way to guide students and improve these skills. After reading a passage, students can use this design to organize their thoughts. This will enable them to process the information learned, use higher-order thinking skills to process the information, and reflect upon background knowledge to better understand an entire issue (Nussbaum & Schraw, 2007). Another website to obtain graphic organizers for this purpose is Houghton Mifflin Harcourt's (2018a) Education Place. This site offers over thirty-five different reading graphic organizers including topics such as flow charts, goal reasoning, clusters, word webs, idea wheels, describing wheels, etc. This site also offers graphic organizers in Spanish as well.

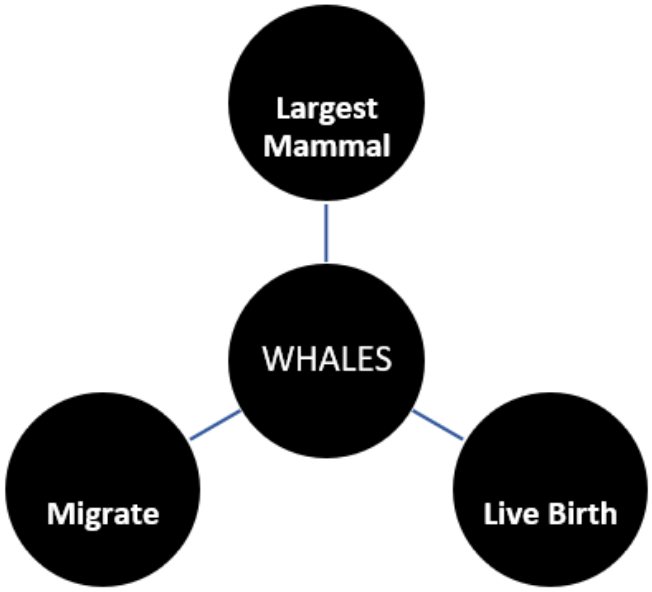

Figure 2. Semantic Map is used to explore key vocabulary. Adapted from, Vaughn & Edmonds, 2006.

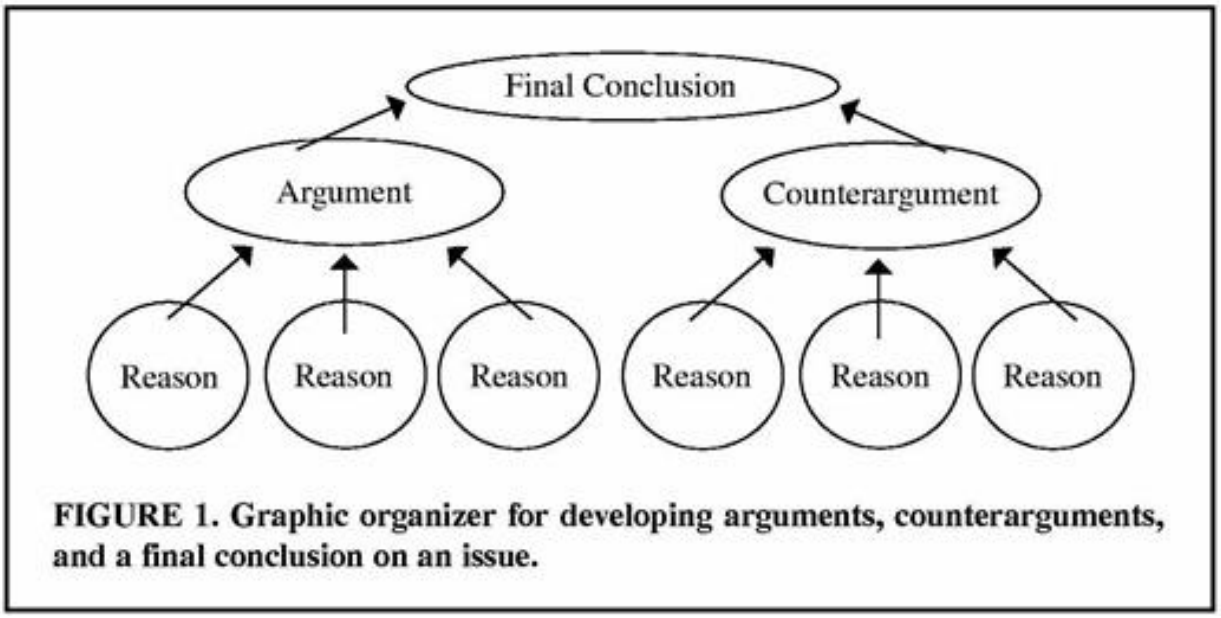

Figure 3. Graphic organizer showing both an argument and the counter-argument. Adapted from Nussbaum & Schraw, 2007

Concept diagrams. Concept diagrams are another favorable tool to improve reading comprehension. Concept diagrams help to make certain key concepts are being understood. They are different from semantic maps in that the questions asked are usually more in-depth and are used to extend the understanding of key concepts in a passage. A concept diagram might require a student to provide examples and non-examples, or answer questions like "what is it similar to" and "what is it like." These questions extend the knowledge the student previously had and thus improves their comprehension of the text they are reading (Vaughn & Edmonds, 2006). *Creately* is a website that provides over twenty-five downloadable concept maps for users to customize as Microsoft Word templates (https://creately.com). In addition to this, this site also offers other graphic organizers as well including flowcharts, mind maps, organizational charts, and Venn diagrams.

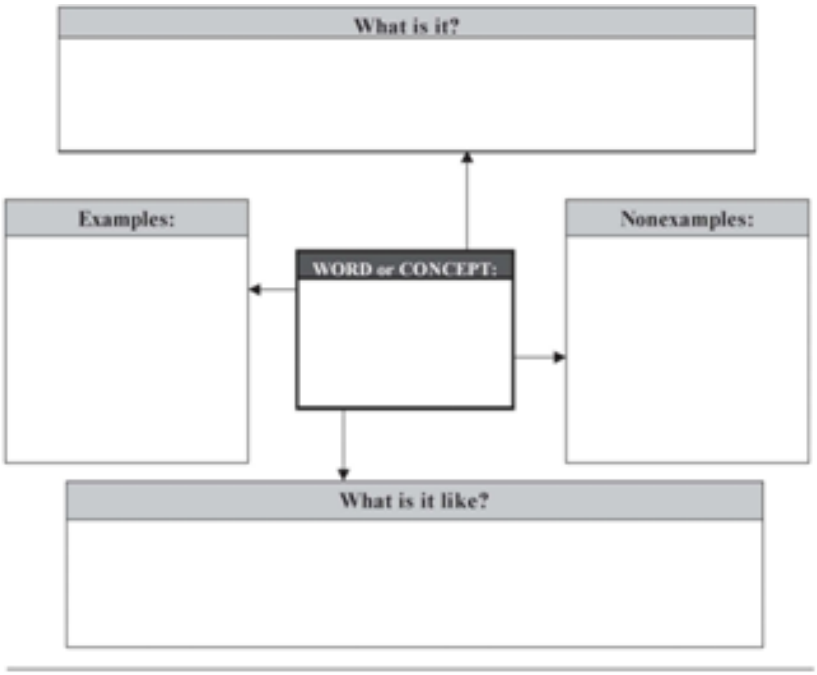

Figure 4. Concept Diagram providing more in-depth information about key vocabulary. Adapted from, Vaughn & Edmonds, 2006.

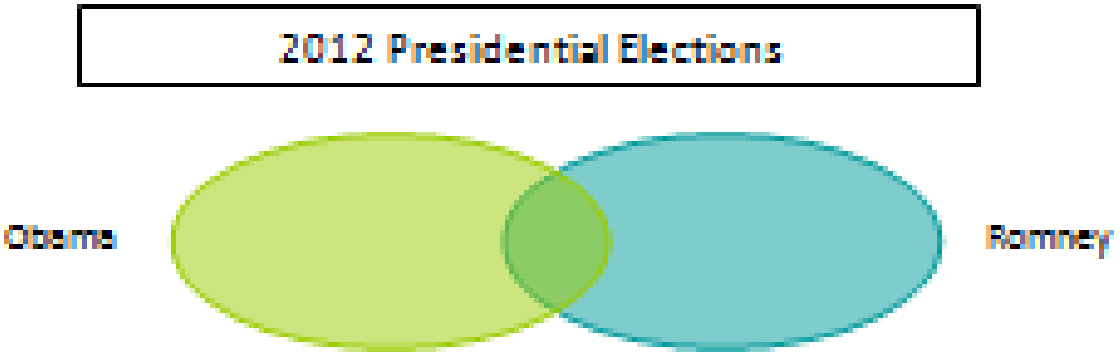

Figure 5. Venn diagram showing comparison and contrast. Adapted from, Vaughn & Edmonds, 2006**.**

Tiered graphic organizers. Classroom teachers can use a tiered approach with the use of graphic organizers in the classroom. Each student's comprehension skills vary dramatically in each classroom. To accommodate for this, a classroom teacher can use several different variations of the same graphic organizers to differentiate instruction and meet students'

individual needs. For example, a teacher can use a simple concept diagram that has only two higher order thinking skills questions for students who are functioning on a lower comprehension level. The same diagram can be used containing one additional question for students who are on an intermediate level. Finally, the same diagram but with a total of four higher level thinking skills can be used for the students who need more of a challenge. This tiered approach is very simple to create and implement without drawing attention to the different comprehension levels of students in the classroom (McMackin & Witherell, 2005).

Partial graphic organizers. Differentiating instruction is very important when working within the general education classroom (Robinson et al., 2006). While still being taught the same classroom material, varying instruction allows students of different functioning abilities to work independently and experience success on their level. One suggestion for accomplishing this is to provide students who need the most support with a graphic organizer that has been partially filled out for them. This partial organizer allows them to be actively involved in classroom assignments without the assignment being too difficult for them to independently complete (Robinson et al., 2006).

Graphic organizers and reading in the content areas.

Reading in the subject of social studies. Graphic organizers are valuable in other academic areas as well. One such area is social studies. When used consistently, some of the benefits of using graphic organizers in this subject are increased motivation, improved short-term recall, and greater long-term recall (Gallavan & Kottler, 2007). Scholastic offers examples and tangible, downloadable tools teachers can use that specifically explain and address ways to use graphic organizers in the subject of social studies (Longhi, 2006). Another website that offers similar strategies and graphic organizers for helping support students' reading comprehension

skills specifically in the area of social studies is Reading Quest.org: Making Sense in Social Studies (www.readingquest.org). This site offers over twenty-five different graphic organizers teachers can adapt to use with their students who need support in the area of reading. Many of these graphic organizers can be adapted to apply to any subject that requires brainstorming, comparison, or visual representation to analyze material.

Assume and anticipate social studies graphic organizers. In social studies graphic organizers can be used several ways. Before reading, they can be used as a discussion tool to assess background knowledge. During reading, they can assist with note taking. After reading, they can be used as a summative tool to reinforce or assess learning. Another way graphic organizers can be used is to establish what a student knows, what they would like to know, and after reading, what they have learned. This particular method is called a KWL Chart (Gallavan & Kottler, 2007).

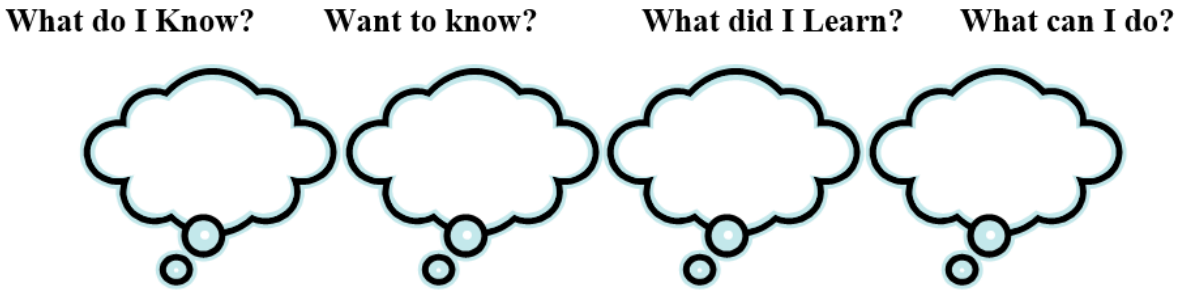

Figure 6. KWL Chart explores what a student knows, wants to know and has learned. Adapted from, Gallavan & Kottler, 2007.

Position and pattern social studies graphic organizers. Throughout reading social studies information, graphic organizers can be used in the form of a timeline to keep track of the chronological order of events. They can also be used to show a sequence of information, compare and contrast information, or show cause and effect (Gallavan & Kottler, 2007).

Compare and contrast graphic organizers. Graphic organizers can also be used to show part-to-whole and whole-to-part relationships as in a Venn diagram. They can also be used to provide details about events and relationships that have been studied in history (Gallavan & Kottler, 2007).

Reading in the subject of mathematics. Reading is an integral part of a student's success in mathematics and because of this, graphic organizers have been designed to help support student learning in this area. According to Ives (2007), students who use graphic organizers in problems that involve both reading and mathematics have a significantly better ability to solve equations than students who did not use them. In a study conducted by Ives, students used graphic organizers which consisted of a table with columns and rows to break down key vocabulary in problems, and then work the problems out in a linear fashion. Ives (2007) found that students who used this process produced more consistent correct answers over time. One of the sites that provides links to organizers that can be used in this fashion is Teacher Vision (https://www.teachervision.com/). Some of the graphic organizers this site offers that provide support in the area of both mathematics and reading are Time Lines, Triple Venn Diagrams, Making Connections, KWL Charts, and Guided Problem Solving.

Another site that ties both reading and math together is a site called Kids' Zone: Learning. This site helps students create graphs and charts. It provides reading support as students decipher between complicated information that is often difficult to understand and information that requires an illustration. (https://nces.ed.gov/nceskids/).

Reading in the subject of science. The use of graphic organizers in a science classroom to assist with reading comprehension will also produce positive results. According to Watson & Johnston (2007) there are four areas in which graphic organizers can be used in assisting students

with reading comprehension in the subject of science. These areas include organization of content, note taking, cognitive assistance, and material modification. Teacher Vision (https://www.teachervision.com/) provides links to many useful science graphic organizers. Two other sites also offer many science-specific graphic organizers; one is called the Teacher Workbooks: Graphic Organizer Series (Technology Publishing Company 2003). A second is the Houghton Mifflin' science website that provides graphic organizers that can accompany their science textbooks or be used in isolation without the textbook. These particular graphic organizers were created for students performing similar to general education students in grades 1-6 (Houghton Mifflin Harcourt, 2018a).

Organization. Students with learning disabilities often have trouble managing large amounts of the information that they read. This can be a problem in, for example, a high school biology or physics classroom. Graphic organizers in science can help students organize the material in a way that will improve the likeliness that they will retain the information read. They also can help students sort through the important material, compare and contrast data (e.g., Venn diagram), and rank information in order of importance (Watson & Johnston, 2007).

Note taking. In the science classroom, in addition to reading the content, a student often has difficulty processing the information. By helping a student take notes on the material, one helps the student cognitively understand, process and organize their thoughts on the material; all of which increases the likeliness of the content becoming part of their long-term memory. After a student has read the material given, one technique a teacher can use is to provide students with a partial outline of their notes for students to fill in while the teacher is talking (Watson & Johnston, 2007).

Cognitive assistance. Classroom teachers can work with students on projects that ask students to identify the main idea and provide guided reading practice. Teachers can have students highlight key terms and concepts. This provides a visual cue for the students and is easier to recall. This improves students' long and short-term memories. Templates such as concept maps and outlines also help students visualize the information (Watson & Johnston, 2007).

Material modification. The fourth area science teachers can use assistive technology in is the area of material modification. This would not typically be used with students with mild disabilities unless a student is also an English Language Learner (ELL). In this area, teachers would use picture symbols to represent the text needing to be read. There are several computer programs such as Boardmaker that make this process easier (Watson & Johnston, 2007).

Locating Websites that Best Meet Needs of Students

It can be a very overwhelming task to choose the correct technology-based graphic organizer or website to use to meet students' unique needs. When searching for support via the web, teachers often feel inundated with choices and can have difficulty determining the most appropriate tool to use. There is very little research in understanding how to choose electronic graphic organizers; instructors must rely on traditional means of analyzing their purpose. When choosing valuable technology-based graphic organizers, one must apply a teacher training model, as described earlier by Kame'enue and Simmons (1999). The key to choosing effective websites lies in determining the best tool to support instruction and finding technology to match that need.

In a study completed by Howard (2011), the perceived risks associated with technology were analyzed. His study found three factors that influence teacher's decisions to use technology

in the classroom to support their instruction. The first concern teachers reported was the ability of a technology tool to solve a problem (Howard, 2011). If teachers feel the technology tool can improve their skills, they were more likely to use that tool. If they felt it was a hindrance or something that made them feel frustrated, teachers were less likely to use it. The second and third areas of concern noted by teachers are interrelated; they are the value of the technological integration and the loss of instructional time (Howard, 2011). If teachers felt a technological tool would improve their quality of teaching, improve student engagement, or the learning experience overall, then teachers again, were more likely to use the tool. If the teachers polled felt technology distracted from student's academic achievement or standardized test results, thus taking up too much of their class time, they were less likely to use it (Howard, 2011).

It is valuable to understand a teacher's likeliness to use technology in his or her classrooms. Technology tools are very helpful to support student learning; however, this is a very new area and it can be overwhelming for educators. Sorting through the multitude of tools available, using the chosen tool correctly with the right student and using the tool in the correct manner is very challenging for educators. Therefore, it is important to understand what teacher's think about the use of technology in supporting instruction at the level in which they are functioning, and ultimately impact student learning and move them to where they need to be. An important focus of this paper is on the use of UDL, graphic organizers, and the use of instructional technology for students with disabilities. As students in the 21st century there are many advantages through the development of technology that were not available merely ten years ago. Despite the availability of technology, do teachers use it? Do they feel it is beneficial to their instruction? If they do, then are they are more likely to use it in their classrooms? If not,

then there is no use for the technology. The remainder of this paper will focus on the issue of teachers' perceptions of its effectiveness.

Teachers' Perceptions of Instructional Technology for Students with Disabilities

Most students in our school's today have grown up surrounded by and immersed in technology. In fact, the present generation of students is often referred to as Digital Natives, or the Net Generation (An & Reigeluth, 2012). Because of this technological awareness, many feel traditional instruction is no longer aligned with the type of learning students are accustomed to outside of the classroom (Prensky, 2010). Because of this, Prensky (2010) feels the "telling and testing" style of instruction is becoming less effective in today's classroom (p. xv). Fortunately, in the past ten years, the use of technology in both the general and special education classrooms has greatly increased (Allsopp, McHatton, & Cranston-Gringas, 2009). As a result of this technological explosion, when provided with the proper training and support, teachers can supplement their instruction to make learning more meaningful, relevant, and useful to students going forward into the future (Prensky, 2010). This finding has been supported by research that point out the benefits of instructional technology on student achievement, as well as the teacher's attitudes towards its success when it is used to support classroom instruction (Allsopp et al., 2009).

Reading comprehension is an important area of content instruction in the secondary classroom. It is a skill that is incorporated in almost all core classrooms at the secondary level and is a large hurdle for students with learning disabilities to overcome (Boon, Fore, & Spencer, 2010). Boon et al. (2010) studied teachers' attitudes and perceptions regarding the use of a computer technology program called Inspiration 6 in three secondary, inclusive World History classrooms. Inspiration 6 is a program that is used to help students create computerized graphic

organizers. Originally, Boon et al. (2005) studied its effects on these students when compared to traditional textbook instruction and the results were favorable for both students with or without disabilities. The authors then examined the classroom teachers' attitudes and perceptions regarding the use of this program as an effective teaching strategy for students with disabilities (Boon et al., 2010). Based on their findings, the teacher satisfaction survey found that the use of Inspiration 6 software in social studies, "had the potential to enhance student achievement, improve time on-task, and increase student motivation in social studies instruction" according to instructors (Boon, et al., 2010, p. 170). Teachers stated they felt it was a useful tool for both students with or without disabilities; however, they did express some concern over issues like access to computer labs and the time involved in learning how to use the software.

In another study, Allsopp et al. (2009) examined the effects of a 1:1 laptop initiative, combined with technology-based instruction on teachers' attitudes and perceptions regarding the use of technology in the classroom. In this southwestern university study, thirteen pre-service teachers in an undergraduate special education program were issued laptops to use throughout their program of study. These college students used their computers for the two years they were enrolled in this program. Some of the ways they used these laptops were to receive online instruction, complete their required course work, and assist with their required field experience. Throughout the program, they were also taught ways to integrate their laptops into the classroom. Their findings showed that with a systematically structured plan, instructional technology can have a positive effect on teachers' attitudes and perceptions, thus increasing their likeliness to use them in their own classroom (Allsopp et al., 2009).

These results were very similar to Ertmer, Ottenbreit-Leftwich, and York (2007) who interviewed pre-determined, exemplary, technology-savvy teachers to evaluate what they, the

technology-savvy teachers, felt caused other non-tech savvy teachers to choose not to use technology in the same manner in which they had chosen. Their findings were that the interviewed teachers felt other non-technology-using teachers were not using technology because they were not as comfortable with the tool, and they were not confident enough to use it correctly. The tech-savvy teachers felt that if other teachers had more confidence in their own self and their ability to understand and learn how to use a tool, then they were more likely to use it (Ertmer et al., 2007).

Through a year-long exploratory study, Allsopp et al., (2012) conducted another investigation in which the authors analyzed six teachers of students in elementary, middle and high school grades to evaluate their perception and use of interactive whiteboard technology. The interactive whiteboard technology included the use of a whiteboard for instruction, the software that accompanies the board, as well as a learner-response system (also known as clickers) for students to use for instantaneous participation in class. This was a qualitative study that relied on classroom observations, interviews, focus groups, and field notes. Findings indicated that teachers felt this was a useful tool due to its interactive nature; students were better able to kinesthetically manipulate the tools (both the white board and the clicker) and seemed to enjoy that component (Allsopp et al., 2012). Teachers also discussed liking the use of the interactive whiteboard technology as a formative assessment tool. The immediacy of the learner-response system gave teachers and students alike immediate feedback on their performance. This allowed teachers the ability to adapt their instruction quicker than more traditional means. Perhaps most importantly teachers felt the students were more actively engaged in their learning than more traditional means. They felt this engagement was one of the most important benefits of the white board technology (Allsopp et al., 2012).

Similar results were found in a larger study of 126 teachers from 27 schools in grades K-12, in which a Likert-style questionnaire and open-ended question study was conducted. The findings indicated that when teachers were asked to consider teaching and learning that they reported having positive attitudes towards its use. They reported feeling as if technology has become integral to student learning, enables them to complete tasks more effectively, is more efficient, and the majority were willing to learn new technologies as they developed (An & Reigeluth, 2012).

Finally, a study by Chiang and Jacobs (2010) analyzed teachers' perceptions regarding the use of the Kurzweil 3000 program with students with special needs. Kurzweil 3000 is a computer-based program that has text-to-speech capabilities, assists with taking notes, creates graphic organizers, and the program also includes a writing component. The program was used to assist students with reading comprehension, reading rate, and time spent reading (Chiang & Jacobs, 2010). The outcome of their study found that teachers felt it was a reasonable accommodation for students with special needs. Chiang and Jacobs (2010) stated that the teachers who used the program reported that it was "effective and it enhanced student learning" (p. 352). They also stated that students seemed to become more involved in their learning because they could see progress more immediately and make corrections in a timelier manner.

The most successful means of technology integration might be when it is design is coordinated with the principles of UDL. Rappolt-Schlichtmann et al. (2013) who work for CAST used UDL principles to design a more precise electronic notebook for students to record their science answers when conducting an experiment. Students used their notebook to collect, analyze and display data they discovered, as well as record notes and space to reflect upon their experiments. This very carefully designed technological tool using UDL principles proved to be

much more effective for students when compared to more traditional paper/pencil techniques for recording experimental data. In addition, when interviewed regarding their perceptions of its effectiveness, the overwhelming majority of students and teachers reported that this electronic notebook was much more useful and effective than other more traditional means (Rappolt-Schlichtmann et al.,2013).

Overall, students learn in many different ways; however, teachers often focus on a single learning style which places many students at a disadvantage who do not learn best using that particular style (Chiang & Jacobs, 2009). Although there are many benefits to supplementing instruction through the use of technology, there are barriers as well. Both Chiang & Jacobs (2010) and Boon et al., (2010) state that teachers reported there were drawbacks in the use of this technology including access to computers and time spent learning to use the computer programs. Despite the drawbacks, Knapczyk and Hew (2007) state that online teaching with the correct classroom supports can be a very successful tool when used with students with mild disabilities.

Technology is a fundamental part of the implementation of UDL instructional design (Basham et al., 2010). UDL also has an inter-dependent relationship with computer technology in that both technology and UDL work to "overcome barriers, provide access, and support participation for students with disabilities" (Basham et al., 2010, p. 245). The barriers mentioned above (access to computers and time spent learning the programs) must be addressed and surmounted. In addition to overcoming these barriers, teachers need to vary their instructional approach (Knapczyk & Hew, 2007). Without the face-to-face interaction, teaching methods such as lectures, discussions, handouts and presentations are less effective (Knapczyk & Hew, 2007). The use of conventional means to teach online classes or to use computer technology in the classroom can lead to higher dropout rates and decreased student motivation if students are not

involved in their learning (Knapczyk & Hew, 2007); however, with varied instructional strategies, computer technology can be a very effective tool (Chiang & Jacobs, 2010). Through professional development and other means, teachers can learn new ways to integrate computer technology into their classrooms in order to vary and support their instruction (Allsopp et al., 2009). When implemented correctly, this supported instruction can have a positive impact on teachers' attitudes and perceptions and the likeliness of them using it in their own classrooms (Allsopp et al., 2009).

Conclusion

In summary, this chapter began with a review of the federal legislative acts that pertain specifically to students with disabilities. The foundational focus is on assistive technology, the legislative actions that pertain to this issue were also discussed. In addition to this, the landmark court cases that have had a direct impact on the education of students with disabilities, as well as the court cases that supported assistive technology used in the classroom to supplement instruction were reviewed.

The next issue discussed was the use of technology as a supportive resource in the classroom. Universal Design for Learning was introduced, and the role assistive and instructional technology plays in its development was reviewed as well. Differentiated instruction is vital to this process. Teachers need to know their students as well as how to target their instructional needs. The use of computerized graphic organizers to assist with reading instruction can help meet this comprehensive need. Finally, teachers' perceptions of the effectiveness of this modern, 21st century-style of instruction were evaluated. Because of this investigation, it is evident that more research is needed to validate the use of computerized graphic organizers as an effective

means of enhancing the reading comprehension and vocabulary acquisition needs of high-school aged students.

Chapter III: Methodology

Students selected for inclusion in this study were 10th grade students with high-incidence disabilities working towards a standard high school diploma. These students lived in a rural area of the Southeast United States. They were educated in a public school, instructed by highly qualified teachers, and spent the majority of their school day (80% or more) in the general education classrooms with their same aged peers.

Participants

The students identified for inclusion in this study were students who demonstrated a need for targeted instruction because they (1) possessed below-average vocabulary skills as defined as students who had previously received remediation and accommodations in the subject of vocabulary by their grade level and special education teacher (2) had reading goals identified in his or her Individualized Education Plan (IEP) and (3) were recommended by his/her current general education English teacher based on an agreed upon need. The students involved in this study had previously received vocabulary instruction in both the general education classroom and the resource-room setting which is a common practice in helping to meet their grade-level, subject-area standards and individual course requirements. Past vocabulary instruction included instruction from both the general and special education teacher with a goal of learning five vocabulary words each week through the use of oral instruction, flashcards, vocabulary games, conversational activities, as well as both formative and summative assessments.

As all three students were working on the standard diploma pathway, they also participated in all of the same state issued tests as their same-aged peers. Most recently all three students took the state-mandated 10th grade ACT Aspire exam. This assessment is a precursor to the ACT college entrance exam and provides students and their parents/guardians with

indications as to the potential of how well they may perform on the official ACT exam in the 11th grade. Their scores on the ACT Aspire test are recorded in Table 11. Each students' scores were in the Close (Level 2) or In Need of Support (Level 1) except for Jack who scored in the Ready area (Level 3) for reading, although not English. Their low scores on this 10th grade assessment justifies the validity of this study as well as the fact that each student individually has expressed a desire to apply and attend college. As they are all working towards a standard diploma, they will also take the upcoming 11th grade ACT exam during the spring of their 11th grade school year, this also documents a need for improvement in this area. Therefore, vocabulary instruction was deemed necessary and is also typical instruction for these students' due to their deficits in vocabulary as well as their significant reading deficits.

Two of the three students included in this study received special education support due to their eligibility of a specific learning disability. The third student in this study had been identified as having an "Other Health Impairment" due to documented mental health issues. Demographic information is included in Tables 8 and Tables 9.

Table 8

Participant Demographic Information

Student	**Age**	**Ethnicity**	**Grade Level**	**Disability**	**Free Lunch*****	**Years in SpEd**	**I.Q.**
Jack	15	C*	10	SLD**	Yes	4	93****
Nicole	16	C*	10	SLD**	Yes	10	110****
Lulu	16	C*	10	OHI***	Yes	6	82****

* Caucasian
** Specific Learning Disability
*** Other Health Impaired
**** As stated in each student's IEP
***** Per central office records, all three students qualified for free lunch at the time of this study

Table 9

Standard Score for IQ and Achievement Scores in Reading

Student	Disability	FS IQ*	Predicted Achievement	Achievement: Overall
Jack	LD	93	95	65
Nicole	LD	110	106	73
Lulu	OHI	82	N/A	81

* Full Scale IQ

Each student participated in the 10th grade ACT Aspire test given by the state department, and their scores are described in the table below (Table 11). Additionally, each student participated in ACT Aspire Interim testing offered during their tenure at the high school. The ACT Aspire Interim test was a formative assessment measure purchased and issued by their local high school that assessed each student's progress at three intervals during their 10th grade school year (fall, winter, and spring). The purpose for both assessments was to provide both general and special education teachers with benchmarks to guide instruction and help improve students' progress toward the goal of improved performance on the 11th grade ACT exam. Their performance on these scores can be found on the tables below (Table 10 and 11).

Table 10

*ACT Aspire Interim Scores in Reading and English**

ACT Aspire Interim Test Dates:	Jack	Nicole	Lulu
Fall 2016, English	58%	42%	31%
Fall of 2016, Reading	40%	33%	20%
Winter of 2016, English	72%	44%	50%
Winter of 2016, Reading	60%	33%	13%
Spring of 2017, English	44%	n/a	42%
Spring of 2017, Reading	33%	n/a	20%

*Scores rendered are in percent indicating the percentage of questions answered correctly by each student.
n/a = information not available (e.g. student absent on day test was given)

Table 11

*State Mandated, 10th Grade ACT Aspire Scores in English and Reading**

Name	English	Reading
Jack	427 (Close)	429 (Ready)
Nicole	416 (In Need of Support)	418 (In Need of Support)
Lulu	417 (In Need of Support)	414 (In Need of Support)

*Performance Level Descriptors:

i. Exceeding – Level 4, highest category
ii. Ready - Level 3
iii. Close – Level 2
iv. In Need of Support – Level 1, lowest possible category

The first participant, Jack, was a 15-year-old boy in the 10th grade identified with a learning disability in 2012 when he was in the 6th grade. Jack's IQ was based on the Universal Nonverbal Intelligence Test [UNIT] (Bracken & McCallam, 1998), an overall full-scale IQ standard score of 93 was obtained. In Alabama, a Predicted Achievement chart is used to determine eligibility for services through the label of Learning Disability. These calculations assume a .65 level of correlation. According to this chart, an IQ of a 93 renders a Predicted Achievement score of a 95. Also, in this state, in order to qualify as having a learning disability using the Severe Discrepancy model, a student must have 16 points between their Predicted Achievement score and their overall achievement score on a separate measure. In Alabama, there are other methods in which a student can qualify as having a learning disability including the Strengths and Weaknesses Model and the Response to Intervention Model, but this student qualified using the traditional 16-point method. His overall achievement score on the Kaufman Test of Educational Achievement II produced a total standard score of 65. This indicated a 30-point difference between his IQ and his achievement.

Jack received support in both his general education classroom by the resource teacher and in the resource room for pull-out services. Throughout his 9th and 10th grade school years, he

sought assistance for many of his assignments, including the subject of English. He would often present as a student who was unsure of his ability to complete his given assignments and requested help and assurance that he was completing them correctly. With support and guidance, he was successful in the general education classroom and continues to be at this time.

With regards to his reading comprehension and vocabulary needs, Jack's English teacher recommended him for participation in this study based on personal experience while working with this student as well as work produced by this student. As part of the general education English 10 classroom, Jack took weekly vocabulary assessments based on terms taught each week, and each week, despite extended study time with the resource teacher Jack had to study and retake each week's vocabulary tests in smaller chunks to obtain a satisfactory passage rates.

The second participant, Nicole, was a 16-year-old student in the 10th grade. She received special education services since she was 5 years old. According to her most recent eligibility information, she obtained an IQ standard score of a 110, which was equivalent to a Predicted Achievement score of a 106. When compared with her overall achievement score of a 73, this produced a 33-point difference between her IQ and her achievement, therefore making her eligible for services through the diagnosis of a learning disability through the same Severe Discrepancy model. In English class this past school year she struggled greatly despite her diligence to succeed. This was most significantly noticeable on her vocabulary tests taken each week. Similar to Jack, Nicole received additional instruction and support in both the general education class and the resource room. Regardless, she continued to need to retake tests in the resource room with additional time to study 1:1 with the resource teacher using notecards prior to taking the test.

Nicole sought out assistance from both the general education teacher and resource teacher many times unnecessarily for verbal reassurance, to double check her understanding of classroom instructions, or to check her homework. The resource teacher often worked with her to increase her confidence in her own ability as well as to teach her strategies for this, such as improved note-taking, and employing the help of peer-buddies.

The third participant, Lulu, was a 16-year-old student in the 10th grade. She has received services through special education since she was 10 years old. Her eligibility is Other Health Impaired (OHI) as a result of her psychiatric issues, among which include Obsessive-Compulsive Disorder (OCD), depression with psychotic features, general anxiety disorder, and a sensory processing disorder. She is treated with medication, is seen by a mental health professional monthly, but still has many absences throughout the school year related to her health issues including repeated hospitalizations and doctors' appointments. Additionally, she has legal issues related to personal significant situations outside of school that have resulted in several court appearances throughout her tenure in high school.

These issues have had a direct impact on her performance in the general education classroom, specifically in the area of reading. Her final grades in English this past school year have been a 79 in the first half of English 10 and a 72 in the second half, both earned with accommodations from the resource teacher. Lulu was provided with support and accommodations in both the general and resource classroom. As previously stated, the resource teacher went into the general education teacher's classroom to provide support for all three students, as well as pull students out for individual and small group support when rendered necessary. Despite this support, she regularly retook her vocabulary tests with the resource

teacher due to her need for a smaller setting with fewer distractions and additional time to study and complete her test.

The English teacher who recommended each of these students reported that each student appeared to be reluctant learners within her general education classroom. She felt all three participated minimally during class, needed continuous support from both the general and special education teacher to be successful, and despite this, often continued to be unsuccessful, demonstrating the need for additional instruction from the resource teacher. She felt that each of these three students' scores on their ACT Aspire Interim progress-based monitoring tests were reputed to be indicators of their performance on the upcoming ACT test each would take as 11th graders, and therefore, she conveyed that any additional instruction they could receive focused on this assessment would be beneficial for them. Finally, she expressed concern for their performance in the 11th grade and felt that additional vocabulary instruction would better prepare them for the more difficult content they would encounter in the upcoming school year.

Setting

The setting for this study was a public education high school situated in a small town of approximately six thousand citizens. The city-school system consisted of an elementary, middle and high school, all three of which qualify for Title I services. The high school was comprised of approximately 490 students in grades 9-12, of which 81.5% received free lunch services; at the time of the study, no students qualified for reduced lunch prices and all three students in this study qualified for free lunch. Overall, there were forty-six students who qualified for special education services, which is roughly 9.4% of the school population. Sixty percent of the students at the high school are Caucasian, while thirty-six percent are African-American, and four percent fall into the "other" category. With regards to the setting of implementation, this study was

conducted during the summer months, between each of the three students' 10th and 11th grade, in a one-to-one setting within a high school conference room by the special education teacher, who was also the researcher.

Materials

Materials used in this study included a computer-generated, vocabulary graphic organizer, entitled *Real-World Connections Vocabulary* published by Dr. Edwin Ellis' *Differentiated Visual Tools* Model (2015). In addition to this, the researcher, along with a consensus of experts, chose 30 commonly encountered vocabulary words from a list of words provided by *College Board's Top 100 Common SAT/ACT Vocabulary Words* **(**Appendix C)**.** The experts consisted of one professor in the college of education at Auburn University, four high school English professors, the Special Education Director for Roanoke City Schools, one guidance counselor, and one assistant superintendent and this researcher. This researcher then created five different probes with ten vocabulary words on each probe; each probe included various combinations of the thirty vocabulary words, these probes are included in Appendix E. The reason for five different measures was an attempt to combat the testing effect which can threaten the internal validity of a study (Campbell & Stanley, 1963). By creating multiple probes, the researcher decreased the likeliness of the student memorizing the test answers as opposed to learning the vocabulary word and its definition.

At the conclusion of the study, students completed a researcher-created, questionnaire (Social Validity Checklist, see Appendix G). This questionnaire was composed of nine questions in total; four were Likert-style perception questions and five were open-ended opinion questions. The questions were posed by the researcher regarding their likes, dislikes and thoughts of the effectiveness, concerning various components of the study.

Experimental Design

The research design utilized was a single-subject, multiple probe across participants design. The multiple probe design was most appropriate for this study as it allowed the researcher to verify the presence of a functional relation between the intervention and behavior through the replication of effects across different participants (Horner & Baer, 1978). The use of a multiple probe approach was preferred over a multiple baseline as it addresses several of the difficulties associated with multiple baseline which are extended baseline and intervention phases (Horner & Baer, 1978). In multiple probe design, data is collected intermittently instead of continually. This allows the researcher to contrast performance and demonstrate effectiveness while avoiding difficulties that can arise from extending the baseline and intervention phases too long (Horner & Baer, 1978).

Stability is an integral part of single-subject design. This ensures that a student's performance is consistent across time and thus, a true reflection of their ability (Horner et al. 2005). This is demonstrated visually by the variability and trend remaining consistent during each phase (O'Neill et al., 2011). Additionally, in order to demonstrate experimental control, a study must demonstrate that it can be replicated. According to Horner, et al. (2005) for evidence within a study to demonstrate experimental control, it must be demonstrated at a minimum of three different points in time, in this case, by changing participants this researcher demonstrated experimental control. During the baseline phase for each student, the researcher defined stability as a minimum of three data points at forty percent or below. Additionally, the final three data points had no more than 10% variance of the mean rate of responding.

Once the first student demonstrated stability, the researcher implemented instruction using the *Real-World Connections Vocabulary,* graphic organizer (Ellis, 2015). Intervention

involved students receiving instruction regarding the meaning of chosen vocabulary words and their completion of the computerized-graphic organizer. The researcher taught five vocabulary words each session and introduced a total of ten new words each week. Students were assessed every other session during the intervention phase. Probes were completed prior to the lesson taught. Once the first student earned a 90% or higher on three probes in succession, the researcher began intervention wit the next student. The first student remained in intervention until a score of 90% or higher was obtained on each of the five probes to ensure mastery of all thirty vocabulary words. Once this had been achieved, the student was then moved to maintenance. Maintenance data was collected, in the form of a probe, once a week for the remainder of the study.

Independent and Dependent Variables

The independent variable consisted of the Differentiated Visual Tools (DVT), *Real-World Connections Vocabulary* graphic organizer (Ellis, 2015). This graphic organizer is but one component of a program called Differentiated Visual Tools created by Edwin Ellis. These tools integrate instruction and technology to produce formative assessment data that can be used to simplify complex instruction. This model is based on multiple principles: (1) technology can be used to enhance instruction without compromising the integrity of classroom curriculum, (2) clarity of instruction is critical as students become older and curriculum becomes more complex, (3) standards are sequentially ordered and therefore indicate that learning should be scaffolded, (4) teacher's time is limited, which can make planning difficult, therefore technology-based instructional resources can be used to help speed the planning process, (5) when learners are engaged, performance is maximized, (6) teachers should be afforded latitude when selecting tactics

that best align with their instructional styles, and (7) visual and semantic prompts are powerful instructional tools (Ellis, 2015).

Fidelity is an integral part of any program and ensures replication by others (Horner, et al, 2005).In order for this program to be carried out with fidelity, the DVT curriculum sets the tone for instruction which states that during a lesson, students should identify key phrases or vocabulary terms, create summary statements, and note them on their *Real-World Connections Vocabulary* graphic organizer (Ellis, 2015).

The dependent variable used in this study was vocabulary acquisition defined as the percent of correct ACT vocabulary words and definitions mastered each session. Vocabulary was deemed an important reading skill to focus on because of this state's department of education requiring that each general and special education student in Alabama take the ACT college-placement exam during their upcoming 11th grade school year (barring students on an alternative diploma). The ACT exam has been the focus of instruction for three years in this state, and as a result, each of these three students have taken the ACT Aspire test (the pre-ACT test) since the 8th grade**.** Each year this test is given, and a score is rendered that is a predictor of that student's possible performance on the 11th grade, ACT test. Additionally, another measure was purchased by these student's school system called The ACT Interim Test. It was given three times a year in these students 9th and 10th grades, and produced the scores listed in Table 10. The ACT Interim tests were given as a formative assessment measure to guide instruction in the general education classroom and also to help the students identify areas of weakness in preparation for their upcoming ACT exam in the 11th grade. This researcher, along with a consensus of experts, identified the 30 words used in this study from a list of commonly encountered vocabulary words provided by *College Board's Top 100 Common SAT/ACT Vocabulary Words* (Appendix C).

Each student's need for this instruction was based on an identified deficit area using their IEP as well as input from their general education teacher and verified by the pretest probe given to each student. Their general education teacher was an English 10 teacher who had taught each student for an entire school year. A sample pretest probe is provided in Appendix D.

Procedures

Prior to implementation of this study, the researcher obtained permission from Auburn University's Internal Review Board (IRB). In an effort to recruit participants, the 9th and 10th grade special education teacher distributed materials to the students identified by the English teacher who would benefit from additional vocabulary instruction. The materials included a parental recruitment flyer and a parent consent letter. The researcher also provided a minor assent letter, a video release and consent form. These students were chosen based on their academic performance described above (those who possessed below average vocabulary skills, had reading goals identified in his or her Individualized Education Plan, and were recommended by his or her current general education English teacher). Students were asked to take the flyer home to their parent/guardian for permission to participate in the study which included contact information if parents had questions or concerns. After one week, the teacher sent a second packet via U.S.P.S. mail to the homes of students who did not return the initial packet. The letters mailed home also included a self-addressed, stamped envelope to ease the return. This rendered the three students utilized in this study, therefore further means of recruitment were not necessary.

In order to be considered for this study, several items were considered. The first step was to identify students in high-incidence disability areas. Once those students were identified, the second step was to ensure that each student had an IEP in place that included goals related to

reading comprehension. Additionally, prior to baseline, the researcher administered the Woodcock Reading Mastery Test (WRMT-III; Woodcock, 2011), which is a norm-referenced achievement test (Woodcock, 2011), to assess students' current achievement level in the subset area of word comprehension. The three areas within the word comprehension subtest include antonyms, synonyms, and analogies. This subtest took less than 30 minutes to complete and was administered individually. Jack's performance on the WRMT-III (Woodcock, 2011) in the subset area of word comprehension produced a standard score of a 55, while Nicole produced a SS of a 91, and Lulu earned a standard score of a 65.

In addition to this, students were administered a pretest that assesses their knowledge of all thirty vocabulary words covered; a post-test was also given at the completion of this study with the intention of measuring growth. As per the IRB, only students with a reading deficit who scored below a 40% on the pretest were considered for this study. Jack's pretest score was a 33% as he answered 10 out of 30 questions correctly. Both Nicole and Lulu answered 11/30 questions correctly earning them a 37% on their pretest. Thereby, as outlined, each of the three students included in this study scored below a 40%.

Placement and pretesting. This researcher administered the placement test, the WRMT-III (Woodcock, 2011) subset area of 'word comprehension' as well as the pre-test of the thirty words to be covered in this study. In all, both tests involved less than one hour of the students' time.

Baseline procedures. This researcher created five different probes with ten vocabulary words on each probe; each probe included various combinations of the thirty vocabulary words. On these probes, students had four answer choices and circled the correct meaning of each word (Appendix E). The definition of stability for establishing baseline was that the final three data

points would vary no more than 10% from the mean. Once the definition of stability had been met and at least five pieces of data have been collected (to ensure that each of the 30 vocabulary words had been assessed), the first participant moved to intervention phase, while the remaining participants remained in baseline. Student were not given feedback on these probes during baseline or intervention.

Intervention phase. This study's intervention involved students receiving instruction regarding the meaning of chosen vocabulary words and their completion of a computer-generated graphic organizer. Specifically, the researcher introduced an ACT vocabulary word, stated the exact definition of the new word and its meaning, used the word in a sentence, discussed synonyms and antonyms of the word, then asked the student to complete a Differentiated Visual Tools, *Real-World Connections Vocabulary* graphic organizer (Ellis, 2015) line (Appendix B). These steps were repeated five times, for each of the five words of the day, then reviewed orally and printed for posterity sake. The researcher taught five vocabulary words each session and introduced a total of ten new words each week. Students were assessed three times a week during the intervention phase. Probes were completed prior to the lesson taught. Once the first student has made 90% or higher on three probes, the researcher began intervention with the next student. Once a student has reached 90% on all five probes, demonstrating mastery of all five vocabulary words, the participant was moved to maintenance.

Post testing. After the maintenance phase, each student was again given the synonym, antonym, and analogies subtest of the WRMT-III, the section deemed 'word comprehension', (Woodcock, 2011) as well as a post-test which mirrored the pre-test. The test consisted of thirty questions, one for each of the thirty vocabulary words encompassed in this study. The test was not timed; all three students demonstrated improvement on both the WRMT-III and the post-test.

Scoring procedures. Interobserver agreement is important to ensure that more than one individual agrees, with confidence, that the researcher has operationally defined a behavior and that the changes observed in that behavior are a result of the intervention (Horner, et al., 2005). In this study, the researcher scored each item as either correct or incorrect, then calculated the number and percent correct on each probe and graphed the data. A special education teacher with 15 years' experience and a master's degree checked 20% of the probes for interobserver reliability. Agreement was calculated on a question by question basis by dividing the number of agreements by the total number of agreements and disagreements and multiplying that by 100. As no errors were noted, this method rendered a score of a 100% interobserver reliability.

Maintenance and generalization procedures. Once students reached the agreed upon criteria, 90% on three probes during the Intervention phase, the student was then moved to the Maintenance phase. During this phase, the student was administered maintenance probes to determine if the participant continued to maintain comprehension of the vocabulary words and definition over time. Each student was given a maintenance probe once a week upon the conclusion of the intervention. The purpose of this study was to determine if a functional relation exists between a computerized graphic organizer and vocabulary acquisition. This was ascertained through the comparison of each student's performance on pre- and post-tests.

Probes. To eliminate potential threats to internal validity, thus the test/retest effect, five assessments (probes) were created by this researcher, each containing a carefully chosen mixture of ten multiple choice items **(**See Appendix E).

Nineteen 10th graders were given the probes to assess the reliability of the instrument. After they completed the assessment, they were scored as either correct or incorrect. To determine the reliability of the instrument, a Spearman-Brown Coefficient was applied using

SPSS. To obtain good (a >0.8) or excellent (a>0.9) internal consistency, a Cronbach's Alpha of .8 or better was required. Reliability tests were conducted and yielded a Cronbach's Alpha Coefficient of r = .986.

Treatment fidelity. A *Treatment Integrity Checklist* (Appendix F) was administered through the assistance of recorded video observation. One out of every three sessions were recorded for evaluation purposes using the checklist **(**see Appendix F). The special education teacher who completed the checklist has a master's degree and fifteen years' experience in the classroom. Treatment integrity was carried out with 100% accuracy for 100% of each of the recorded sessions.

Video recording of instruction was obtained digitally and stored on the researcher's computer. Recordings were shared with the researcher's faculty advisor through face-to-face meetings with this researcher's faculty advisor via thumb drive and were destroyed/deleted once the study ended and data was analyzed. Video recordings were concentrated on the instructor only to obtain a dependable measure of treatment fidelity.

Social validity. After the study, a *Social Validity Checklist* was orally given to each student to determine the social relevance of the computer-based graphic organizer and instructional technology on ACT vocabulary instruction (**see** Appendix G). As with all single-subject research, it is important that the research conducted be socially relevant to those that participated in the study, not simply convenient for the researcher (Horner et al., 2005; Kazdin, 1977; Wolf 1978). On this assessment, nine questions were posed to the students pertaining to their perceived effectiveness and usefulness of the study (ACT vocabulary words). Four of the questions were Yes/Maybe/No questions. These four specifically addressed (1) whether or not the students liked the computer-generated graphic organizer, (2) if it helped them learn new

vocabulary words, (3) if they thought the words learned would be on the ACT exam, and (4) would they recommend using the program again. Five of the questions were open-ended in nature. The open-ended questions assessed (1) what the students felt they learned from using the vocabulary graphic organizer, (2) what they liked best about the tool, (3) what they did not like regarding the tool, (4) what might they change about the tool, and (5) if there was anything else they wanted to say regarding the program.

Data Analysis

Student performance regarding the percent correct on each probe was plotted on a graph. This data was then analyzed through visual inspection. In order to demonstrate a functional relation between the independent and dependent variable, the researcher assessed the level, variability, immediacy of effect, amount of non-overlapping data, and trend both within and across phases of the study (O'Neill et al., 2011). During baseline, a minimum of five data points was required in order to ensure that each of the 30 vocabulary words had been assessed. In this phase, the researcher defined stability as a minimum of three data points at forty percent or below, which was true in each case. Additionally, the final three data points had no more than 10% variance among the mean. Visually for each student, the researcher noted that in each case, the students' baseline data points had an overall level between 30% and 40%, therefore meeting the above criteria. Moreover, for each student, the variability was consistent within the baseline phase and the trend, or slope of the data, showed very little change, thus remaining flat, neutral, or demonstrating no change in the occurrence of the behavior, across the baseline phase.

The initial criteria for each student moving from baseline to the intervention phase was that the prior student must obtain three data points above 90%. So once the first student had three data points at or above 90%, the second student could start intervention phase. However, the

researcher then determined that while each student was in the intervention phase, they would need to earn a 90% or higher on all five final probes before moving to the maintenance phase. The researcher would then be able to determine that each student had demonstrated mastery not just of three probes at 90% but of all 30 vocabulary words before progressing to the final phase. Visually, it was evident that there was an increase in the occurrence of the behavior. The trend was positive, thus indicating with each student that their vocabulary knowledge increased. The researcher established stability within the intervention phase prior to the student moving to the maintenance phase. This was demonstrated by the final five points for each student remaining consistent and varying no more than 10%. Within this phase, the researcher noted immediacy of effect once each student moved into the intervention phase as evidenced by their initial improvement of performance once intervention began, this quick of an improvement is also considered a rapid change between levels (Horner, 2008). Also, in analysis of the graph, one can observe that there was not any evidence of overlapping data between the baseline and intervention phases.

During the intervention phase, each student demonstrated their knowledge of all 30 vocabulary words by earning a 90% or above on the five final intervention data points. Effect size was analyzed using a Tau-U statistic. The Tau-U statistic was first proposed by Parker, Vannest, Davis, & Sauber (2011) to measure effect size for single-case design. To support generalization, the pre/post-test and the scores on the subset area of 'word comprehension' of the WRMT-III (Woodcock, 2011) were used to analyze and report students' improvement.

Chapter IV: Results

When examining the functional relation of the computerized graphic organizer, *Real-World Connections Vocabulary*" published by Dr. Edwin Ellis' Differentiated Visual Tools Model on vocabulary acquisition (2015), the percent correct on each teacher-created probe were graphed and analyzed. Each probe consisted of ten vocabulary words; there were five different probes. Each student was required to identify the correct definition to the given vocabulary word and circle their answer. Each correct answer was assumed to be successive approximations towards the end goal of vocabulary acquisition. Within single-subject research, power, or significance is determined by replication. In this case, significance is visible through replication across participants (Horner, et al. 2005).

Additionally, a second outcome of this study was to examine the possible generalization effect of vocabulary acquisition on standardized measures of reading comprehension. In order to examine this effect, pre- and post-test scores on the WRMT-III (Woodcock, 2011) were evaluated. Each student took this reading mastery test, along with a pre- and post-test of all 30 vocabulary words. The results of these two tests were reported and can be found in Tables 1-4.

Finally, as social validity is a basic requirement of single case design (Baer, Wolf, & Risley, 1968; O'Neill, 2011) all three students were administered a social validity questionnaire at the conclusion of this study. This was an attempt to evaluate the social relevance of the chosen computer-based, graphic organizer, albeit instructional technology, on ACT vocabulary instruction. The results of this survey were reported as well.

Baseline Data

Prior to onset of intervention, each student completed baseline probes. Each of the three students' performance was stable across the behavior examined, ranging only between 30% and 40% for all. Once the first student Jack demonstrated stability, this researcher began use of

the intervention, "*Real-World Connections Vocabulary*," computerized graphic organizer (Ellis, 2015).

- Jack. Jack's baseline mean performance was 36% with a range of 30% to 40%. The data path showed a neutral trend.
- Nicole. Nicole's baseline level was 38% with a range of 30% to 40%. Her data path showed a neutral trend as well.
- Lulu. Lulu's baseline level was a 36% with a range from 30% to 40%. Her data path also showed a neutral trend.

Performance during Instruction

Jack. Jack was the first student to begin intervention. The mean level of performance was 81.1% with his scores ranging between 60% to 100% mastery of content. When this information was compared to Jack's mastery during the baseline phase of 36%, the researcher was able to indicate a rapid change between levels. Such a pronounced slope is strong evidence that the behavior has changed, and that the intervention proven to be effective and significant. There was an observable, immediate effect from the last data point in the baseline to the first data point in intervention and there was no overlap of data points between phases. The trend consistently increased with regard to level and variability, thus indicating that his vocabulary knowledge increased throughout the intervention phase.

. During his fifth session, he scored a 100% and then a 90% on the next two intervention probes, thus, he technically reached criterion mastery during his seventh session. As a result of his first three scores being above a 90%, as dictated, the second student Nicole, began intervention, but Jack continued at intervention until he had demonstrated mastery on all 30

words scoring above 90%. As stated above, his mean level of performance was an 81% with a 45% mean difference between baseline and intervention phase averages (Figure 7).

In conjunction with the visual analysis of Jack's above graphed data, non-overlap points were calculated and indicated 100% non-overlapping data with a +2 change in performance level. A Tau-U was used to calculate the effect size. The Tau-U is a relatively new non-parametric index for single case research which combines overlap of data while controlling for undesirable baseline trend. The results from the Tau-U statistic were significant, $p < .05$ with an effect size as ES = 0.9556 with a confidence interval of $CI_{90} = .407 < > 1$. This indicates large academic benefits from the *Real-World Connections Vocabulary* graphic organizer (Ellis, 2015; Table 16).

Generalization was indicated in the area of 'word comprehension' on the WRMT-III (Woodcock, 2011) which evaluated Jack's' knowledge of synonyms, antonyms, and analogies. Using this measure, his grade level change was a + 7.0 months, and his age equivalency changed + 9 months. His scores, plus his net change are reported in Table 12.

Table 12

Standardized Scores, Grade Equivalent, and Age Equivalent for Jack Pre/Post-Test

WRMT-III Subtest	**Pre-Test Standard Score**	**Grade Equivalency**	**Age Equiv.**	**Post-Test Standard Score**	**Grade Equiv.**	**Age Equiv.**	**Net Change (Standard Score)**
Word Compre-hension	56	2.4	7:10	63	3.1	8:8	+8

Nicole. Nicole's was the second student to begin intervention. Her mean level of performance during the baseline phase was 38% but improved during the intervention phase to a mean level of performance of 85.7% with her scores ranging between 60% to 100%. This

indicated a rapid change between levels, and there was an immediacy of effect from the last data point in the baseline to the first data point in intervention, with none of the data points overlapping. Similar to Jack's performance, the trend positively increased with regard to level and variability, thus demonstrating an increase in vocabulary knowledge.

Nicole scored a 90% during her third session, and by her fifth session she had obtained criterion mastery. At this point, per the parameters of this study, the third student, Lulu, began intervention, but Nicole continued in the intervention phase until she had demonstrated mastery and scored above a 90% on all 30 words; this occurred during her seventh session. Her mean level of performance was an 86% with a 48% mean difference between baseline and intervention phase averages (Figure 7).

Similar to Jack, non-overlap points were calculated and indicated 100% non-overlapping data with a +2 change in performance level. A Tau-U was again used to calculate the effect size. The results from the Tau-U statistic were significant, $p < .05$ with an effect size as $ES = 0.9429$ with a confidence interval of $CI_{90} = .364 < > 1$. This indicates meaningful academic benefits from the *Real-World Connections Vocabulary* graphic organizer (Ellis, 2015; Table 16).

Generalization was also indicated in the area of 'word comprehension' on the WRMT-III (Woodcock, 2011) which evaluated Nicole's knowledge of synonyms, antonyms, and analogies. Using this measure, her grade level change was a + 2years, 3months, and her age equivalency changed + 2.2 years. Her scores, plus her net change are reported in Table 13.

Table 13

Standardized Scores, Grade Equivalent, and Age Equivalent for Nicole Pre/Post-Test

WRMT-III Subtest	Pre-Test Standard Score	Grade Equivalency	Age Equiv.	Post-Test Standard Score	Grade Equiv.	Age Equiv.	Net Change (Standard Score)
Word Compre-hension	75	5.1	10:7	85	7.4	12:9	+10

Lulu. Lulu was the third student to begin intervention. Her mean level of performance during baseline was a 36% but increased to 83.75% during the intervention phase with scores ranging between 70% and 90%. The trend steadily increased throughout intervention, immediacy of effect was observable and there were no overlapping data points between the baseline and intervention phase.

Lulu scored a 90% during her fourth session, and by her sixth session she had obtained criterion mastery, but Intervention was continued until she had demonstrated mastery and scored above a 90% on all 30 words; this occurred during her eighth session. Her mean level of performance was an 84% with a 48% mean difference between baseline and intervention phase averages (Figure 7).

Lulu's non-overlap points were calculated and indicated 100% non-overlapping data with a +2 change in performance level. A Tau-U was used to calculate the effect size. The results from the Tau-U statistic were significant, $p < .05$ with an effect size as ES = 0.9500 with a confidence interval of $CI_{90} = .388 < > 1$. This indicates meaningful academic benefits from the *Real-World Connections Vocabulary* graphic organizer (Ellis, 2015; Table 16).

Generalization was also indicated in the area of 'word comprehension' on the WRMT-III (Woodcock, 2011) which evaluated Lulu's knowledge of synonyms, antonyms, and analogies.

Using this measure, her grade level change was +2.5 years, and her age equivalency changed + 2.4 years. Her scores, plus her net change are reported below in Table 14.

Table 14

Standardized Scores, Grade Equivalent, and Age Equivalent for Lulu Pre/Post-Test

WRMT -III Subtest	Pre-Test Standard Score	Grade Equivalency	Age Equiv.	Post-Test Standard Score	Grade Equiv.	Age Equiv.	Net Change (Standard Score)
Word Compre-hension	64	3.4	9.0	79	5.9	11.4	+15

Figure 9. Combined Graph of Each Student's Independent and Dependent Variable Performance

The overall results across all three students from the Tau-U statistic were significant as well. With a $p < .05$, the data indicated an effect size of ES = 0.9496 with a confidence interval of $CI_{95} = .5622 < > 1$. Visually, there is a difference, but the Tau-U explains how significant of a difference. With an effect size greater than .9, this indicates a functional relation and meaningful academic benefits overall related to the *Real-World Connections Vocabulary* graphic organizer (Ellis, 2015, Table 16).

Pre- and Post-Test Data

In addition to the WRMT-III (Woodcock, 2011) data described above, each student was given a pre- and post-test using the 30 vocabulary words used during the intervention phase of this study. All three students demonstrated significant progress when comparing their progress from pre- to post-testing. Jack who had scored a standard score 56 on the WRMT-III pre-test (Woodcock, 2011), scored a 63 on the post-test. Nicole scored a 75 on the pre-test, scored a standard score of an 85 on the post-test. Finally, Lulu scored a SS of a 64 on the pretest, scored a 79 on the post-test. Concurrently, Jack scored a 97% on the post-test, Nicole scored a 100% on the post-test, and Lulu scored a 93% on the post-test (Table 15).

Table 15

Pre- and Post-Test Performance on Researcher-Created Probes

Student	Pre-test Number Correct (Percentage)	Post-Test Number Correct (Percentage)	Net Change
Jack	10 out of 30 (33%)	29 out of 30 (97%)	+19 (+64%)
Nicole	11 out of 30 (37%)	30 out of 30 (100%)	+19 (+63%)
Lulu	11 out of 30 (37%)	29 out of 30 (97%)	+18 (+60%)

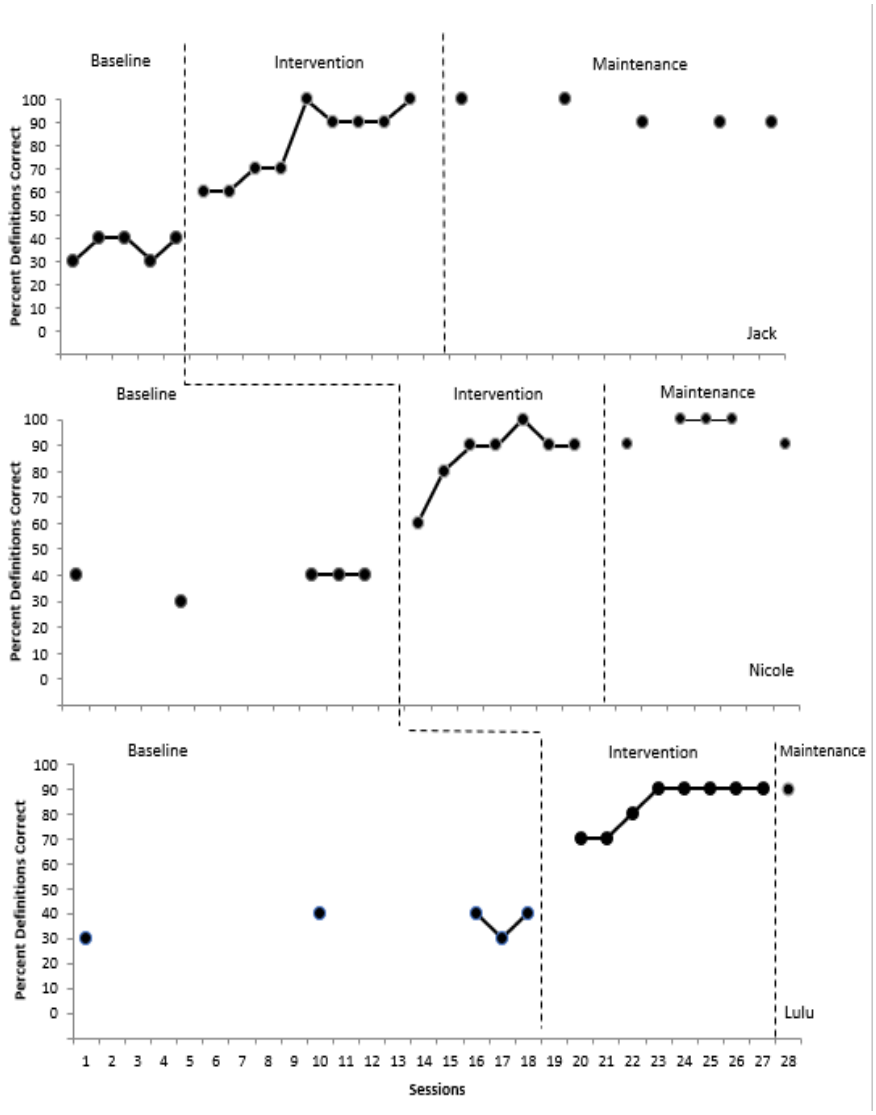

Figure 7. Students' Performance on ACT Vocabulary

Table 16

Tau-U Statistical Information

	Non-Overlapping Data	Change in Perform-ance Level	Statistical Significance	Effect Size	Confidence Interval	Significant Academic Benefit
Jack	100%	+2	p<.05	0.9556	CI_{90} = .407 < > 1	Meaningful
Nicole	100%	+2	p<.05	0.9429	CI_{90} = .364 < > 1	Meaningful
Lulu	100%	+2	p<.05	0.9500	CI_{90} = .388 < > 1	Meaningful
Overall	100%	+2	p<.05	0.9496	CI_{95} = .5622< > 1	Meaningful

Treatment Fidelity

Fidelity, within a study is vital and is documented by consistent measurement of the independent variable (Horner et al., 2005). Fidelity helps to insure interobserver agreement by operationalizing the definition and ensuring that the change in the dependent variable is due to the intervention (Baer et al., 1968; O'Neill et al., 2011). For this reason, a special education teacher with a master's degree and fifteen years teaching experience conducted the fidelity measures. Every third session was recorded, and the observer evaluated each of these via video recordings. This faculty member observed 33% of the sessions and measured fidelity using the *Treatment Integrity Checklist* (see Appendix F). This checklist used by the observer encompassed eight necessary steps to be carried out for each of the five vocabulary words. The steps assessed included the (1) introduction of the ACT vocabulary word, (2) stating the exact definition, (3) discussing the meaning of the word and (4) definition, (5) the use of the word in a sentence, (6) synonym and (7) antonym of the vocabulary word, and (8) the completion of one row of the computerized graphic organizer. There were five rows on each graphic organizer, one for each vocabulary word, therefore there were five columns on the checklist. The observer repeated the above eight-step process for each of the five words recorded during each session.

This observer determined that treatment fidelity was carried out with 100% accuracy for 100% of each of the observed sessions.

Interobserver Reliability

Both the researcher and a special education teacher with fifteen years teaching experience and a master's degree calculated the percent correct on 33% of the observed sessions. The observer was trained to score each participants' responses as either correct (+) or incorrect (-). Each of these independent observations was compared and, based on these measures, there was 100% interobserver agreement; therefore, reliability was assumed.

Maintenance Procedures

The maintenance phase began when each student reached 90% proficiency on three probes during the Intervention phase. Once a student had moved to this phase, once a week for the continuation of this study, they were given a maintenance probe to determine if the participant-maintained comprehension over time of both the ACT vocabulary word and definition. Results indicated in Figures 1-3 that participants maintained the skills mastered during the Intervention phase.

Social Validity

All three participants were orally administered a nine-question, questionnaire to measure the social validity of this study. A researcher-created tool called the *Social Validity Checklist* was used (see Appendix G) to determine the relevance of both the computerized graphic organizer and its perceived effect on vocabulary acquisition. With regards to the four Likert-style questions, all student indicated that they liked the graphic organizer and felt it helped them learn the ACT vocabulary words. They also felt these words would be seen on the ACT exam and that they would use this computerized graphic organizer again if requested to do so by a future

instructor. In the five question, open-ended response section, Jack stated that he liked the fact that the tool was computerized best because he felt it saved him "oxygen" in the form of trees, paper, and "technically, animals too." Nicole felt she learned vocabulary words that she would encounter both on the ACT exam as well as in the "real world, too." She liked how the program was organized with the word first, then the meaning, then the sentence, essentially in a linear form. Lulu, my student with an educational diagnosis of OHI related to her mental health issues stated she liked learning new words, and most specifically she appreciated learning that the ACT vocabulary word, 'asylum' does not mean 'a bad place' as she had once thought based on various movies she had seen before. She also felt this tool was helpful and made the information (being taught) less confusing. Each of the three students, who gave up a considerable portion of their summer to participate in this study, reported that it was a positive experience and two of the three students asked independently if they could return to the high school to work in this teacher's classroom or to help the principal more throughout the summer. One student said she was very thankful to get to come sit in the air conditioning and that, alone, was motivation enough for her to come to school each summer day, as her home does not provide her with this luxury.

Chapter V: Discussion

This study examined the effects of a computer-based, graphic organizer, Dr. Edwin Ellis' (2015) "*Real-World Connections Vocabulary*," on the improvement of 10th grade students' reading comprehension, and more specifically, the subset area of vocabulary acquisition. The results from this indicate a functional relation does exist between these two variables. In this single-subject, multiple probe design across participants, all three students demonstrated mastery of 30 ACT vocabulary words taught through the use of this tool. These results verify that this rigorous, age-appropriate content (ACT vocabulary words) married with a modern, technologized tool (computerized graphic-organizer) rendered positive results. Additionally, because of the results of the social validity component included in this multiple-probe design, one can also verify the social relevance of such a tool.

The importance of these results supports the initial goal outlined in this study of closing the reading performance gap via the use of more modern, 21st century tools. The pervasiveness of technology in schools is increasing rapidly (Cuillo & Reutebuch, 2013). According to the most recent statistics from the National Center for Educational Statistics (2017), 98% of teachers' report having varying degrees of access to computers for instructional purposes. They also state the overall, nationwide ratio of students to instructional computers with internet access is 3:1. This information demonstrates that access to technology is increasing, it is, therefore, up to teachers and administration to determine the efficacy of these tools for educational purposes. Additionally, as a result of this increase, researchers interest in its usage and effectiveness is increasing (Cuillo & Reutebuch, 2013), thus increasing the demand for quality materials.

All of this information combined indicates a need to provide teachers with tools which are researched-based to ensure the most effective student outcomes. With regards to this program

and the data rendered in this study, it has been demonstrated that students made significant gains when provided with appropriate, assistive technology tools and instruction.

Implications

This study was a single-subject study, and with regards to the research question posed, confirms and extends previous research. It is undeniable that the number of special education students is growing exponentially (National Center for Educational Statistics, 2017; Elder-Hinshaw et al., 2006; Lakin & Braddock, 2010). With regards to improving vocabulary acquisition, graphic organizers have proven to provide students with disabilities a visual and spatial modality to better acquire new information through their use of lines, arrows and graphic arrangements (Bos & Vaughn, 2002; Darch & Eaves, 1986; Taylor, Harris & Pearson, 1988; Kim et al., 2004; Rivera & Smith, 1997). The overall question this study answered was, in this modern age of technology, can this technique be used most effectively to tackle this ongoing problem? As computers are becoming more commonplace in the classroom, the true question becomes are they effective and do they positively impact student learning (Kennedy et al., 2014; Kuder, 2017). As teachers become more dependent upon their usefulness, research is needed to verify their strengths, and this study supports this.

Three specific implications for this study include, first, technology should be considered as an effective means of instruction in Tier 2, Response to Intervention (RtI). Tier 2 instruction is integral to the RtI process and often averts students from being referred to special education services (Individuals with Disabilities Education Improvement Act, 2004; Smith & Okolo, 2010). With extra support and accommodations, these students are often successful without the need for the special education referral process (Smith & Okolo, 2010) The use of technology to

support teacher's traditional instruction, as in the case of this study, is a viable means of support that renders positive results.

A second implication from this study is that, through the use of computerized graphic organizers, evidence further supports the benefits of using technology as a Universal Design for Learning practice and Differentiated Instruction technique. The use of UDL, DI, and the inclusion of technology provides credence to effective evidence-based practices for increasing the performance of students with high incidence disabilities (CAST; Meyer & Rose, 1998; Tomlinson, 1999).

The third implication from this study is that through the use of technology, specifically computerized graphic organizers, students are better able to increase vocabulary knowledge which ultimately better prepares students with disabilities for their post-transition goals (Kim et al., 2017; Vaughn et al., 2015; Watson et al., 2012). Overall, in these ways, results from this study positively supports that further evidence exists regarding the effectiveness of computerized graphic organizers helps to increase vocabulary acquisition of students with high incidence disabilities.

Results

The results of this study extend findings by confirming that technology can be combined effectively with traditional instruction to meet students with high incidence disabilities need to acquire vocabulary (Elder-Hinshaw et al., 2006; Puckett et al., 2009; Rose et al., 2005). It is well established that traditional paper/pencil graphic organizers are effective tools for improving reading comprehension, specifically vocabulary acquisition in students with disabilities (Ausubel, 1963; Ciullo & Reutebuch, 2013; Mayer, 1984; Simmons, Griffin, Kame'enue, 1988). Despite the fact that there is no peer-reviewed research specifically regarding the *Real-World*

Connections Vocabulary graphic organizer (Ellis, 2015), this study proves that this tool does provide an answer to the overall essential question that technology-driven, graphic organizers can be as useful in improving student performance as effectively as traditional graphic organizers. Overall, in this particular study, Student #1, Jack, demonstrated a net change of +64% from his performance on his pre-test to his post-test knowledge of pre-determined ACT vocabulary words and their definitions. Student 2, Nicole's ACT vocabulary knowledge improved 63%, and student #3, Lulu's performance increased 60% on the same pre- and post-test measures. Throughout this study, treatment fidelity was established and maintained throughout.

Due to the success of the three participants in this study, it is beneficial to explore the factors that may have contributed to the efficacy of this program for these students. According to Gajria et al. (2007), the primary difference in reading comprehension between elementary grades and secondary grades is that in elementary grades, students are "learning to read," whereas in secondary grades, students' needs shift to obtaining skills that improve their vocabulary skills because they are being asked to "read to learn" (p. 210). Williams (2005) states that students with disabilities often possess a severe problem in this area despite being able to recall words; this was true for each of these participants. Each was able to recall and pronounce correctly the ACT terminology but were not familiar with the word's meanings. This study focused on the need to improve students' understanding of the terminology. In a study by Bos and Anders (1990), secondary students who were provided with interactive semantic maps proved to make greater gains in the acquisition of science vocabulary than students in a direct instruction group. In fact, Gajria et al. (2007) completed a meta-analysis and as part of their study, they discovered that in eleven studies there was strong support for the use of computer-assisted, graphic organizers or otherwise technology-driven, text enhancement tools. In each of these studies,

these tools were more effective in facilitating content area comprehension for students with mild disabilities, including those with learning disabilities.

In this study all three participants, through the use of technology-enhanced graphic organizers, were able to master key ACT vocabulary terms as well as generalize these skills to a norm-referenced test of reading achievement. Testing of word comprehension improved both on the pre- and post-tests as well as the WRMT-III (Woodcock, 2011) achievement assessment. Due to the rapid rate of skill acquisition, factors affecting their speed will be discussed. Typically, all three participants are educated in the general education classroom along with other general education students for their reading and language arts needs. As per their IEP committee's decision, 80%-100% of their day is spent with their non-disabled peers. This study was conducted on a one-on-one basis, during the summer months, when each student was free of all other academic demands. These demands include any undue pressure from necessary homework, classwork, tests, school, teachers, etcetera as well as distraction from neighboring classmates. As a result, their time was undivided, and they were able to focus solely on the task at hand with as few environmental distractions as possible. Lessons proceeded at each student's own comfort level and speed as time was not a factor. Given that all three students were significantly below grade level in word comprehension, it is likely that each student would benefit from individual instruction to assist with the acquisition of key vocabulary terms needed in their general education classrooms. Factors affecting individual performance are discussed below.

Jack. Jack was a fifteen-year-old, male Caucasian student in the 10th grade who received services in special education as a result of a learning disability. He was a very well-mannered student, who came to each session eager to work. He was a very verbal student who liked to

create his *"Real-World Connection Vocabulary*" (Ellis, 2015) sentences around items of interest to him (e.g. "The band Metallica made a song about an asylum.") His grade equivalency scores on the WRMT-III (Woodcock, 2011) for both the pre-test (2.4) and the post-test (3.1) were lower than the other two students and he stayed in the intervention phase of the study the longest. Most likely this is due to the fact that although his IQ is 93, his overall achievement score was a 65. This achievement score is a good indication of why he stayed in the intervention phase the longest.

Nicole. Nicole was the second participant in this study. She was a sixteen-year-old Caucasian student in the 10th grade who also had been diagnosed with a learning disability. Similar to Jack, she was very willing to participate in this study. She, too, was a social student who liked to share stories with the researcher. This was evidenced by each session beginning with a lengthy discussion regarding her summer antics. Once this conversation was presumed to be exhausted, she was eager to begin. She began this study with the highest-grade equivalency level on the WRMT-III (Woodcock, 2011) of all three students (5.1) and ended at the highest as well (7.4). She completed the intervention phase of the study in the least amount of time as well. Her FS IQ was the highest of the three students in this study, but her achievement score was lower than Lulu. Her internal motivation to succeed most likely had the greatest influence on her performance during this study. An example of this is that after the very first pre-test measures she was visually distraught with her own self-perceived performance and asked to take that, and each subsequent probe, again so she could try to do better. This, of course, was not permitted, but serves as one piece of evidence towards her desire to perform well throughout this study.

Lulu. Lulu was the third participant in this study. She was a sixteen-year-old student in the 10th grade who received services under the category 'Other Health Impaired.' Her diagnosis

is a result of multiple psychiatric issues including OCD, depression with psychotic features, general anxiety disorder, and a sensory processing disorder. Her sessions were much different than the first two. She, again, was very amenable and worked very hard throughout each session from beginning to end, but her psychological issues, and personal and familial battles were evident as well. Due to confidentiality issues, they will not be discussed in this dissertation, but they were significant and, if one were to assume them to be true, would cause emotional distractions to most teenaged female participants. Therefore, it is felt these issues had an impact on the speed at which vocabulary was acquired by her during the intervention phase of this study. Despite these issues, she began the study with a grade equivalency of 3.4 and ended the study with a grade equivalency of a 5.9 according to the WRMT-III (Woodcock, 2011).

The results of this study indicate that the computer-based, graphic organizer, Dr. Edwin Ellis' (2015) "*Real-World Connections Vocabulary*," demonstrated improvement of 10th grade students' reading comprehension, and more specifically, their ability to acquire vocabulary. Of note, the student with the highest achievement score made the largest gains, while the student with the lowest made the least gains. Additionally, the student with the lowest achievement score who made the least amount of gains also took the longest to master the content. Despite the minimal number of participants, the results from this study indicate student achievement implies rate of mastery as well as extent of gains.

Additionally, social validity measures indicate this tool was positively received by each of the three students. According to their responses, each student felt the computer-based, graphic organizer was effective in their mastery of ACT vocabulary, would assist them on their upcoming ACT exam given during the eleventh grade, and would be beneficial if used for future vocabulary acquisition.

Limitations

The findings from this study do indicate a functional relation between a computer-based, graphic organizer, using Dr. Edwin Ellis' (2015) "*Real-World Connections Vocabulary*," and 10th grade students' vocabulary acquisition, but some limitations do exist. First, since treatment integrity was only completed in 33% of the studies, this presents a threat to internal validity and future studies might increase the percentage of sessions assessed (Ciullo & Reutebuch, 2013; Swanson, Wanzek, Haring, Ciullo & McCulley, 2013). Also, this study was conducted during the summer months when each student was free of other academic restraints. This lack of other concerns and obligations may have sped up mastery of content. Additionally, the constraints of this study mandate each student proceed to mastery in a one-on-one setting. This type of setting is not traditional, nor typical in nature, thus a larger group might have rendered a different outcome. This study was completed by a special education teacher known to these students. In fact, this researcher has known each of these students for over two school years, this creates a limitation in that it is not known if another researcher, not known to these students, would have received the same amount of return. This researcher is also a special education teacher. A general education teacher, one that is untrained to work with students with disabilities, might, too, have seen a different outcome. Moreover, this study involved only student with high-incidence, mild disabilities. A wider net, one that included students with different disabilities, might have produced different results. Each of the students within this study were either fifteen or sixteen years old 10th graders, therefore one cannot generalize the results to another age group or grade. Finally, a larger sampling of students with disabilities and varying levels of academic abilities would allow one to generalize these results to a larger population.

Recommendations for Future Research

Because of the limitations discussed in the previous section, there are several recommendations for future research with regards to the use of computerized graphic organizers with students with high-incidence disabilities. The first would be the need to replicate this study to confirm the independent variable, in this case, the computerized graphic organizer *Real-World Connections Vocabulary* (Ellis, 2015), is effective with a larger sample size. The second would be to establish effectiveness with students with disabilities other than those addressed in this study to, again, confirm effectiveness with a larger group of students with disabilities.

Conclusion

Analysis of data collected regarding the effectiveness of a computer-based graphic organizer on increasing the ACT vocabulary knowledge of secondary students with high-incidence disabilities rendered positive results. This study provides additional support that technology-driven, graphic organizers can be as useful in improving student performance as traditional graphic organizers.

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Appendix A

Woodcock Reading Mastery Test (WRMT-III; Woodcock, 2011)

WOODCOCK READING MASTERY TESTS

WRMT-III

Richard W. Woodcock, EdD

FORM A

Name: _____ Sex ☐M ☐F

Grade: _____ School: _____

Examiner: _____

Norms Used: ☐Age ☐Grade

	YEAR	MONTH	DAY
Test Date			
Birth Date			
Age			

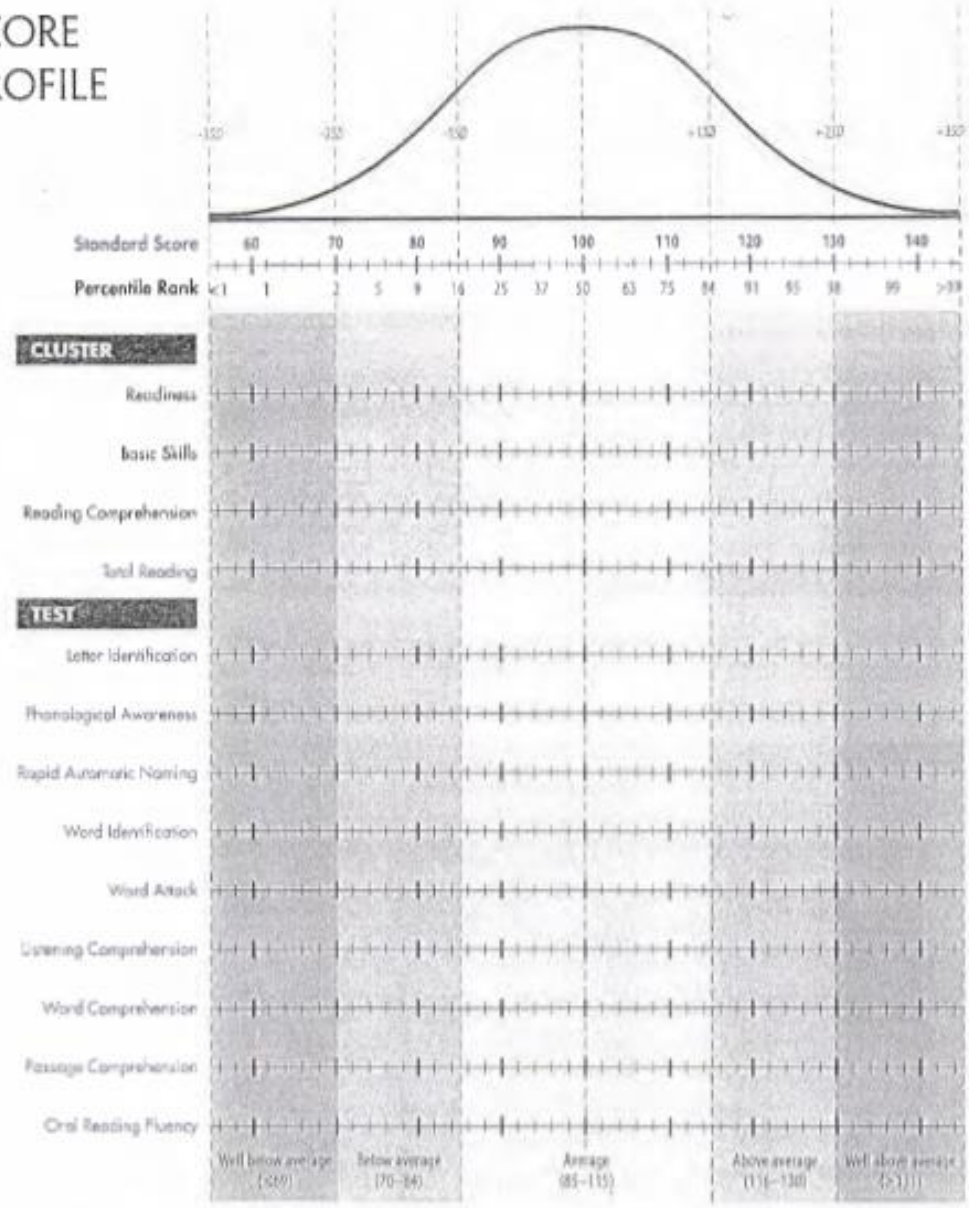
SCORE SUMMARY

COMPARISON TO TOTAL READING

Total Reading SS _____

	Raw Score	STANDARD SCORE: Test (A.1/A.3)	STANDARD SCORE: Cluster (A.2/A.4)	Confidence Interval ☐ 90% ☐ 95% (A.5/A.6)	%ile Rank (A.9)	GSV (A.7/A.8)	Equiv. ☐ Grade ☐ Age	RPI (A.20–A.23)	DIF. (Test or Cluster–TR)	Sig. (A.12–A.15)	Freq.	Personal Strength (PS)/ Weakness (PW)	
1. Letter Identification						A		/90		NS .05 .01	<15% <10% <5%	PS	PW
2. Phonological Awareness						B		/90		NS .05 .01	<15% <10% <5%	PS	PW
3. Rapid Automatic Naming						C		/90		NS .05 .01	<15% <10% <5%	PS	PW
READINESS						(A+B+C)/3		/90		NS .05 .01	<15% <10% <5%	PS	PW
4. Word Identification						D		/90		NS .05 .01	<15% <10% <5%	PS	PW
5. Word Attack						E		/90		NS .05 .01	<15% <10% <5%	PS	PW
BASIC SKILLS						(D+E)/2		/90		NS .05 .01	<15% <10% <5%	PS	PW
7. Word Comprehension						F		/90		NS .05 .01	<15% <10% <5%	PS	PW
8. Passage Comprehension						G		/90		NS .05 .01	<15% <10% <5%	PS	PW
READING COMP						(F+G)/2		/90		NS .05 .01	<15% <10% <5%	PS	PW
6. Listening Comprehension								/90		NS .05 .01	<15% <10% <5%	PS	PW
9. Oral Reading Fluency	RW					H		/90		NS .05 .01	<15% <10% <5%	PS	PW
TOTAL READING						(C+E+F+G+H)/5		/90					

SCORE PROFILE



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7 WORD COMPREHENSION

Range: Grade 1–Adult

BASAL RULE: Three (nonconsecutive) items correct before meeting discontinue rule (per section)
DISCONTINUE RULE: Four consecutive scores of 0 (per section)

Section A: ANTONYMS

	ITEM		RESPONSE	SCORE	
I 1+	A.	yes	no		
	B.	big	little		
I 1 & 2	1.	bad	good	1	0
	2.	new	old	1	0
	3.	dirty	clean	1	0
I 3 & 4	4.	alive	dead	1	0
	5.	male	female	1	0
I 5–8	6.	different	same	1	0
	7.	west	east	1	0
I 9+	8.	forget	remember	1	0
	9.	hungry	full	1	0
	10.	whisper	shout	1	0
	11.	finale	beginning	1	0
	12.	temporary	permanent	1	0
	13.	fictitious	factual	1	0
	14.	none	all	1	0
	15.	pessimist	optimist	1	0
	16.	ignorance	knowledge	1	0
	17.	protagonist	antagonist	1	0
	18.	elevate	lower	1	0
	19.	archaic	modern	1	0
	20.	sophisticated	simple	1	0
	21.	meager	abundant	1	0
	22.	flippant	serious	1	0
	23.	spry	sluggish	1	0

SECTION A SUBTOTAL (max = 23)

Section B: SYNONYMS

	ITEM		RESPONSE	SCORE	
GR 1+	A.	big	large		
	B.	look	see		
GR 1–6	1.	gift	present	1	0
	2.	mug	cup	1	0
	3.	sketch	draw(ing)	1	0
GR 7–9	4.	zero	nothing	1	0
	5.	locate	find	1	0
	6.	ancient	old(est)	1	0
GR 10+	7.	tale	story	1	0
	8.	equivalent	equal	1	0
	9.	educate	teach	1	0
	10.	timber	wood	1	0
	11.	comics	cartoons	1	0
	12.	ponder	consider	1	0
	13.	figurine	doll	1	0
	14.	agriculture	farming	1	0
	15.	transmit	send	1	0
	16.	ballad	song	1	0
	17.	inquisitive	curious	1	0
	18.	humidity	dampness	1	0
	19.	ally	partner	1	0
	20.	triad	threesome	1	0
	21.	agrarian	agriculture	1	0
	22.	mundane	common	1	0
	23.	cede	surrender	1	0

SECTION B SUBTOTAL (max = 23)

7 WORD COMPREHENSION

Range: Grade 1–Adult

BASAL RULE: Three (nonconsecutive) items correct before meeting discontinue rule (per section)
DISCONTINUE RULE: Four consecutive scores of 0 (per section)

Section A: ANTONYMS

	ITEM		RESPONSE	SCORE
1+	A.	yes	no	
	B.	big	little	
1 & 2	1.	bad	good	1 0
	2.	new	old	1 0
	3.	dirty	clean	1 0
3 & 4	4.	alive	dead	1 0
	5.	male	female	1 0
5–8	6.	different	same	1 0
	7.	west	east	1 0
9+	8.	forget	remember	1 0
	9.	hungry	full	1 0
	10.	whisper	shout	1 0
	11.	finale	beginning	1 0
	12.	temporary	permanent	1 0
	13.	fictitious	factual	1 0
	14.	none	all	1 0
	15.	pessimist	optimist	1 0
	16.	ignorance	knowledge	1 0
	17.	protagonist	antagonist	1 0
	18.	elevate	lower	1 0
	19.	archaic	modern	1 0
	20.	sophisticated	simple	1 0
	21.	meager	abundant	1 0
	22.	flippant	serious	1 0
	23.	spry	sluggish	1 0

SECTION A SUBTOTAL (max = 23)

Section B: SYNONYMS

	ITEM		RESPONSE	SCORE
GR 1+	A.	big	large	
	B.	look	see	
GR 1–6	1.	gift	present	1 0
	2.	mug	cup	1 0
	3.	sketch	draw(ing)	1 0
GR 7–9	4.	zero	nothing	1 0
	5.	locate	find	1 0
	6.	ancient	old(en)	1 0
GR 10+	7.	tale	story	1 0
	8.	equivalent	equal	1 0
	9.	educate	teach	1 0
	10.	timber	wood	1 0
	11.	comics	cartoons	1 0
	12.	ponder	consider	1 0
	13.	figurine	doll	1 0
	14.	agriculture	farming	1 0
	15.	transmit	send	1 0
	16.	ballad	song	1 0
	17.	inquisitive	curious	1 0
	18.	humidity	dampness	1 0
	19.	ally	partner	1 0
	20.	triad	threesome	1 0
	21.	agrarian	agriculture	1 0
	22.	mundane	common	1 0
	23.	cede	surrender	1 0

SECTION B SUBTOTAL (max = 23)

Section C: ANALOGIES

	ITEM		RESPONSE	SCORE
I 1+	A.	dog–walks **bird–**	flies	
	B.	one–two **three–**	four, six	
	C.	snow–cold **sun–**	hot	
I 1–3	1.	red–stop **green–**	go	1 0
	2.	fire–hot **ice–**	cold	1 0
	3.	brother–boy **sister–**	girl	1 0
	4.	eye–see **ear–**	hear	1 0
	5.	bark–dog **quack–**	duck	1 0
	6.	eight–seven **six–**	five	1 0
I 4–6	7.	love–hate **good–**	bad	1 0
	8.	foot–toes **hand–**	fingers	1 0
	9.	empty–full **quiet–**	noisy	1 0
	10.	night–moon **day–**	sun	1 0
I 7–9	11.	bear–fur **bird–**	feather(s)	1 0
	12.	whisper–soft **yell–**	loud	1 0
	13.	blanket–bed **rug–**	floor	1 0
	14.	walk–run **slow–**	fast	1 0
I 10+	15.	sponge–scrub **broom–**	sweep	1 0
	16.	red–color **square–**	shape	1 0
	17.	river–water **forest–**	trees	1 0
	18.	plumber–wrench **painter–**	brush	1 0
	19.	umbrella–dry **sweater–**	warm	1 0
	20.	act–play **chapter–**	book	1 0
	21.	initiate–begin **conclude–**	end	1 0
	22.	skater–athlete **violinist–**	musician	1 0
	23.	comedy–funny **tragedy–**	sad	1 0
	24.	rose–flower **elm–**	tree	1 0
	25.	cloth–scissors **wood–**	saw	1 0
	26.	town–county **state–**	country	1 0
	27.	adorn–decorate **display–**	exhibit	1 0
	28.	carpenter–wood **welder–**	metal	1 0
	29.	building–pillar **table–**	leg	1 0
	30.	water–well **coal–**	mine(s)	1 0
	31.	manufacturing–factory **agriculture–**	farm	1 0
	32.	famine–hunger **epidemic–**	disease	1 0
	33.	country–rural **city–**	urban	1 0
	34.	cinnamon–spice **wheat–**	grain	1 0
	35.	suggest–command **sip–**	gulp	1 0
	36.	brave–cowardly **generous–**	cheap	1 0
	37.	mentor–guide **beginner–**	amateur	1 0
	38.	quarrelsome–argumentative **stylish–**	fashionable	1 0
	39.	reject–accept **agitate–**	calm	1 0
	40.	wind–gale **rain–**	downpour	1 0

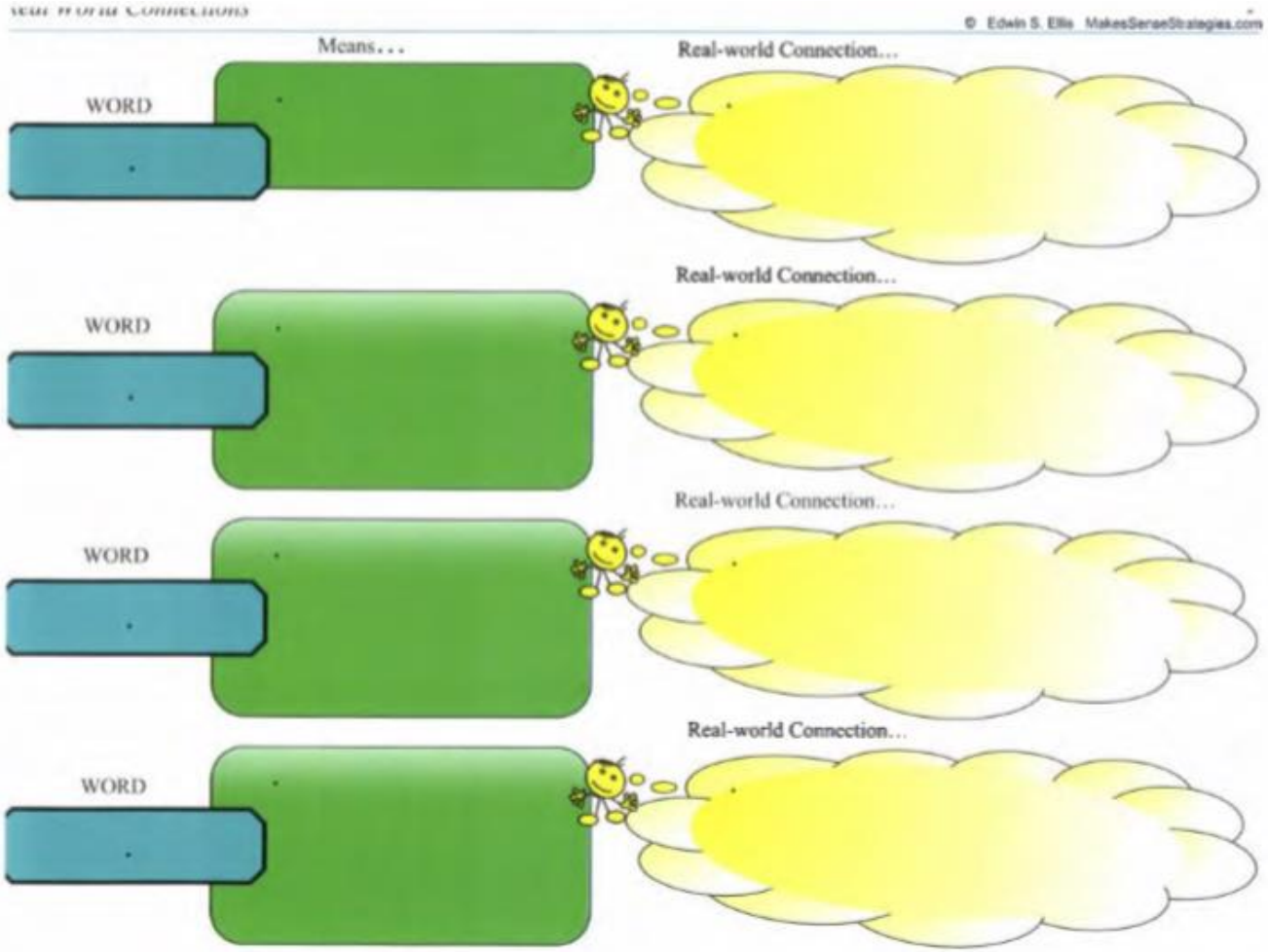
SECTION C SUBTOTAL
(max = 40)

WORD COMPREHENSION TOTAL RAW SCORE
(Sum of Sections A through C, max = 86)

Appendix B

Differentiated Visual Tools, *Real-World Connections* PowerPoint Sample (Ellis, 2015)

Real World Connections Vocabulary by Differentiated Visual Tools:


Real-world Connections
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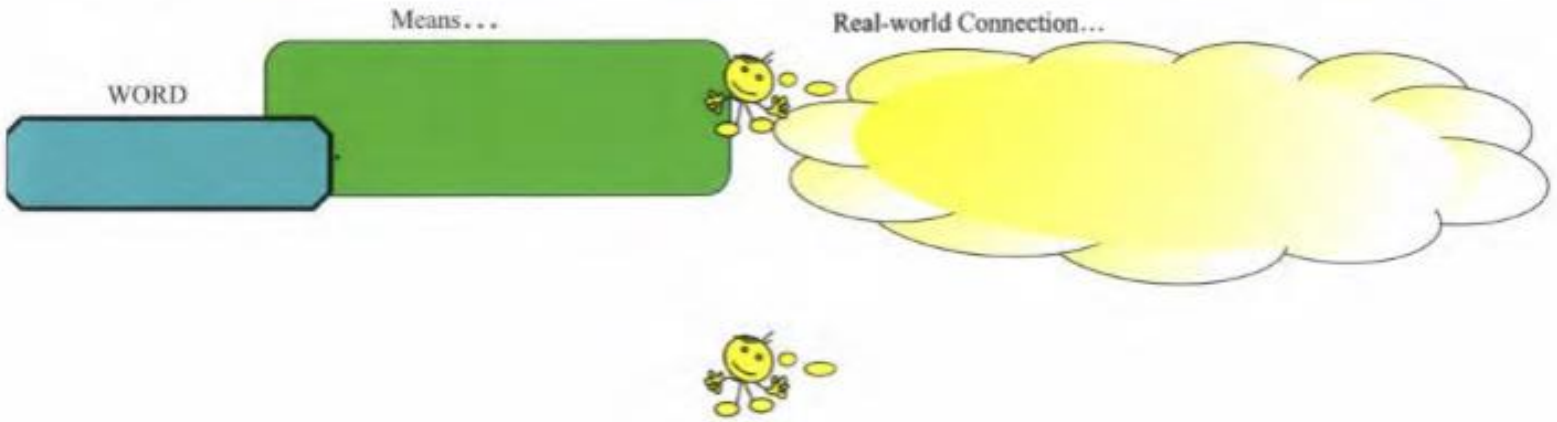

Appendix C

List of 30 ACT Vocabulary Words and Definitions

30 Vocabulary Words and their Definitions Adapted from
College Board's Top 100 Common SAT/ACT Vocabulary Words

1. Adversity – misfortune
2. Anecdote – short account of event
3. Asylum – sanctuary
4. Censure – to criticize harshly
5. Collaborate – to work together
6. Compassion – sympathy, mercy
7. Compromise – to settle differences
8. Condescending – patronize
9. Diligent – hard-working
10. Divergent – variant, moving apart
11. Empathy – sharing of feelings
12. Enhance – improve augment
13. Exemplary – outstanding
14. Frugal – thrifty
15. Hypothesis – theory requiring proof
16. Incompatible – unable to work together
17. Intuitive – instinctive, untaught
18. Longevity – long life
19. Nonchalant – calm, casual
20. Novice – beginner
21. Precocious –talented beyond one's age
22. Procrastinate – to delay unnecessarily
23. Prudent – wise, careful, cautious
24. Resilient – quick to recover
25. Spontaneity – impulsive action
26. Substantiate – to verify, confirm
27. Superficial – lacking in depth
28. Tactful – diplomatic, polite
29. Tenacious – persistent, resolute
30. Wary – watchful, alert

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Appendix D

Teacher-Created Pre/Post Test

Name: _____ Vocabulary – Pre/Post

Directions: Circle the correct answer that identifies the meaning of each word.

1) Adversity means:
   a. Shorten
   b. Misfortune
   c. Peaceful
   d. Momentary

2) Nonchalant means:
   a. Flushed
   b. Lucky
   c. Calm, casual
   d. Trustworthy

3) Compassion means:
   a. Hard working
   b. Regard with scorn
   c. Fearless
   d. Sympathy, mercy

4) Prudent means:
   a. Wise, careful, cautious
   b. Elusive, sly, ambiguous
   c. Controlled, restricted
   d. Respectable due to age

5) Empathy means:
   a. Pleasure seeker
   b. Overused, too much
   c. Tiring, weakening
   d. Sharing of feelings

6) Wary means:
   a. Persistent, resolute
   b. To clear from blame
   c. Watchful, alert
   d. Temporary, fleeting

7) Incompatible means:
   a. Unable to work together
   b. To attribute to someone
   c. Rash impulsive
   d. Unavoidable, certain

8) Asylum means:
   a. Trivial
   b. Beginner
   c. Speaker
   d. Sanctuary

9) Precocious means:
   a. Persuader of legislators
   b. Talented beyond one's age
   c. To attribute to someone
   d. Pompous, self-important

10) Substantiate means:
   a. To verify, confirm
   b. Impulsive action
   c. Profound respect
   d. Secret, stealthy

11) Anecdote means:
   a. To delay unnecessarily
   b. Short lived, an image
   c. Short account of event
   d. To work together

12) Intuitive means:
   a. Improve, augment
   b. Instinctive, untaught
   c. Rash, impulsive
   d. Dried up

13) Compromise means:
   a. To settle differences
   b. Misfortune
   c. Disloyal
   d. Hard-working

14) Procrastinate means:
   a. Overused, clichéd
   b. Momentary, fleeting
   c. To delay unnecessarily
   d. Respectable due to age

15) Tenacious means:
   a. To end an activity
   b. Persistent, resolute
   c. To clear from blame
   d. To observe carefully

16) Superficial means:
   a. Wealth, success
   b. Inflammatory
   c. Controlled, restricted
   d. Lacking in depth

17) Condescending means:
   a. Nameless
   b. Arrogant
   c. Patronizing
   d. Impulsive

18) Exemplary means:
   a. Unavoidable
   b. Outstanding
   c. Harmful
   d. Ornate

19) Longevity means:
   a. Honesty
   b. Decency
   c. Disloyal
   d. Long life

20) Tactful means:
   a. Temporary, fleeting
   b. Diplomatic, polite
   c. To observe secretly
   d. Elusive, shy

21) Diligent means:
   a. Short account of event
   b. Indirect, roundabout
   c. Sympathy, mercy
   d. Hard-working

22) Censure means:
   a. Theory requiring proof
   b. To criticize harshly
   c. Beginner
   d. Fearless, adventurous

23) Spontaneity means:
   a. Clear from blame
   b. Impulsive action
   c. Persistent, resolute
   d. Diplomatic, polite

24) Frugal means:
   a. Thrifty
   b. Lucky
   c. Ornate
   d. Helpful

25) Hypothesis means:
   a. Final decision
   b. Short lived, an image
   c. Theory requiring proof
   d. Unavoidable, certain

26) Resilient means:
   a. Quick to recover
   b. Time consuming
   c. Slow, hermit-like
   d. Ambiguous

27) Novice means:
   a. Beginner
   b. Misfortune
   c. Agreeable
   d. Opponent

28) Divergent means:
   a. Shorten, abridge
   b. Act of refraining from
   c. Variant, moving apart
   d. Out of date

29) Collaborate means:
   a. Sanctuary
   b. To work together
   c. Nameless
   d. Friendly, helpful

30) Enhance means:
   a. Patronizing
   b. Extremely dry
   c. Trust among friends
   d. Improve, augment

Appendix E

Teacher-Created Test Probes A-E

Name: _____ Vocabulary – Test A

Directions: Circle the correct answer that identifies the meaning of each word.

1) Adversity means:
   a. Shorten
   b. Misfortune
   c. Peaceful
   d. Momentary

2) Nonchalant means:
   a. Flushed
   b. Lucky
   c. Calm, casual
   d. Trustworthy

3) Compassion means:
   a. Hard working
   b. Regard with scorn
   c. Fearless
   d. Sympathy, mercy

4) Prudent means:
   a. Wise, careful, cautious
   b. Elusive, sly, ambiguous
   c. Controlled, restricted
   d. Respectable due to age

5) Empathy means:
   a. Pleasure seeker
   b. Overused, too much
   c. Tiring, weakening
   d. Sharing of feelings

6) Wary means:
   a. Persistent, resolute
   b. To clear from blame
   c. Watchful, alert
   d. Temporary, fleeting

7) Incompatible means:
   a. Unable to work together
   b. To attribute to someone
   c. Rash impulsive
   d. Unavoidable, certain

8) Asylum means:
   a. Trivial
   b. Beginner
   c. Speaker
   d. Sanctuary

9) Precocious means:
   a. Persuader of legislators
   b. Talented beyond one's age
   c. To attribute to someone
   d. Pompous, self-important

10) Substantiate means:
   a. To verify, confirm
   b. Impulsive action
   c. Profound respect
   d. Secret, stealthy

Key: Test A

1) B
2) C
3) D
4) A
5) D
6) C
7) A
8) D
9) B
10) A

Name: _____ Vocabulary – Test B

Directions: Circle the correct answer that identifies the meaning of each word.

1) Anecdote means:
   a. To delay unnecessarily
   b. Short lived, an image
   c. Short account of event
   d. To work together

2) Intuitive means:
   a. Improve, augment
   b. Instinctive, untaught
   c. Rash, impulsive
   d. Dried up

3) Compromise means:
   a. To settle differences
   b. Misfortune
   c. Disloyal
   d. Hard-working

4) Procrastinate means:
   a. Overused, clichéd
   b. Momentary, fleeting
   c. To delay unnecessarily
   d. Respectable due to age

5) Tenacious means:
   a. To end an activity
   b. Persistent, resolute
   c. To clear from blame
   d. To observe carefully

6) Superficial means:
   a. Wealth, success
   b. Inflammatory
   c. Controlled, restricted
   d. Lacking in depth

7) Adversity means:
   a. Shorten
   b. High praise
   c. Misfortune
   d. Agreeable

8) Enhance means:
   a. Patronizing
   b. Extremely dry
   c. Trust among friends
   d. Improve, augment

9) Longevity means:
   a. Long life
   b. Dishonor
   c. Friendly
   d. Nameless

10) Frugal means:
   a. Flushed
   b. Thrifty
   c. Arrogant
   d. Wealthy

Key Test B

1. C
2. B
3. A
4. C
5. B
6. D
7. C
8. D
9. A
10. B

Name: _____ Vocabulary – Test C

Directions: Circle the correct answer that identifies the meaning of each word.

1) Asylum means:
   a. Sanctuary
   b. Trivial
   c. Harmful
   d. Opponent

2) Condescending means:
   a. Nameless
   b. Arrogant
   c. Patronizing
   d. Impulsive

3) Exemplary means:
   a. Unavoidable
   b. Outstanding
   c. Harmful
   d. Ornate

4) Longevity means:
   a. Honesty
   b. Decency
   c. Disloyal
   d. Long life

5) Prudent means:
   a. Phony, false
   b. Controlled, restricted
   c. Profound respect
   d. Wise, careful, cautious

6) Tactful means:
   a. Temporary, fleeting
   b. Diplomatic, polite
   c. To observe secretly
   d. Elusive, shy

7) Divergent means:
   a. Variant, Moving apart
   b. Trust among friends
   c. Follower of customs
   d. Regard with scorn

8) Substantiate means:
   a. To end an activity
   b. Watchful, alert
   c. Irritable, hateful
   d. To verify, confirm

9) Procrastinate means:
   a. Rash, impulsive
   b. Joy, exultation
   c. To delay unnecessarily
   d. Ordinary, common

10) Intuitive means:
   a. Guilt diminishing
   b. Short lived
   c. Instinctive, untaught
   d. Improve, augment

Key Test C

1. A
2. C
3. B
4. D
5. D
6. B
7. A
8. D
9. C
10. C

Name: _____ Vocabulary – Test D

Directions: Circle the correct answer that identifies the meaning of each word.

1) Censure means:
   a. Theory requiring proof
   b. To criticize harshly
   c. Beginner
   d. Fearless, adventurous

2) Spontaneity means:
   a. Clear from blame
   b. Impulsive action
   c. Persistent, resolute
   d. Diplomatic, polite

3) Frugal means:
   a. Thrifty
   b. Lucky
   c. Ornate
   d. Helpful

4) Hypothesis means:
   a. Final decision
   b. Short lived, an image
   c. Theory requiring proof
   d. Unavoidable, certain

5) Precocious means:
   a. Persuader of legislators
   b. To attribute to someone
   c. Unable to work together
   d. Talented beyond one's age

6) Diligent means:
   a. Short account of event
   b. Indirect, roundabout
   c. Sympathy, mercy
   d. Hard-working

7) Nonchalant means:
   a. Calm, casual
   b. Concerned, intense
   c. Planned, careful
   d. Harmful, joining of parts

8) Tenacious means:
   a. Uncaring, uninvolved
   b. Afraid, weak
   c. Persistent, resolute
   d. Uncontrolled, withdrawn

9) Resilient means:
   a. Quick to recover
   b. Time consuming
   c. Slow, hermit-like
   d. Ambiguous

10) Condescending means:
   a. Overused
   b. Outstanding
   c. Sympathizer
   d. Patronizing

Key Test D

1. B
2. B
3. A
4. C
5. D
6. D
7. A
8. C
9. A
10. D

Name: _____ Vocabulary – Test E

Directions: Circle the correct answer that identifies the meaning of each word.

1) Incompatible means:
   a. Extremely dry
   b. Pertaining to beauty
   c. High praise
   d. Unable to work together

2) Novice means:
   a. Beginner
   b. Misfortune
   c. Agreeable
   d. Opponent

3) Divergent means:
   a. Shorten, abridge
   b. Act of refraining from
   c. Variant, moving apart
   d. Out of date

4) Collaborate means:
   a. Sanctuary
   b. To work together
   c. Nameless
   d. Friendly, helpful

5) Resilient means:
   a. Quick to recover
   b. Wealthy, success
   c. Inflammatory
   d. Profound respect

6) Spontaneity means:
   a. Impulsive action
   b. Controlled, restricted
   c. Short account of event
   d. To observe carefully

7) Exemplary means:
   a. Trivial
   b. Honesty, decency
   c. Disloyal
   d. Outstanding

8) Wary means:
   a. Diplomatic, polite
   b. Watchful, alert
   c. Temporary, fleeting
   d. Persistent, resolute

9) Hypothesis means:
   a. Arrogant, condescending
   b. Theory requiring proof
   c. Pleasure seeker
   d. Fearless, adventurous

10) Compassion means:
   a. To regard with scorn
   b. Dishonor, disgrace
   c. Sympathy, mercy
   d. Joining of parts

Key Test E

1. D
2. A
3. C
4. B
5. A
6. A
7. D
8. B
9. B
10. C

Appendix F

Treatment Integrity Checklist

Treatment Integrity Checklist

ACT Vocabulary and

Differentiated Visual Tools, "Real World Vocabulary" Graphic Organizer

Student: _____ Date: _____

For each cell, insert a 1 for 'Yes' or a 0 for 'No' indicating whether or not the teacher completed the task requested below.

Steps	Word 1	Word 2	Word 3	Word 4	Word 5
1. Introduce ACT vocabulary word.					
2. State the exact ACT definition of the new word.					
3. Discuss the meaning of the new vocabulary word.					
4. Discuss the meaning of the vocabulary word's definition.					
5. Use the word in a sentence.					
6. Discuss synonyms of the vocabulary word.					
7. Discuss antonyms of the vocabulary word.					
8. Have student complete one row of the computerized graphic organizer.					

Note: After 1st word is placed on graphic organizer, teacher begins same process for vocabulary words 2-5.

Overall Score / Total
/ 40

= _____%

Observer's Signature: _____

Appendix G

Social Validity Checklist

Social Validity Checklist

Social Validity Interview (Student Form)

Student: _____ Interviewer: _____ Date: _____

Say, "I have some questions to ask you. I just want to know how you feel about the computer-generated, graphic organizer you have been using."

Questions:

1) Did you like the computer-generated, graphic organizer?	Yes Maybe No
2) Did the graphic organizer help you learn new vocabulary words?	Yes Maybe No
3) Do you think these vocabulary words will be on the ACT test?	Yes Maybe No
4) Would you use the program again if the teacher wanted you to?	Yes Maybe No
5) What did you learn from using the vocabulary graphic organizer?	
6) What did you like best about the tool?	
7) What did you not like about the tool?	

8) If you were to change, what would you have changed about the tool?
9) Is there anything else you want to say about the program?

Appendix H

Data Collection Sheet (Front and Back Side)

"Effects of Computer Based Graphic Organizers and Instructional Technology for Students with High-Incidence Disabilities"
Researcher: Cynthia Massey

Data Collection Sheet

Student's Assigned Name: _____

Baseline Data

WRMT-III, Word Comprehension (Antonyms, Synonyms, and Analogies)	Raw Score =	SS =
Pretest score (30 ACT vocabulary words)	/30	%

Intervention Data
(Scores on ACT Vocabulary Assessment Probes)

Test Session #:																							
Test Version: (A-E)																							
Score: (10 questions)	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10	/10
Percentage Correct:	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%

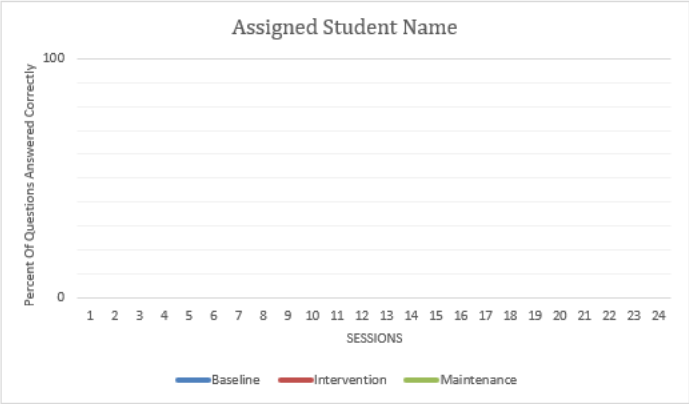
Post-Test Data

Post-test score (30 ACT vocabulary words)	/30	%
Completion of Social Validity Checklist	(Circle Yes or ~~No~~)	Yes or No

Data Collection Sheet

Student's Assigned Name: _____

Graph of Data



Appendix I

Parental Permission/Child Assent Form Approved by

Auburn University's Internal Review Board (IRB)

AUBURN UNIVERSITY

DEPARTMENT OF
SPECIAL EDUCATION,
REHABILITATION, AND COUNSELING

(NOTE: DO NOT AGREE TO PARTICIPATE UNLESS AN IRB APPROVAL STAMP WITH CURRENT DATES HAS BEEN APPLIED TO THIS DOCUMENT.)

PARENTAL PERMISSION/CHILD ASSENT
for a Research Study entitled
"Effects of Computer-Based Graphic Organizers and Instructional Technology for Students with Disabilities"

Your son or daughter is invited to participate in a research study to determine the effects of instructional technology in reading vocabulary for individuals with mild disabilities. In this study, instructional technology is the use of computer technology, specifically a computerized graphic organizer, to support traditional instruction. The study is being conducted by *Cynthia Massey, Ph.D. student* at Auburn University under the direction of Dr. Peggy Shippen, Professor, in the Auburn University Department of Special Education, Rehabilitation, and Counseling. Your son or daughter is invited to participate because he or she is a secondary student who might benefit from additional instruction in the area of reading comprehension and has been recommended by his/her teacher. Since he/she is age 18 or younger we must have your permission to include him/her in the study.

What will be involved if your son/daughter participates? If you decide to allow him/her to participate in this research study, he/she will be asked to begin by taking two baseline tests to identify their appropriateness for this study. After this has been determined, he/she will participate in daily vocabulary instruction which involves introducing/reviewing ACT vocabulary words each day then completing a computerized graphic organizer, and three times a week, taking a multiple-choice assessment to examine what they have learned. Your son/daughter's total time commitment will be approximately 30 minutes daily for eight weeks. With your permission, approximately 30% of the instructional sessions will be videotaped to ensure that the teacher follows the procedures provided within the vocabulary program.

Instruction will begin on June 5, 2017 at Handley High School and will be from 9:00 to 9:30 each day until school starts. Once school begins, the sessions will be from 3:30 to 4:00 each afternoon.

Are there any risks or discomforts? The risks associated with participating in this study are breach of confidentiality. To minimize these risks, we will not directly state your son/daughter's name or divulge any other identifiable information regarding the data collected.

Are there any benefits to yourself or others? If he/she participates in this study, he/she can expect to improve his/her reading vocabulary skills. We/I cannot promise that your son/daughter will receive any or all of the benefits described. If he/she participates and completes the study, regardless of the outcome, he/she will be given a $30 Visa gift card.

Parent/Guardian Initials _____
Participant Initials _____

The Auburn University Institutional Review Board has approved this Document for use from 05/17/2017 to 05/16/2018
Protocol # 17-169 MR 1705

If you (or your son/daughter) change your mind about his/her participation, he/she can be withdrawn at any time during the study. His/her participation is completely voluntary. If you choose to withdraw your son/daughter, his/her data can be withdrawn as long as it is identifiable. Your decision about whether or not to allow your son/daughter to participate or to stop participating will not jeopardize you or his/her future relations with Auburn University, the Department of Special Education, Rehabilitation and Counseling, this researcher, or Roanoke City Schools.

Your son/daughter's privacy will be protected. Any information obtained in connection with this study will remain confidential. The data collected will be protected by assigning an alternate identification during the data collection process. Information obtained through his/her participation may be used to fulfill requirements for a dissertation.

If you (or your son/daughter) have questions about this study, *please ask them now or* contact Cynthia Massey at 334-863-1282 or Dr. Peggy Shippen at 334-844-2123. A copy of this document will be given to you to keep.

If you have questions about your child's rights as a research participant, you may contact the Auburn University Office of Research Compliance or the Institutional Review Board by phone (334)-844-5966 or e-mail at IRBadmin@auburn.edu or IRBChair@auburn.edu.

HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE WHETHER OR NOT YOU WISH FOR YOUR SON OR DAUGHTER TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE INDICATES YOUR WILLINGNESS TO ALLOW HIM OR HER TO PARTICIPATE. YOUR SON/DAUGHTER'S SIGNATURE INDICATES HIS/HER WILLINGNESS TO PARTICIPATE.

Participant's Signature	Date	Investigator Obtaining Consent	Date
Printed Name		Printed Name	
Parent/Guardian Signature	Date	Co-Investigator	Date
Printed Name		Printed Name	

The Auburn University Institutional Review Board has approved this Document for use from 05/17/2017 to 05/16/2018
Protocol # 17-169 MR 1705