USING THE MULTIMEDIA STRATEGIES OF LEARNER-GENERATED DRAWING AND PEER DISCUSSION TO RETAIN TERMINOLOGY IN MIDDLE SCHOOL SECONDARY EDUCATION SCIENCE CLASSROOMS

by

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ABSTRACT

THERESA M. KASAY. Using the Multimedia Strategies of Learner-generated Drawing and Peer Discussion to Retain Terminology in Middle School Secondary Education Science Classrooms
(Under the direction of DR. REBECCA SHORE)

The purpose of this quantitative study was to compare and evaluate two types of vocabulary interventions using grade 9 physics vocabulary terms using two lists of 10 words. A quasi experimental crossover research design was used to compare the two interventions, presented during two separate sessions, 1) active, multimedia that includes the combined strategies of learner-generated drawing followed by peer discussion; and 2) passive that included students reading and copying. This study was conducted with 209 middle school students in grades 6, 7, and 8. Prior to each intervention, active, multimedia and passive, students completed a pretest to determine level of word knowledge. Immediately following the two vocabulary interventions, participants completed a posttest to measure vocabulary acquisition and a second posttest 24 hours later to measure vocabulary retention. The research questions address whether (a) students retained more using the active, multimedia or passive intervention, (b) student reading ability (2) students reading below grade level effect retention following the active, multimedia intervention, (c) males retained more than females, (d) student pretest performance predicted posttest results following both interventions.

There was no statically significant difference between the active, multimedia and passive interventions for students reading at or above grade level; however, there was a main effect for the active, multimedia intervention for students reading below grade level.

The study also found no statically significant difference between male and female participants. Pretest performance was found to be a predictor of posttest performance.

DEDICATION

To my Lord and Savior, Jesus Christ, I claimed this verse for my higher education journey and have clung to it to completion.

I can do all things through him who strengthens me.

Philippians 4:13

Dedicated to Steven, Caroline, Savannah, and Christopher, because God blessed me with each of you, I became an aunt. Because God made each of you with a generous heart, I have felt your love. Because God gave each of you the joy of the Lord, I am most thankful, and it is my greatest honor, that I may call you friends.

To John and Laura who have always loved and encouraged me, I am forever grateful for your support.

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LIST OF ABBREVIATIONS

ADD	Attention Deficit Disorder
CTP 4	Comprehensive Testing Program – Version 4
ERB	Educational Records Bureau
IRA	International Reading Association
JK-12	Junior Kindergarten (students age 4 & 5) through Grade 12
L	Lexile Reading Level
LMS	Learning Management System
NAEP	National Assessment of Educational Progress
NCTE	National Council for Teachers of English
NCTM	National Council for Teachers of Math
SOI	Select, Organize, and Integrate
STEM	Science, Technology, Engineering, and Math

CHAPTER ONE: INTRODUCTION

Overview

From the dawn of the space race, when the Russian satellite, Sputnik, took the country by unawares, the United States quest for scientific advancement and innovation has continued to result in the United States woefully lacking and consistently finishing in the middle of the international pack (McFarland, Hussar, de Brey, Snyder, Wang, Wilkinson-Flicker, Gebrekristos, Zhang, Rathbun, Barmer, Bullock Mann, & Hinz, NCES, 2017; NSB, 2018; OECD 2007; Poland & Plevyak, 2015). Repeatedly, since the 1950s, multiple entities, including the Federal government and titans of industry have attempted to tackle the elusive task of reforming science education. Alarmingly, even with the recent influx of interest and funding centered on STEM (Science, Technology, Engineering, and Math) initiatives, national science growth scores are failing or flatlined (McFarland et. al, NCES 2017; NSB, 2018; OECD 2007; Poland & Plevyak, 2015).

Lagging science scores have spurred national initiatives, and increased science funding belie the concerning state of science achievement. Effective instructional environments require knowledgeable teachers, a steady stream of funds and a robust reservoir of resources. Additionally, it is imperative for teachers to implement instructional techniques and strategies that actively engage students which in turn maximize learning and long-term content retention. In the current national state of American schools' culture of accountability through standardized testing, combined with a shortage of high-quality science teachers, many teaching and learning environments are often reduced to the lowest common denominators, direct instruction, rote learning, and textbook reliant modes of content delivery (Betts 2009; Crocco & Costigan, 2007).

In this historic and current paradigm, a domino effect has occurred. Students are not learning at levels hoped for in science classrooms; thus, they lack critical content knowledge. Inadequate knowledge may inhibit students from pursuing high school and post-secondary courses of study in the sciences which may help explain the current gap that exists between science achievement scores for elementary and middle school students and those of high school students (Poland & Plevyak, 2015). Lack of student capacity thus impacts the ability to complete degrees that require advanced science competencies and to pursue STEM-related careers. Thus, the waning and low interest in science and science-related fields and occupations is a long-running and continued national concern (Andree & Hannson, 2014).

In addition to the lacking global science scores, a specific subgroup concern is the gap between male and female science achievement scores. The data from achievement assessments indicate that male students outperformed female students (McFarland et al., NCES 2017; NSB, 2018; OECD 2007; Poland & Plevyak, 2015). This disparity in achievement may be an indicator as to why more males enter science fields than females.

Even with the myriad of variable factors that impact the state of science achievement, the one factor that may make an impact is the implementation of effective teaching and learning strategies and techniques used to teach science. Importantly, a core of content specific, non-fiction reading comprehension and learning are understanding the content-specific vocabulary. Comprehending the content-specific text (Young, 2010) is imperative. The most current national initiative for reform, the Next Generation Science Standards, (2010) is the foundation of the merging hope for science achievement (Poland & Plevyak, 2015).

Related Learning Theories

Active learning is an impactful teaching model. Modern educational theorists, including the work of Dewey and Piaget, highlight the importance of active cognitive engagement. John Dewey (1916) stated that people learn best through experiences, learning by doing. In his seminal book, *Democracy in Education* Dewey explained, "if knowledge comes from the impressions made upon us by natural objects, it is impossible to procure knowledge without the use of objects which impress the mind" (Dewey, 1916, p. 217–18).

Years later, Swiss psychologist Jean Piaget introduced his theory of constructivism which states that it is the confluence of one's experiences and ideas which brings about essential knowledge for the learner (Piaget, 1936). The foundation of both theorists' work centers on the importance of the learner's active connection and interaction with concepts, their ideas, and their thinking.

Models and Techniques of Teaching and Learning

1.1 Transmission Model

During the industrial revolution and in a time when education was restructured to formalize a model to support both a growing population and to respond to the increased demand for labor in the new mechanized factories, school was designed to generate assembly line laborers. At that time, the instruction was contingent upon information "poured in" by the teacher. This belief dictated the early, formal design of American schools, the transmission model. This traditional instructional model is teacher-centered where the teacher disseminates information to the learners in a structured format (Jenkins, 2016). While the teacher leads the instruction, the student listens to the lecture, takes notes, and then regurgitates the content back to the teacher as evidence of learning (Siegel, 2016). In the transmission model, focused on the most basic levels of learning, knowledge acquisition requires much from the teacher and less from the learner. The transition model makes few demands on the learner to make connections, to think critically, or to engage in higher-order thinking tasks.

As we race headlong in the new millennium, American schools must produce innovative learners to meet the modern demands from the technology and innovation fronts. Teachers no longer have mutually exclusive rights to information. In this the information age, technology allows everyone to access information instantaneously. Additionally, unlike the understandings of old, emerging concepts and understandings in cognitive science provide progressive insights into the brain and how it learns. While many colleges of education are making attempts to integrate these concepts into their curriculum for teacher preparation, only a small percentage of programs have successfully accomplished this integration. In addition, the shortage of science teachers in our country, and subsequent filling of those positions through lateral entry or other less thorough credentialing routes have compounded the absence of more innovative pedagogy established with more formally trained teachers of science and many science teachers continue to rely on the transition model. Many schools around the world have implemented a more student-centered approach. Numerous schools in Europe, Australia, and Scandinavia, are focused on active, student-centered instructional models (OECD, 2009).

Meanwhile, many American schools still function with teachers as the gatekeepers of information. While national standards or state standardized tests dictate curriculum, teachers determine the importance and relevance of the content provided through their delivery, unfortunately often through lecture, notes, and a textbook (Moreno & Mayer, 2000). While current research, industry demands, and lagging science scores indicate a need to implement more innovative, active instructional models, many American schools continue to depend on the transmission model as the primary mode of instruction.

1.2 Cognitive Theory of Multimedia Learning

Mayer's (1997) theory of multimedia learning provides an alternative instructional method to that of the transmission model. The multimedia model is student-centered with the learner actively selecting information visually and verbally to construct knowledge. Chi and Wylie (2014) state that in the multimedia learning model, students participate in "discovery learning" to draw conclusions based on student-generated rules and constructs.

The Cognitive Theory of Multimedia fosters active student engagement. This model encourages collaboration, critical thinking, higher level cognition, and content retention, all behaviors conducive to preparing students for advanced scientific study and career preparation in science, technology, and innovation.

1.3 Cognitive Load Theory Sweller's (1994) Cognitive Load Theory focuses on the demand placed on the brain's working memory while performing a cognitive task. Sweller (1994) states increased cognitive load demands and poor instructional design negatively impact student learning. Chi (2009) adds that learning outcomes are enhanced when cognitive load reduces the memory load. She also states that active, constructive and interactive learning positively impacts student learning. Additionally, the inclusion of drawing tasks when learning new concepts reduces the cognitive load demand, therefore increasing cognition.

Statement of the Problem

Various studies have indicated active student engagement in their learning, positively impacted both achievement and content retention. Student practice, product generation, and interactive student responses focused on the learning content have shown increased student retention (Shore, Ray, & Goolkasian, 2015; Bertsch, Pesta, Wiscott, & McDaniel, 2007; Jacoby, 1978; Slamecka & Graf, 1978). Mayer (1997) introduced an instructional model, multimedia learning, that incorporates a strategically selected combination of active learning strategies to increase the effectiveness of teaching interventions. By Mayer's construct, partnering student-generated drawings and discussion creates a multimedia learning environment (Mayer, 1997; Mayer, 2008; Schwamborn, Thillmann, Opfermann, & Leutner, 2011). When students draw and collaborate through peer discussion, multiple cognitive learning processes including metacognition (thinking about thinking), and cognitive reasoning strategies are engaged (Karpicke, Butler, & Roediger, 2009). This firing of the cognition furnace is key to searing information into the students' memories, thus impacting learning and retention (Shore et al., 2015; Van Meter & Garner, 2005; Van Meter, Aleksie, Schwarts, & Garner, 2006).

Purpose of the Study

The study participants are middle school students enrolled in a private school in the Southeastern United States. School admission requires the students to complete a thorough admissions process including the submission of an application and transcripts, standardized test scores, teacher recommendations, and a day visit and interview. Enrollment in the school is voluntary. Families who enroll their children pay tuition annually. The school embraces diversity ethnically and socioeconomically. Financial aid is available to faculty members and school families. While students enrolled at the school have participated in and cleared an admissions process, the population is comprised of students with varied ability and includes students with diverse learning profiles including students diagnosed ADD, and language-based, reading, math, and writing learning disabilities. This study, unlike many conducted in a clinical setting, will take place in students' daily learning environment, their science classroom.

The purpose of this research is to determine the effectiveness of active, multimedia learning strategies, based on cognitive science principles, in a regular, private school classroom setting. The study will evaluate if an active, multimedia vocabulary intervention that features learner-generated drawings and peer interactions focused in discussion and collaboration increases student retention of science vocabulary terms presented to the students. The study will measure the students' acquisition and retention of science vocabulary words to assess if the active, multimedia intervention yields greater learning and retention results than the passive vocabulary intervention - read, copy, and study the terms.

Need for the Study

A twenty-first century which demands the cultivation of students and professionals who are prepared to lead technological advancements and to drive innovation is at the heart of the shift to modernize educational models. The current educational design must shift from preparing students for work in the agricultural production and the factories of the industrial revolution of the past 100 years to the current world of technology and automation and to preparing students for fields where innovation is rapidly evolving from ideas not yet realized. On all fronts, the United States government, global industry, and institutions of higher education have grave concern for the deficit of qualified, able human resources in the fields of science and technology that are vital for national security, global advancements, and economic development (Andree & Hanson, 2014; Poland & Plevyak, 2015). In order to prepare students for a future to support the global and economic demands of advancing technology and innovation, and to prepare technology leaders who can staunchly defend our country from cyber-attacks that will depend on a foundation of scientific prowess, it is critical to prioritize science instruction.

In order to foster a learning culture that makes science both approachable and available to all, educators must implement research-based, cognitively impactful methods of teaching and learning. Teacher-centered, textbook driven, lecture-based science instruction is predominant in secondary classrooms and is a widely accepted instructional model, yet is relatively ineffective (Groves, 1995; Freeman, Eddy, McDonough, Smith, Okoroafor, Jordt, & Wenderoth, 2014) "Approximately 38% of fourth graders, 34% of eighth graders, and 22% of twelfth graders achieved a level of proficient or higher on the 2015 NAEP (National Assessment of Educational Progress) science assessment" (NSB, 2018, p. 1) and the current gap between middle school and high school student science achievement indicates the need to focus on middle school science instruction. This middle school focus may indeed be the tipping point to position students for success in science as they enter high school and intuitions of higher education. The implementation of the most effective instructional strategies to build a firm science vocabulary foundation which will enhance science concepts mastery and will support the students' successful pursuit of rigorous science course offerings in upper secondary education and higher education settings, and in turn will promote student scientists for the future.

National and local responses to bolster lagging science achievement have resulted in an explosion of STEM magnet schools and an increased high school and early college focus on science and technology courses for career readiness. Additionally, private and charter schools have also implemented STEM and science focused programming to address national science deficits with many marketing themselves as an answer to the failing instructional model practiced in public schools.

This study investigates the implementation of student-centered, active learning processes for science vocabulary interventions aimed at improving learning for middle school students. When students practice information retrieval, learning is improved (Purrell, Erdie, & Kasay, 2017) and vocabulary retention also increases (Craik & Lockhart, 1972; Conway & Gathercole, 1987; Karpicke & Aromb 2010; Matcalfe & Kornell, 2007; Slameka & Graf, 1978). Thus, increased retrieval and vocabulary retention positively impact student understandings and increase content retention "In the U.S. Department of Education's study, Organizing Instruction and Study to Improve Student Learning (Pashler et al., 2007), …(t)he study found the most effective strategies for increasing learning are using quizzes to re-expose students to information and helping students build explanations by asking and answering deep questions (Pashler et al., 2007)" (Purrell et al., 2017 p. 68). "Metacognitive skills, in addition to self-regulated learning, help the learner to plan, monitor, and evaluate. Thus, educators should consider strategies and techniques to reinforce self-regulated learning (SRL) through the metacognitive practices (active learning), which reinforce motivation toward learning" (Purrell et al., 2017, p. 69). Shore et al. (2015) state,

> research is needed to better define and categorize which specific activities or combination of activities are associated with the accepted cognitive science principles and effects. Even more importantly, once defined and designed, these instructional strategies need to be tested in typical American classrooms with today's teachers (p. 236).

Higher education upper secondary education settings have conducted similar research to this study, but this study replication is conducted in a middle school classroom setting, a pivotal environment to influence long-term science achievement outcomes, as well as, the course of study selection and career trajectories.

Research Questions

1) How will the active, multimedia learning strategies of student-generated drawing combined with discussion effect student acquisition and retention of content specific science terms when introduced as a study method in middle school science classrooms compared to passive models of learning: reading, copying, and independently studying science terms based on post-intervention assessments?
2) How will student reading ability, as measured by reading level, following the intervention of active, multimedia learning strategies of student-generated drawing combined with discussion effect student acquisition and retention of content specific science terms when introduced as a study method in middle school science classroom based on post-intervention assessments?
    a) How will below grade level readers perform on post-intervention assessments?
3) How will the active, multimedia learning strategies of student-generated drawing combined with discussion effect male vs. female student acquisition and retention of content specific science terms when

introduced as a study method in middle school science classrooms compared to the passive model of learning: reading, copying and independently studying science terms based on post-intervention assessments?

4) How will student performance on the science vocabulary pretest predict posttest performance following the active, multimedia learning strategies of student-generated drawing combined with discussion and the passive model of learning: reading, copying, and independently studying science terms?

Research Process

This retention study, using the active, multimedia intervention to measure vocabulary acquisition and retention, is conducted with 267 middle school students, grades 6, 7, and 8, from a large, local, suburban JK-12 private independent school in the southeast. The researcher will collaborate with the three science teachers who make up the middle school science department to determine the 20 specific science vocabulary words for the study's interventions using 10 vocabulary words for each list, List 1 and List 2. In each grade level, two intervention sessions will be selected to test the two interventions. The first intervention (10 words) introduces the active learning strategy using multimedia principles of learner-generated drawing and learner collaborations through peer discussions. The passive intervention (10 words) introduces the more passive learning strategy, implementing independent studying, copying terms and reviewing independently.

The science teachers in collaboration with the researcher will determine the class sections, representing half the total number of class sections, will be the first to receive the active, multimedia intervention using grade 9 physics course of study vocabulary words and thus, will receive the passive learning intervention next. Conversely, those students who receive the passive learning intervention in the first session will receive the active, multimedia intervention in the second session. Immediately following both intervention treatments, the students will take a post-intervention assessment to determine the level of retention of the ten vocabulary words presented during the intervention. The following day, twenty-four hours later, the students will take another, identical in content, but varied in presentation, posttest to determine the retention level of the same ten vocabulary words presented in the previous day’s intervention, active or passive.

Before the interventions, the teachers, in collaboration with the researcher, will select twenty words from the grade 9 physics course of study. Because the grade 9 physics course content is unknown to middle school students, the corresponding vocabulary is expected to be unfamiliar to the students; therefore, the students, as anticipated, will have limited prior knowledge. A vocabulary pretest was conducted to have an accurate representation of the students' prior knowledge with the physics content vocabulary and to ensure the ten vocabulary words introduced in each of the two interventions are unknown to the participating students. All pre-selected vocabulary words from the physics course of study to yield pretest and posttest data will be used to determine levels of vocabulary acquisition and retention. Following the pretest and before the interventions, the grade 9 physics content vocabulary lists, each of ten words, will be approved by the university professor leading the researcher. The list of words, including their definitions, will be used by the researcher to create a vocabulary study sheet for distribution to students as part of the vocabulary interventions study.

The active, multimedia and passive interventions, conducted in the classrooms, are for a thirty-minute duration. Students in the classes participating in the active, multimedia intervention will create drawings, for 15 minutes, to represent the grade 9 physics course of study pre-selected vocabulary words presented by the teacher using a study sheet created by the researcher and will then discuss them, for 15 minutes, with their peers for a total intervention time of 30 minutes. Students in classes participating in the passive intervention will read, copy, and review the physics course of study pre-selected vocabulary words presented by the teacher using a study sheet created by the researcher for 30 minutes. Both treatment models, active and passive, will last for thirty minutes. Immediately following each of the thirty-minute interventions, the students will complete a digital assessment designed to show retention of the science vocabulary terms.

For this study, the post-intervention assessment, drafted by the researcher, will use identical vocabulary, definition of terms, and language to create assessments to mirror the study sheets utilized during each intervention closely; however, the terms, varied in order, will be used on the assessment from the study guide and the first and second assessments. This adherence to the original study guide language will ensure students do not have to incorporate any additional cognitive strategies or demands in addition to those evaluated in the study. The assessment will be completed using a school-issued Apple iPad Pro that students regularly use as a part of the school's one-to-one device initiative. The assessment will include ten definitions introduced to the students during the interventions. Each definition presented on the assessment will have a drop-down list of all ten vocabulary terms to select the matching term to its definition. Students complete the assessment. Both their responses and grades automatically record in the Google Forms application. To determine student retention of the vocabulary word meanings from the interventions, students will complete the assessment immediately following the thirty-minute interventions with no teacher support. To determine the students' retention of the vocabulary word meanings after twenty-four hours, a second assessment with identical content, but altered in order from the first assessment will be completed by the students, again with no teacher support.

Delimitations

This study will include three teachers and 270 students in 15 middle school science class sections in grades 6, 7, and 8. Each grade level has a specific science course of study; grade 6, physical science, grade 7 life science, and grade 8 earth science. This study focuses on middle school students; therefore, neither elementary nor high school students are included.

Unlike many studies conducted in public school settings, the researcher is not required to strategically select students or be cognizant of specific grade levels or science courses of studies' state administered end-of-grade or end-of-course test because the students in this study are private school pupils that do not, like public school students, complete public school required state tests. Additionally, because the students are in a private, college preparatory school, with an extensive admissions process and protocol, the range of student ability may vary from that of a public school environment. However, the private school selected for the study does have an academic support program that provides a range of academic support for students with diagnosed learning disabilities that vary in intensity. The program includes support for students through student academic plans, student accommodations - both in the classroom and on tests, tutor support, and an academic support course offering for students who meet the criterion for more intensive intervention. Students who qualify for the academic support course have an average or above average IQ score range and have a diagnosed learning disability that requires more intensive classroom support that may, but not always, require long-term academic intervention to support academic progress.

The academic support course is not a self-contained learning environment; instead, it is one of six class sections in the official middle school schedule. The design models that of a learning resource setting. Students in middle school are required to complete three years of science courses and three years of math courses. While science classes do not have differentiated offering levels, math courses which can impact science achievement, are differentiated. Students in grade 6 may enroll in either honors or college-prep grade 6 Math. Students in grade 7 may enroll in either college prep grade 7 Math, Pre-Algebra, or Algebra 1. Students in grade 8 may enroll in Pre-Algebra, Algebra 1, or Geometry. The school uses five different data points, including standardized test scores and an assessment that analyzes overall math acumen including algebra concepts, to determine math readiness for all offered courses.

Limitations

Students with learning differences may have difficulty with various elements of the interventions. Students with language-based disabilities, dyslexia, dysgraphia, and language processing may struggle with interventions that are heavily text and reading dependent (Seifert & Espin, 2012). Students with short-term memory deficits may struggle to hold the newly introduced information in their short-term memory, which may, therefore, impede information transfer from short term to long-term memory. This disruption in transfer may impact vocabulary retention, both short-term and long-term (Clark & Mayer, 2008; Mayer, 2005; Shore et al., 2015; Stull & Mayer, 2007). Weak overall processing speed may, for some students, create a challenge to process the information in the allotted time, thirty minutes, for each intervention. Students who struggle with accessing prior knowledge may be inefficient and ineffective when attempting to generate drawings during the active, multimedia intervention. The learner is required to use reasoning skills to create and organize drawings based on prior knowledge when constructing learner-generated drawings (Van Meter & Garner, 2005; Mayer, 2008; Mayer & Johnson, 2008). Constructing irrelevant learner-generated drawings consume valuable territory in the working memory (Clark & Mayer, 2008; Mayer, 2005; Shore et al., 2015; Stull & Mayer, 2007).

Students with ADD (Attention Deficit Disorder) may have difficulty focusing on the requirements of the intervention to maintain sustained focus for the full thirty-minute intervention. Additionally, the structure of the passive intervention and passive learning by definition may impede the implementation of the intervention. Because of the limited interaction between teacher and student, the teachers will potentially have no ability to discern if a student has remained actively, cognitively engaged during the reading and copying process and fully utilized the allotted time during the passive intervention.

Assumptions

The active, multimedia intervention engages multiple learning modalities that increase the impact of cognitive engagement that influences effective retention and commitment to long-term memory. During the active, multimedia intervention, which incorporates reading, drawing, and speaking, engages numerous segments of the brain. The frontal lobe is engaged when speaking and writing; the temporal lobe is engaged in understanding language, auditory input (hearing), and memory; the parietal lobe deciphers signals of what visual input (vision) and what auditory input (hearing); and the occipital lobe is the gatekeeper for planning, problem-solving, and concentration (Blakemore & Frith, 2005). Because of the increased cognitive engagement during the learning process stimulated when implementing the active, multimedia intervention, it is the assumption that the active, multimedia intervention will yield greater retention results than those from the passive intervention of reading, copying, and independently reviewing.

The students, it is assumed, identified as proficient readers will potentially perform well with both the active, multimedia vocabulary intervention including reading, drawing, and talking and the passive vocabulary intervention including reading, copying, and independently reviewing (Shore et al., 2015). Additionally, students who have reading deficits, including a diagnosed reading disability, are assumed to have more difficulty with comprehension, thus impacting their retention and memory. Research shows that when students have reading skill deficits, content comprehension is impacted (Hawkins, Hale, & Ling, 2011). It is also an assumption that students with strong reading ability will perform well on both the first and second assessments because of the decreased cognitive load demand (Blakemore & Frith, 2005), resulting in greater ability to engage short and long-term memory structures.

Because students with reading deficits struggle with comprehension, researchers believe that students, when interacting with text-heavy content, rely on discussion and pictures to engage the compensatory strategies, both visually and auditorily, to understand the information they cannot grasp during the reading and comprehension processes (Shore et al., 2015). Based on this premise, it is the assumption that the active, multimedia intervention will yield greater retention results for students with reading deficits than those from the passive intervention of reading, copying, and independently studying.

Along with the nation's increased emphasis on science achievement over the past sixty years, the past twenty years has also ushered in the age of gender equality resulting in initiatives and programs designed to encourage females to pursue courses, degrees, and careers in the sciences. During this study, the researcher overhead a young girl comment to her father, "Daddy, did you know Barbie was a doctor?". This comment is an authentic example of the cultural shift surrounding females and science. While males currently outperform females on national and international assessments (NCES 2017; NSB, 2018;

OECD 2007; Poland & Plevyak, 2015), it is the assumption that the active, multimedia intervention will yield equivalent results for male and female students.

Definition of Relevant Terms

The following are defined terms associated with and relevant to this study:

Active learning techniques

Based on the foundations of constructive and interactive learning, student-centered strategies that focus on self and peer critiques (Carr, Palmer, & Hagel, 2015; Shore et al., 2015). In this model, the cognitive engagement of the students is critical to the learning process. Included in the study are the active learning techniques - drawing and discussing. These strategies will be applied to grade 9 physics vocabulary terms.

Peer Discussion/Collaboration

Process in which students engage with their peers to orally share, explain, and discuss concepts, ideas, and information (Lin et al., 2015).

Learning

The cognitive process that occurs when the learner's brain is engaged during interaction with the environment to acquire information and skills (DeHouwer, Barnes-Holmes & Moors, 2013).

Multimedia Learning

A theory developed by Mayer based on an instructional model that simultaneously utilizes two or more learning modalities to maximize learning, for example, students use diagrams and drawings to facilitate discussions based on information presented via text or written form (Mayer, 1997; Mayer & Massa, 2003; Mayer, 2008).

Passive learning techniques

A teacher-centered, direct instruction model that is hallmarked by teacher lecture and rote copying and independent review.

JK-12 College preparatory school

A private, independent private school that serves students in grade JK, junior kindergarten, typically students who are 4-5 years old through grade 12. The school's curriculum and academic program are rigorous and designed to prepare students for college and beyond.

Organization of the Study

Middle school students in a JK-12 private, independent school will participate in a study to determine the effect of two different vocabulary learning interventions. Using grade 9 physics vocabulary, students will engage in an active, multimedia intervention where students both draw and discuss the ten new vocabulary words presented by the classroom teacher. The second intervention is a passive vocabulary intervention where students will read, copy, and independently study ten grade 9 physics vocabulary terms. Following each intervention, students will complete an online assessment written by the researcher using language that mirrors that of the study guide presented to the students.

The following day, the students will take a second assessment that also mirrors the study guide language, but in a new order. The assessments for this study are to measure the students' retention and mastery of vocabulary words practiced during the two interventions, active, multimedia learning method and the passive learning method. When students use the active, multimedia intervention, it is anticipated they will learn and retain more of the presented science vocabulary terms than when they use the passive learning intervention method.

In Chapter 1, the introduction, provided the history and background of the state of science education in the United States. National reports and data indicated science achievement continues to wane. It is imperative that more innovative, research based instructional strategies need to be implemented in the 21st-century classroom. Chapter 1 stated the significance of the study is based on the active, multimedia vocabulary intervention to positively impact vocabulary acquisition and retention. Chapter 2 included a literature review outlining numerous studies highlighting the effectiveness of learner-generated drawing and peer discussion for increased cognitive engagement and student learning. The literature review also presented emerging research in multimedia instructional methods. Chapter 3 presented the quantitative research design and methodology, participants, variables, the active and passive vocabulary interventions, and the study's procedure. An explanation of the data from the ERB (Educational Records Bureau) CTP 4 (Comprehensive Testing Program) and Lexile reading levels, including the test of reliably and validity for the CTP 4, are defined. The study compared student outcomes from the active, multimedia intervention compared to the passive vocabulary interventions. The study also evaluated participants pretest posttest performance, the impact of participant reading levels and the impact of gender on assessment performance outcomes. Chapter 4 reported the findings of this study and Chapter 5 discussed the implications on science education and instruction and future areas of research.

CHAPTER TWO: LITERATURE REVIEW

Overview

The concerning state of science education and applied innovations at the national level dates back to the launch of Russia's satellite, Sputnik, in 1957 when the United States was shaken from complacency and urgently entered the Golden Age of Science that endured until 1976. A mere seven years later, in 1983, an eighteen-member commission was formed to assess the current state of American schools during the Reagan administration and released the "A Nation at Risk" report that highlighted the need for extensive school reform. "A Nation at Risk" made thirty-eight recommendations for educational reform citing the concerning state of underperformance, lack of career preparedness, and lagging national and global achievement statistics.

As American educational reforms and improvement initiatives progressed over the next three decades: Project 2016 (1993); No Child Left Behind Act, The Math and Science Partnership Program (2002); American Competitive Initiative (2006); A Nation Accountable (2008); America COMPETES Reauthorization Act (2010); Next Generation Science Standards (2010), the country began to incorporate a myriad of programs and initiatives designed to address failing or flat-lining scores and deficient global achievement representation, particularly in the area of science.

The most recent National Science Foundation, Elementary and Secondary Mathematics and Science Education report indicated that less than half of students tested in grades 4, 8, and 12 achieved proficient (solid academic performance) on the 2015 NAEP (National Assessment of Educational Progress) test (NSB, 2018). "Approximately

38% of fourth graders, 34% of eighth graders, and 22% of twelfth graders achieved a level of proficient or higher in the NAEP assessment in 2015" (NSB, 2018, p.1).

When dissecting factors that contributed to the mediocre scores, some contributing factors emerged: 1) increased curricular volume and rigor; 2) staid, passive instructional practices have impacted science achievement. Increased content in both volume and rigor, much of it presented using the transmission model (passive, direct instruction strategies) resulted in students who were overwhelmed, disengaged, and detached from effective learning processes; and 3) low student reading levels that impact all areas of learning, including science. Specifically, science instruction tends to be textbook-centered, with an emphasis on rote memory and the acquisition of an overwhelming amount of content-specific vocabulary, terms not typically found in day-to-day language experiences for students (Groves, 1995; Yeager, 1983).

Additionally, variable sources of funding and volatile economic shifts impact school and program monies. Fully equipped science labs are costly and consumptive requiring ongoing funds to maintain plentiful resources. As a result, textbooks have become the default instructional resource for science instruction in schools. Notably, in secondary school settings, not only does fiscal economy impact learning but high stakes, high accountability schools also create a pressure cooker atmosphere where an abundance of time is scarce. As a result, teachers default to direct instruction, reading the textbook, and teacher lecture (Betts, 2009; Crocco & Costigan, 2007; Shore et al., 2015).

Another critical factor in school performance, including science performance, is student reading levels. Student reading ability directly impacts all academic areas (Lai, Wilson, McNaughton, & Hsiao, 2014). Student mastery of both reading vocabulary and content-specific vocabulary directly impacts student reading comprehension and content understandings (Moje, 2008). Therefore, students with average to above average IQs with diagnosed reading disabilities typically measure reading below grade level on both formal and informal reading assessments. The causal analysis of student reading permeance reveals that vocabulary knowledge, or lack thereof, is a crucial variable for students below average or below grade level reading performance (Allington, 2012).

In addition to the country's science score deficits, research indicates that American students' reading scores are equally depressed. According to the NAEP (National Assessment of Educational Progress) (2017) reading results, national scores for students in grade 4 were as follows: 9% were identified advanced; 27% were proficient; 31% were basic; 32% were below basic. National scores for students in grade 8 were as follows: 4% were identified as advanced; 32% proficient; 40% basic; 24% below basic. The 2017 NAEP report did not include reading data for grade 12 students, but the 2015 NAEP report indicated the reading level percentages for students in grade 12 were as follows: 6% were identified as advanced; 31% proficient; 35% basic; 22% below basic. Students in grades 4 and 8, when combining basic and below basic data, 64% of the population is performing at a level below what NAEP classifies as proficient. Using the same paradigm, 57% of students in grade 12 were identified as performing below proficient.

Establishing firm foundations of middle school science instruction is vital to building student readiness for secondary and post-secondary science courses of study.

Poorly prepared students who are disengaged are less likely to pursue more complex science content (Poland & Plevyak, 2015). To foster learners who are ready for the 21st-century workforce, we must implement 21st-century teaching methods and learning standards. A change in instructional strategies from passive models of learning to active, multimedia learning environments is needed. Research indicates students who are actively engaged in their learning are more likely to learn the content and to improve retention (Chi & Wylie, 2014).

Constructivist Learning Theory and Generative Learning

Beginning with early learning theorists, learner engagement in experiential, active learning models positively impacts student learning. John Dewey theorized and promoted the importance of learners authentically experiencing learning tasks. Piaget's constructivist learning theory, a nod to Dewey's work, emphasizes that students learn by doing. Piaget's (1926) theory of cognitive development and emphasis on prior knowledge is also an important factor in learning and cognition.

Following Piaget, Bartlett (1932) presented that learning is an act of construction. Wittrock (1972, 1989), influenced by the early theorists and psychologists, presented his theory of generative model of learning. Learners "generate perceptions of and meanings that are consistent with their prior knowledge" (Whittrock 1974, p.88). Whittrock's generative model of learning gave life to Mayer's (2009, 2011, 2014) select-organize-integrate (SOI) model, a subset of Mayer's (2009, 2014) multimedia learning theory.

Mayer's (2009, 2014) SOI model proposes that three cognitive processes based in types of memory, sensory, working and long-term, are essential to the learning processes

(Fiorella & Mayer, 2016). Generative learning, "helping learners to actively make sense of the material so they can build meaningful outcomes that allow them to transfer what they have learned to solving new problems" is foundational for all students (Fiorella & Mayer, 2015, p. vii). Generative learning helps to solidify understanding and create personal connections to prior knowledge (Fiorella & Mayer, 2015). Menekse, Stump, Krause & Chi (2013) found that in order for learning to occur meaning is formed based on the experiences of the learner. Interactive, constructive learning activities have significantly greater impact than passive learning activities (Meneske et al., 2013). The generative learning activity of learner-generated drawings fosters student engagement and active learning and helps the learner to develop deeper understandings by linking the cognitive process to prior knowledge (DeJong, 2005; Whittrock, 1990). The cognitive theory of multimedia learning (Mayer, 2009) and generative theories (DeJong, 2005; Van Meter & Gardner, 2005; Whittrock, 1990) is the basis for the study.

Students in this study will participate in the generative theory of learning by accessing prior knowledge to link to new learning as they plan their drawings. Students will then generate drawings of presented science terms. They will be cognitively engaged in the learning process, cognitive theory. Following the drawing session, the students will participate and actively engage in discussions about their drawings and the science terms, a multimedia learning strategy. This study is to determine if active strategies have a more significant impact on information retention than that of passive learning strategies.

The Framework of Learning

2.1 Passive: Reading and Copying Passive learning strategies, particularly in secondary classrooms, are teacher-centered with lecture, note-taking, and copying content from the textbooks. Many teachers utilize handouts and digital presentations to support classroom lecture which requires little to no student interaction. This transmission model of instruction creates and allows students to be passive learners who are uninvolved and disengaged. Disengagement removes students from the learning process and circumvents the important cognitive process. The learning strategy of copying notes or information from the board, a textbook, or a digital presentation is a passive learning activity (Chi & Wylie, 2014). D. Van Blerkon, M. Van Blerkon, and Bertsch (2006) found that generative study strategies are more effective than passive strategies. Copying text is a non-generative strategy. Students do not cognitively engage when they copy information (Van Blerkon et al., 2006). Research has found that in the hierarchy of study skills and learning strategies, copying is only singularly better than rereading text (Benassi, Overson, & Hakala, 2014).

For the average learner passive learning strategies are at best ineffective, but for students with reading difficulties, passive strategies compound the learning short circuit. Students with reading difficulties struggle to process content when delivered by the passive methods of reading and copying (Freeman, Eddy, McDonough, Smith, Okoroafor, Jordt, & Wenderoth, 2014). In today's classroom, the widely implemented passive learning strategies are woefully ineffective. Freeman et al. (2014) conducted a meta-analysis of 225 studies focused on STEM learning environments and evaluated student performance in courses that were passive, lecture-based versus active. Their meta-analysis found that students in classes with passive delivery methods were 1.5 times more likely to fail.

2.2 Cognitive Theory of Multimedia Learning

Based on Sweller's (1988) cognitive load theory, the amount of effort used by working memory during a cognitive task causes learners to have two different pathways for processing auditory and visual information, the dual channels assumption. Learners have a limited capacity for the amount of data they can process at any one time (Harskamp et al., 2007). "Meaningful learning occurs when learners engage in active cognitive processing during learning including paying attention to relevant visual and verbal material, mentally organizing the selected material into a coherent representation, and integrating the incoming material with existing knowledge (Harskamp et al., 2007, p. 466).

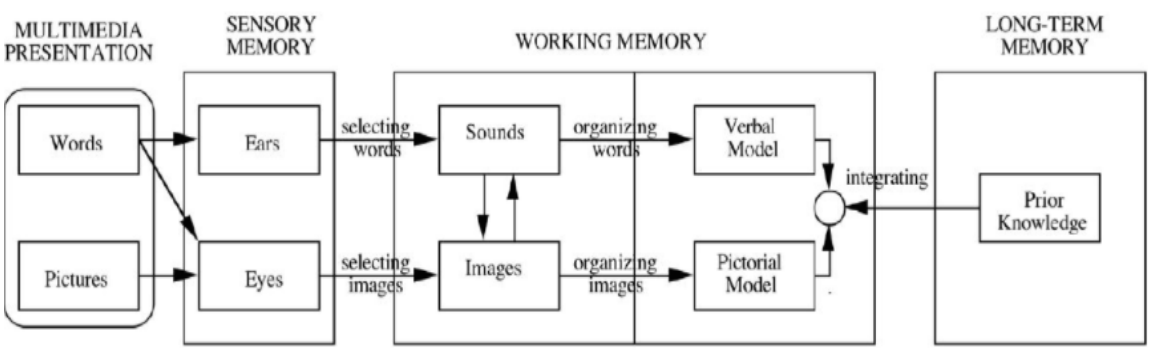

Figure 1: Cognitive theory of multimedia learning

Clark and Mayer (2008) outline all the components of the cognitive theory of multimedia learning: memory processes, learning processes, types of cognitive load and the multimedia instructional model goals (See Figure 1).

The cognitive theory of multimedia learning, based on three cognitive science principles of learning, includes the following:

1) Dual coding principle: Learners have separate learning channels for words and visuals.
2) Limited capacity principle: Learners can process only a limited amount of information in working memory at any one time.
3) Active learning principle: Learning occurs when learners engage in appropriate cognitive processing during learning.

The cognitive theory of multimedia learning specifies five cognitive processes in multimedia learning:

1) selecting relevant words from the presented text or narration
2) selecting relevant images from the presented graphics
3) organizing the selected words into a coherent verbal representation
4) organizing selected images into a coherent pictorial representation
5) integrating the pictorial and verbal representations and prior knowledge

Three demands on the learner's cognitive capacity during learning are:

1) extraneous processing (which is not related to the instructional objective)
2) essential processing (which is needed to mentally represent the essential material as presented)

3) generative processing (aimed at making sense of the material).

Three instructional goals are to:

1) reduce extraneous processing (for extraneous overload situations),

2) manage essential processing (for essential overload situations), and

3) foster generative processing (for generative underuse situations)".

(Mayer, 2008, p. 5-7)

According to Mayer's instructional goals for multimedia instruction, teachers who implement strategies that are aligned with the cognitive theory of multimedia learning will manage and balance all the elements to maximize student learning. According to Mayer, Moreno, Boire, and Vagge, (1999) "Multimedia learning is enhanced when the learner can hold both visual and verbal representations in their working memory at the same time (Mayer et al., 1999, p. 642). The multimedia learning theory integrates both visual and auditory channels, dual coding, to move information into the working memory (Mayer, 2001; Fensi, Sana, Kim & Shore, 2015; Shore et al., 2015). When the learning process actively engages both auditory and visual modalities, dual coding, cognition, and learning are improved (Moreno, Mayer, Spires & Lester, 2001).

Multimedia learning strategies reduce the working memory load which allows learners to prioritize and process relevant information (Mayer et al., 1999). Research indicates that in the implementation of multimedia learning strategies, interventions that include the spoken word, as opposed to the written word, are more effective (Harskamp et al., 2007). Mayer's (2001, 2008) SOI model contends that deep learning depends on the cognitive process of selecting, organizing, and integrating. One of the ways educators can ensure they are actively engaging the student is by designing student-centered learning strategies. Additionally, students who work with a partner can enrich their understanding by collaboratively constructing knowledge with their partner (Menekse et al., 2013).

The student-centered intervention strategies used in the study are to evaluate how students process new information. Teacher-centered instruction emphasizes - lecture and notes, it is essential to focus on the student and their learning process to ensure the implementation of effective learning strategies (Menekse et al., 2013).

Students who engage in multimedia learning strategies stimulate the cognitive learning process through learner-generated drawing and collaborate discussions with their peers. This student-centered instructional model is a form of self-regulated learning because students have to monitor their learning while completing the learning tasks (Leopold et al., (2007); Van Meter, 2001; Van Meter & Garner, 2005). Self-regulation enhances cognitive learning.

2.3 Multimedia Strategies

Unlike passive learning strategies where the teacher is the "sage on the stage" and students "sit and get," multimedia instructional strategies employ multiple, research-based strategies to maximize student learning (Clarke & Mayer, 2008; Fiorella & Mayer, 2015). Chi (2009) finds passive learning spaces are challenging for students because they are unable to interact with and in their learning environment.

Mayer (2015) has conducted extensive research in the area of multimedia learning strategies has expanded on eight active multimedia strategies for student learning. They are: summarizing, mapping, drawing, imagining, self-testing, self-explaining, teaching, and enacting.

Strategy one is summarizing. Typically, students read text or a chapter from their textbook and summarize it using a sentence for each paragraph. Students that summarize must find the main idea, a difficult task for students, and identify the crucial elements of the content and write their summary. Summarizing is not limited only to recording from textbooks. Any form of content delivery, picture, film, lecture or animations can be used to complete a summary (Fiorella & Mayer, 2015). Summarizing can be completed at any time during the unit of study as a front-loading activity or as a cumulative review.

Mayer's second strategy is mapping. When mapping, a student breaks down text and concepts and organizes them into graphic organizers to create a picture or graphic representation of the material. The map allows the student to interact with the information and to organize potentially large amounts of information into manageable, easy to see parts. Fiorella & Mayer (2015) call mapping a visual roadmap of information that allows the learner to compare and contrast concepts. Another learner benefit for mapping is the opportunity for the learner to evaluate how elements of the content are related. Through the process of mapping, the learner has to identify key concepts and prioritize the critical information.

Drawing, the illustration of text-based content, is Mayer's third active learning strategy. Students not only have to draw the new information they have learned, but they also have to cognitively plan when preparing to generate a drawing. The act of drawing engages the brain, but the act itself may also create undue or unexpected stress in the learner. If some students have difficulty with the physical act of drawing, that struggle, rather than the content may become the learner's focus. Mayer (2015) presents that supported learner-generated drawings lead to more successful drawings and a decrease in the stress on the cognitive load. Drawing support may include the teacher coaching a student or providing a partially complete drawing for the student to complete. When students draw to support learning a new concept, they must first create a mental image of their drawing.

The fourth active learning strategy is imagining. In the imagining learning strategy students are instructed to create a mental image of the content delivered through text. Through the process of imagining students have to manipulate and organize information spatially and also are in a position to compare and evaluate causal relationships. In Clark and Mayer's study (2008) students were instructed to select, organize and integrate implementing Mayer's SOI model for learning. In classroom settings, when teachers are coaching students to utilize the imagining strategy, they will instruct the students to make a movie in their mind to represent what they just read in the text.

In the fifth strategy, self-testing, students answer questions about previously presented material which enhances memory recall without using a textbook or information resource while implementing the strategy. Students create and answer self-made practice tests and previously reviewed material to improve their understanding and recall of the information (Fiorella & Mayer, 2015). To increase the results of the self-testing strategy, corrective feedback and generative test-question types - free-recall and cued recall, consistently improve recall of studied information. While this method has been shown to be effective with previously learned material, the strategy's impact on more complex, application-based questions is inconclusive. Self-testing is a metacognitive strategy where students reflect on their level of understanding then they are can focus on the content they have not yet mastered to direct their learning (Roediger, Agarwal, McDaniel, & McDermontt, 2011).

Strategy six, self-explaining, is when a learner reads new information from text or diagrams and makes connections to prior knowledge and builds their understandings by explaining the concept in their own words during learning. The student is learning by self-teaching (Fiorella & Mayer, 2015). In this process, the learner must identify the essential elements of the content, organize the information into an understandable mental model and then must make connections with new information to their existing prior knowledge base. The student must self-reflect and evaluate their understanding to identify areas where they are missing understanding and fill the gaps with the missing content (Chui & Chi, 2014).

In the seventh strategy, teaching involves students reading and studying new material and teaching what they learned to someone else. Students, when informed that they will be teaching the information to others before reading and studying, increased their recall and improved the effectiveness of the intervention.

Strategy eight, enacting, is when a learner engages in movement that directly relates to the content they are learning. This strategy, commonly seen in drama and theater-based classes, but it has applications in any classroom setting. Students' prior knowledge strength and the ability to connect to the new information is essential for the strategy's success. Coached students, guided how to connect the motions to more complex, abstract principles, increases the strategy's effectiveness.

In this study two active, multimedia strategies will be integrated into a classroom learning intervention. During the intervention, the study subjects will create student-generated drawings and will engage in peer discussion (teaching). The students will engage their dual processing pathways by drawing, a visual process to intake information, and discussion, an auditorily intake information. Additionally, the multimedia strategies of imagining and self-explaining will be engaged during the active, multimedia intervention.

2.4 Peer Discussion

Humans, as cognitive science and psychology indicate, are social beings. Interaction with other people is imperative for social and cognitive well-being. Therefore, it is not surprising that studies indicated that human learning improves when people participate in both interactions with self and interaction with others. Slemecka and Graph (1978) conducted a study to determine better methods for recall with words. They found that learners who produced a word from a cue had better results with word recall that of the learners who merely read the word. Slemecka and Graph called this the Generation Effect.

Similarly, the Production Effect as researched by MacLeod, Gopie, Hourihan, Neary, & Ozubko, (2010) is defined as "the fact that producing a word aloud during study, relative to simply reading a word silently, improves explicit memory" (McLeod et al., 2010, p. 671). McLeod et al. (2010) continue to explain production as "bringing unique processing of an item at the time of the study, conferring distinctiveness upon the item" (p. 673). The Production Effect through the interaction with words and concepts by speaking them engages the learner in a cognitive process that helps the student to better retain the information as compared to a student who reads information silently (Forrin, MacLeod, & Ozubko, 2012; Hassall, Quinlin, Turk, Taylor, & Krigolson, 2016, McLeod et al., 2010). Quinlan & Taylor (2013) also determined that mixed verbal production methods such as singing also have a positive impact on recall. Additionally, other production methods, including silently mouthing words to self (McLeod et al., 2010), saying them aloud (Hourihan & MacLeod, 2008) and writing and spelling the words (Forrin et al., 2012), improve memory.

To enhance the production effect and to provide the learner with both purpose and practice, peer collaboration compounds understanding. When students speak the words that were read and can both discuss and listen to peer learners who are studying the same content and terms it increases engagement and retention. Interestingly, (Lin, Anderson, Nguyen-Jahiel, Kuo, Dong, Jadallah, Baker, Kim, Miller, & Wu, 2010) conducted a study that found that while students rarely emulated thinking strategies presented by their teacher, they would readily emulate those of their peers. Chi (2009) found that learning occurs when students listen to one another. When two or more students interact (Lehtinen

& Viiri, 2014) and actively engaged in a discussion, they both contribute to each other's learning (Chi & Wylie, 2014). When peer learners interact while learning new concepts, they engage in collaborative reasoning (Lin et al., 2015). One collaborative classroom model is the think, pair, share strategy (Bonwell, 1997). The think, pair, share strategy (TPS) involves students pairing to collaborate to either answer a question or to problem solve based on an assigned reading passage (Bonwell, 1997). In an active learning model, the TPS construct is extended to include student debate or argument in addition to asking and answering questions (Fiorella & Mayer, 2015).

2.5 Drawing

Beginning with man's early scribblings on cave walls, human communication through the use of drawings has been an essential element of humanity. Because much of the structure of drawing represents unverbalized knowledge, an observer must carefully study a rendered drawing to fully understand and comprehend what is being communicated and represented through drawings (Van Sommers, 1984). While traditional learning models lean heavily on the direct instruction based in lecture, a growing body of research reaching back over the past thirty years suggests that text illustrations have impactful effects on student learning (Levie & Lentz, 1982; Mandl & Levin, 1989; Mayer, 1989, 2001, 2008, 2015; Willows & Houghton, 1987). Levin (1981; Levin, Anglin, & Carney, 1987) has presented five functions of text illustration: 1) decorative - drawing low in relevance and high in enjoyment; 2) representation - illustrations used to help a reader visualize a person, place or occurrence; 3) transformation - illustrations focused on helping a reader hone in on key concepts; 4) organization - illustrations that help bring order or structure to content; 5) interpretation - illustrations that help foster understanding by the reader. Illustrations are a powerful tool to support text-based content. Taking illustrations one step forward, learner-generated drawings, actively engaging the body and brain in the interactive learning process takes learning and cognition to the next level. (Fiorella & Mayer, 2015).

The implementation of self-generated drawing as a learning strategy significantly reduces the learner's cognitive load, especially if the student receives coaching on drawing strategies or is provided a partially completed drawing (Fiorella & Mayer, 2015). While many passive learning strategies foster disengaged learners, the implementation of drawing and a learning strategy is not passive (Schmeck, Mayer, Opfermann, & Pfeiffer, 2014; Mayer, 2009; Schwamborn et al., 2010) and has a compounding positive impact on learner experience and content retention (Shore et al., 2015; Thomas, 2017). Research shows a direct correlation between the implementation of illustrations to support students who have to learn a large volume of information (Balemans, Kooloos, Donders, Van der Zee, 2016; Schwamborn et al., 2011). A new study and note-taking strategy have also emerged, sketchnoting which incorporates note taking with both words and sketches rendered by the learner. (Berman, 2012).

Mayer (1993) presents four ways that the learner may utilize drawings: 1) decorative; 2) representational; 3) organizational; 4) explanative. Mayer (1993) outlines four types of learner-generated drawings: 1) unsupported - no guidance or help; 2) guided - learner is trained on drawing content and production; 3) partial - learner provided a partially completed drawing to complete; and 4) supported - learners are provided with the author's exemplar drawing and are then to compare it with their learner-generated drawing. When students are engaged in self-generated drawings, they are actively engaged (Fiorella & Mayer, 2015). Deeper learning occurs when the learner generates an internal, visual representation of the material and their memory is imprinted (Whittrock, 1990; Mayer, 1990).

Recent Studies

Ongoing work in the fields of cognition, student learning, and effective instructional strategies continues to define and refine the strategies researchers and educators implement with students. Recent studies in learning and learning strategies, specifically how learners learn and process information, provide current and relevant information as to how we best instruct students. Recent studies conducted have explored learner-generated drawings as a strategy to improve learning from expository text. Van Meter, Aleksic, Schwartz, and Garner (2006) conducted a study that found that students utilizing the strategy of learner-generated drawing outperformed their peers who were in a non-drawing control group. Van Meter and Gardner (2007) proposed an extension to Mayer's Generative Theory of Textbook Design.

In a study involving students in a grade 8 middle school classroom, researchers conducted two experiments. One was to draw pictures while reading science text explaining the biological process of influenza; the other was to only read the information (Schmeck et al., 2014). Students who were able to draw as they read performed better on the post intervention assessment (Schmeck et al., 2014). These results support previous study findings that drawing with reading improves student learning.

Fundamentally, Van Meter and Gardner's (2006) process model of drawing construction adheres to Mayer's selection, organization, and integration (SOI) model, but Van Meter & Gardner emphasize the "important differences when the learner constructs nonverbal representations and the integration of verbal and nonverbal representations" (p. 145). Important nonverbal representation occurs when the learner links prior knowledge to the task at hand. This cognitive connection improves the student's concept or content understanding and conversely, students with little or no prior knowledge to connect to are negatively impacted. Successful cognition depends upon foundational understandings (Van Meter et al., 2006). Van Meter et al. (2006) found that "the addition of external support, modeled pictures or partially constructed drawings to guide students in their drawings, (to student-generated drawings) allowed learners to use drawing effectively to improve learning from content area text" (p. 161). As teachers endeavor to support successful reading and student interaction with expository text, which is predominant in STEM related fields, it is imperative to implement research-based interventions. Van Meter et al., (2006) present tangible, impactful classroom strategies with nonfiction text to help students navigate the elements effective of science related reading.

In a third study reviewed, Leopold, Doerner, Leutner, and Dutke (2015) conducted two experiments with students to compare the effects of instructions that help learners make connections between words and pictures with instructions that distract students from creating referential connections essential for learning. "The instruction to write important concepts beside an illustration or right by the respective pictorial counterpart of the illustration evoked a significant difference in the students' mental representations of the content matter and (positively) affected their learning performance" (p. 362). The additional layer of guided instruction with students participating in generated drawing tasks helps teachers to plan this layer into their instruction to improve student learning.

As indicated in prior studies, learner-generated drawings improve student understanding and content retention. (Fiorella and Mayer, 2015). Schwamborn, Thillmann, Mayer & Leopold (2010) in a refining study found that students who created high accuracy drawings performed better on a post intervention assessment than those who constructed low accuracy drawings. The research indicates that deeper cognition and visual stimuli occur when students spend time and add detail to their learner-generated drawings (Schwamborn et al., 2010). Additionally, the study's research suggests that drawing is both a generative and prognostic activity (Schwamborn et al., 2010).

Based on emerging and ongoing research focused on brain science, cognition, and vocabulary acquisition, Shore et al. (2015) found that an active vocabulary intervention including sketching and peer discussion in high school students improved vocabulary acquisition and retention. In a subsequent study, a replication of the Shore et al. (2015) research, Thomas (2017) studied the effect of active vocabulary intervention including sketching and peer discussion in high school students. Thomas' (2017) research also indicated that active multimedia vocabulary intervention positively impacted student vocabulary acquisition and retention.

Summary of Literature Review

Contemporary American schools continue to reflect upon and respond to historical and ongoing shiftless national and international science scores. Based on the analysis of the science assessment data, the scores indicate that middle school students are the first grade levels to present with subpar achievement levels. Effective, active teaching techniques and learning strategies that stimulate cognition, decrease cognitive load demands, and foster content retention are necessary for today's classrooms to address lagging science scores. Learning and understanding content specific science-based vocabulary is imperative to understanding greater science content and concepts.

Early educational theorists and child psychologists found that constructivist learning theory and later the generative learning theory, both with the core tenants of active student engagement, are essential for effective student learning. As cognitive science continued to advance, researchers learned more about the brain, cognitive load, and how the complex neurological matrices best process new information.

As a result, the theory of multimedia learning emerged and is the basis of this study. Based on the current body of research and the review of the literature, the researcher proposes that implementing an active vocabulary intervention in a middle school science classroom that incorporates both student-generated drawing and peer discussion will positively affect student retention of newly presented content-based science vocabulary.

This chapter, the literature review, delineates how various academic disciplines intersect to develop a roadmap for effective instructional practice and learning. Cognitive science, educational theory, instructional pedagogy, reading pedagogy, science content, and science framework of study, from early childhood to higher education are explored to produce an aggregate theory and model of best practice that interlocks six specialties.

The next chapter introduces this study's methodology which includes the study's research questions and design, the instrumentation and data sources, the implementation of the interventions, and the structures for the following data analysis.

CHAPTER THREE: METHODOLOGY

Overview

In a county who storied history includes some of the greatest inventions and advancement in technology and innovation, the current state of student science score both nationally and internationally are in direct contrast, straggling behind many developed nations across the globe, to the foundational mindsets, ideas, and knowhow on which has given birth to prior advancements. This long-chronicled defect, reach back to the 1950's, gravely influences not only student learning, but it also impacts science disciplines in higher education, careers in science, and has implications that impact national security.

In response to this growing deficit in science achievement, researchers are investigating long standing theories of human cognition and developing innovative instructional techniques for science instruction and intervention. The new instructional strategies are based on extensive research in the areas of active, multimedia engagement, drawing, and peer discussion have resulted in improved levels of learning and retention.

As a result, this study, conducted with middle school student in science classrooms, introduced two methods of science vocabulary intervention, active, multimedia and passive. Students in grades 6, 7, and 8 were introduced to the two types of vocabulary intervention to determine the effectiveness of the active, multimedia intervention of learner-generated drawing followed by peer discussion on students versus the passive intervention of reading, copying, and studying vocabulary terms. By measuring the acquisition levels of the presented science vocabulary using a posttest following the intervention and the level of retention by conducting a second posttest 24 hours later, the study evaluated the effectiveness of the interventions. Determining the most effective classroom interventions influences the implementation of best instructional practices in schools; thus, in theory, improving student learning and increasing science achievement in American students.

Research Questions

1) How will the active, multimedia learning strategies of student-generated drawing combined with discussion effect student acquisition and retention of content specific science terms when introduced as a study method in middle school science classrooms compared to passive models of learning: reading, copying and independently studying science terms based on post-intervention assessments?
2) How will student reading ability, as measured by reading level, following the intervention of active, multimedia learning strategies of student-generated drawing combined with discussion effect student acquisition and retention of content specific science terms when introduced as a study method in middle school science classroom based on post-intervention assessments?
    a) How will below grade level readers perform on post-intervention assessments?
3) How will the active, multimedia learning strategies of student-generated drawing combined with discussion effect male vs. female student acquisition and retention of content specific science terms when

introduced as a study method in middle school science classrooms compared to the passive model of learning: reading, copying and independently studying science terms based on post-intervention assessments?

4) How will student performance on the science vocabulary pretest predict posttest performance following the active, multimedia learning strategies of student-generated drawing combined with discussion and the passive model of learning: reading, copying, and independently studying science terms?

Research Design

A quasi-experimental crossover research design was used to study the effectiveness of the multimedia effect on the acquisition (posttest 1) and retention (posttest 2, 24 hours later) of science vocabulary (See Figure 2 & 3). For the first intervention session 15 class sections of students were assigned to intervention groups, active (n = 9) or passive (n = 6), using the flip of a coin, heads active and tails passive, the first section of grade 6 was randomly assigned to the active treatment. The remaining class sections were assigned, alternating between active and passive interventions in relation to the first randomly assigned section. The students completed the List 1 pretest and then completed either the passive (reading, copying, and independently studying) or active (learner generated drawing and peer discussion) intervention. Following the first intervention, students completed posttest 1. Posttest 1 measured the level of vocabulary acquisition of List 1. The next day, 24-hours later, students completed List 1 posttest 2 to determine the students' level of vocabulary retention.

GRADE 6 & 7							
LIST 1	**INTERVENTION 1**						
	DAY 1						
	Period 1	**Period 2**	**Period 3**	**Period 4**	**Period 5**	**Period 6**	**Period 7**
	Pretest ACTIVE Posttest 1	Pretest PASSIVE Posttest 1	Pretest ACTIVE Posttest 1	Pretest PASSIVE Posttest 1		Pretest ACTIVE Posttest 1	
	DAY 2 – 24 HOURS LATER						
	Posttest 2	Posttest 2	Posttest 2	Posttest 2		Posttest 2	
LIST 2	**INTERVENTION 2**						
	DAY 1						
	Period 1	**Period 2**	**Period 3**	**Period 4**	**Period 5**	**Period 6**	**Period 7**
	Pretest PASSIVE Posttest 1	Pretest ACTIVE Posttest 1	Pretest PASSIVE Posttest 1	Pretest ACTIVE Posttest 1		Pretest PASSIVE Posttest 1	
	DAY 2 – 24 HOURS LATER						
	Posttest 2	Posttest 2	Posttest 2	Posttest 2		Posttest 2	

Figure 2: Intervention schedule for grades 6 & 7

GRADE 8							
LIST 1	**INTERVENTION 1**						
	DAY 1						
	Period 1	**Period 2**	**Period 3**	**Period 4**	**Period 5**	**Period 6**	**Period 7**
	Pretest ACTIVE Posttest 1	Pretest PASSIVE Posttest 1	Pretest ACTIVE Posttest 1	Pretest PASSIVE Posttest 1	Pretest ACTIVE Posttest 1		
	DAY 2 – 24 HOURS LATER						
	Posttest 2	Posttest 2	Posttest 2	Posttest 2	Posttest 2		
LIST 2	**INTERVENTION 2**						
	DAY 1						
	Period 1	**Period 2**	**Period 3**	**Period 4**	**Period 5**	**Period 6**	**Period 7**
	Pretest PASSIVE Posttest 1	Pretest ACTIVE Posttest 1	Pretest PASSIVE Posttest 1	Pretest ACTIVE Posttest 1	Pretest PASSIVE Posttest 1		
	DAY 2 – 24 HOURS LATER						
	Posttest 2	Posttest 2	Posttest 2	Posttest 2	Posttest 2		

Figure 3: Intervention schedule for grade 8

The following week, the student groups crossed over and engaged in the other intervention treatment. If the participant completed active, student generated drawing and peer discussion during the first intervention series, they completed the passive intervention during the second intervention series. If the participant completed passive during the first intervention series, they completed the active intervention during the second intervention series (See Figure 4). Following the second intervention, students completed posttest 2. Posttest 1 measured the level of vocabulary acquisition of List 2. The next day, 24-hours later, students completed List 2 posttest 2. Implementing two different vocabulary lists of physics words and transversing two methods of intervention is designed to mitigate any bias or influences on the interventions or the results.

Crossover Design

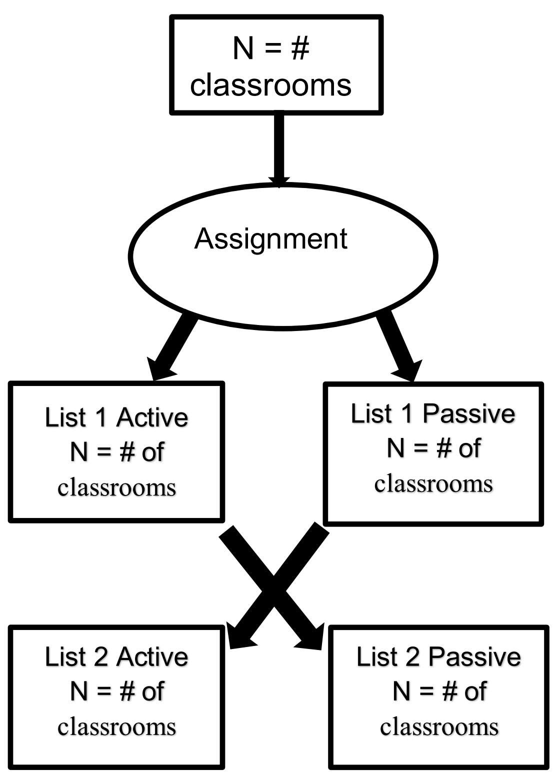

Figure 4: Crossover design

During all intervention sessions the researcher was present to the participant teachers, to monitor that the preintervention script and protocols were followed. During the sessions the researcher mentored the students to ensure they adhered to the directions and guidelines for both interventions.

Population and Sampling Procedure

After university IRB approval, this research study was conducted in a middle school, grades 6, 7, and 8, of a large, suburban, private Junior Kindergarten (JK) through grade 12 school in a large metropolitan city in the southeast United States. The middle school student count comprises 270 of the 1081 students enrolled in the school JK-12. All students in grades 6-8 were asked to volunteer to participate. The students in the middle school range in age from 12-14 years old. Twenty percent of the middle school population is ethnically diverse (See Figure 5). The middle school population is 79% Caucasian, 12.5% African American, 2% Asian, 2% Hispanic, and 4% Other.

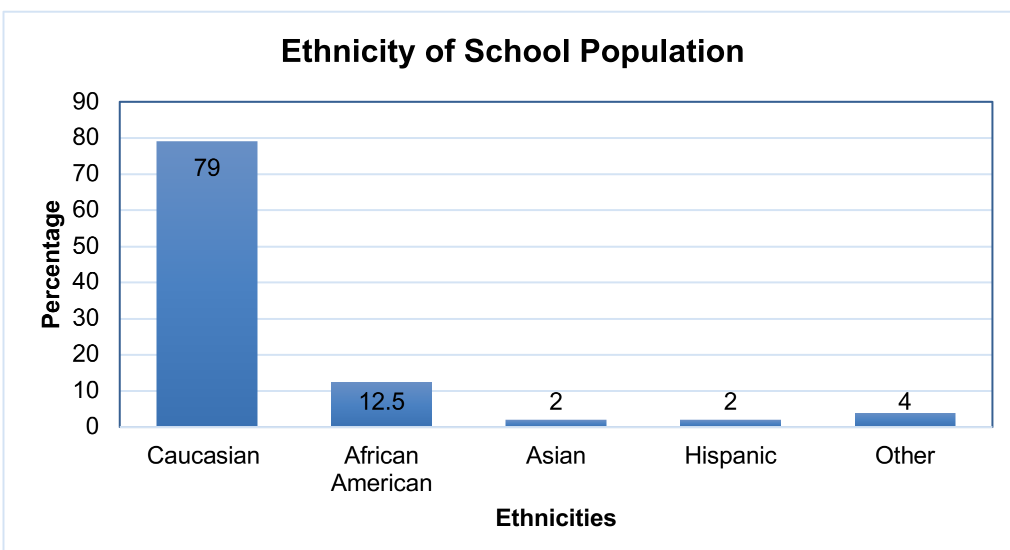

Figure 5: Percentage of school population by ethnicity

The middle school building is situated in the center of campus and is comprised of two attached buildings. The main middle school building was the first building constructed in the 1960s. The adjacent technology building added in the 1990s and houses the middle school science and math departments. As part of the school’s tuition, all students participate in the healthy dining initiative. The school's dining program provides a healthy, nutritious lunch which includes two entree options, soups, salad bar, and a prepared sandwich station daily.

Additionally, the school has implemented a one-to-one device program in the middle and high school. Each middle school student has and uses an iPad Air Pro. It is a school expectation that all students have their iPad at school and fully charged each day. If a student forgets their iPad or brings it to school uncharged, the school provides students with a loaner device and a mobile device charger.

The school follows a traditional school calendar but is not required to follow specific state standards related to the school’s start date each year or the state-mandated 180 school days. The school does, however, meet for approximately 176 school days each year comprised of two academic semesters.

All middle school students enrolled, in attendance, and with parent permission, participated in the study. The researcher informed all parents about the study and was able to opt their child out of the study. The middle school population also is comprised of students with varied abilities. The school has a robust admissions procedure; therefore, the school's population, mainly comprised of average to above average ability students, are readers who perform at or above grade level in reading on standardized tests. The middle school also includes students with diagnosed learning disabilities who receive academic reinforcement and accommodations provided by the school's academic support program. The middle school has an academic honor roll. In the first semester, ten percent of middle school students earned Magna Cum Laude distinction, 4.0 GPA with no grade of A- or lower. Forty-nine percent of middle school students earned Cum Laude distinction, 3.5 GPA with no grade of B- or lower.

There are three branches of science instruction in the middle school: grade 6 physical science, grade 7 life science, and grade 8 earth science. Each grade level science teacher teaches five sections of homogeneously grouped students with no honors distinction.

Three veteran science classroom teachers volunteered to participate in the science vocabulary study. The three experienced science teachers, two Caucasian female teachers, and one Vietnamese American female teacher comprise the middle school science department. Two of the science teachers are professional scientists, one an engineer and the other a chemist. The teachers each have more than three years of teaching experience, ranging from five to eighteen years, and have a combined total of thirty-seven years teaching experience.

Instrumentation and Source Data

In preparation for the study, the teachers and the researcher determined the science vocabulary terms for the study. The team selected vocabulary terms from the physics textbook. To ensure content validity, the middle school science teachers and the researcher conducted a fifty-term pretest of physics vocabulary to identify and select the twenty most unknown words. Using the student response data from the fifty-term word identification pretest, the 20 words that received the most incorrect or “I don’t know” responses, were selected for the two science vocabulary lists, List 1 (See Figure 6) and List 2 (See Figure 7).

LIST 1	
VOCABULARY TERM	**DEFINITION**
aberration	Distortion in an image produced by a lens
electrostatics	The study of Electric charges at rest
excited state	A state with greater energy than an atom's lowest state
Hooke’s Law	The distance of stretch or squeeze (extension or compression) of an elastic material is directly proportional to the applied force
node	Any part of a standing wave that remains stationary
perigee	The point in a satellite's elliptical orbit where it is nearest the center of the earth
postulate	A fundamental assumption
simple harmonic motion	The back-and-forth vibratory motion of a swinging pendulum
spectroscope	An instrument used to separate the light from a hot gas or other light source into its constituent frequencies
time dilation	An observable stretching, or slowing, of time in a frame of reference moving past the observer at a speed approaching the speed of light

Figure 6: List 1

LIST 2	
VOCABULARY TERM	**DEFINITION**
destructive interference	Combination of waves where crests of one wave overlap troughs of another, resulting in a wave of decreased amplitude
entropy	A measure of the amount of disorder in a system
geodesics	Lines of shortest distance between two points in curved space
length contraction	The observable shortening of objects moving at speeds approaching the speed of light
penumbra	A partial shadow that appears where light from part of the source is blocked and light from another part of the source is not blocked
perturbation	The deviation of an orbiting object from its path around a center of force caused by the action of an additional center of force
rarefaction	A disturbance in air (or matter) in which the pressure is lowered. Opposite of compression
sine curve	A curve whose shape represents the crests and troughs of a wave, as traced out by a swinging pendulum that drops a trail of sand over a moving conveyer belt
tangential speed	The speed of an object moving along a circular path
vector	An arrow whose length represents the magnitude of a quantity and who's direction represents the direction of the quantity

Figure 7: List 2

Following the identification of the twenty least know words, the list was divided by a rotating assignment of every other word to List 1 and List 2. The 50 words included on the term selection pretest are present alphabetically. Finally, the researcher and the university study chair reviewed and approved final lists of words and definitions for the study.

Immediately following the thirty-minute active or passive learning strategy, the students took an online Google Form assessment using their school-issued iPad Air Pro devices to evaluate the student retention of the presented vocabulary terms. The next day the students took a second posttest, using the same test content presented in varied order, to measure retention of the same ten vocabulary words twenty-four hours later. Each student accessed the pretest 1 and posttests 1 and 2 in Canvas, the school's learning management system (LMS) to submit their responses.

The students completed all assessments, pretest, and posttests, using Google Forms to eliminate the possibility of human error in the assessment grading process. The researcher carefully reviewed all the data to ensure there were no technical or grading errors in the data collection process.

The digital assessment required students to enter their first and last names and their grade level. The test design included the ten definitions implemented during the active or passive vocabulary activity. Under each definition, the test had a drop-down list including all ten science vocabulary terms used in the intervention. The digital test page, Google Form, was presented as a single screen, so the students did not have to toggle between multiple test screens to complete their responses. The assessment program recorded test and submission data including time and date submitted and the duration of the test.

Only the students participating in the interventions completed the assessments with no outside assistance. The grading scale range on the assessment was from 0 to 10.

To protect the student and study confidentiality, all research data and assessment results were maintained in a password protected file. Moreover, participant names were secured and re-coded by the researcher. Both teacher and student data, coded by using letters for teachers and numbers for students, ensured anonymity and protected against bias. The researcher designed and generated all assessments implemented in the study.

Participant gender, ethnicity, and reading levels, descriptors obtained from the fall administration of the Educational Records Bureau (ERB) and Comprehensive Testing Program 4 (CTP) test for grades 1-11 were used to generate the study's data set. According to the Educational Records Bureau,

> The Comprehensive Testing Program (CTP) is a rigorous assessment for high achieving students in areas such as reading, listening, vocabulary, writing, science…and mathematics. Verbal and quantitative reasoning subtests are part of the CTP beginning in Grade 3. The CTP helps compare content specific, curriculum-based performance to the more conceptual knowledge base found in reasoning tests (Educational Records Bureau, p. 1).

The ERB has structured two test administration windows, fall and spring. The CTP 4 assessment levels are 1-11. The test level may be administered in the spring of the correlating graded level or the fall on the following grade level. For example, the CTP 4 Level 1 assessment may be administered in the spring of the students' grade 1 year on the in fall of the following year in grade 2. ERB has calculated two norm groups, one for spring and one for fall administrations. The participant school's ERB data were collected in the Fall of 2017; therefore, the study participant students in grades 6, 7, and 8 all took the corresponding test that is the level of their previous grade in school, Levels 5, 6, and 7. The data were compared to the Fall test administration norms.

Educational Records Bureau, through its partnership with MetaMetrics, Inc., a privately held educational measurement company, created a Lexile reading scale using student performance data on the Reading Comprehension subtest of the CTP 4 test to determine individual student reading Lexile levels. A Lexile measure is defined as "the numeric representation of an individual's reading ability or a text's readability (or difficulty), followed by an "L" (Lexile)" (MetaMetrics, 2018). According to Educational Records Bureau:

> MetaMetrics creates its proprietary Lexile scale, they conduct a scaling study to link their scale to our CTP Reading Comprehension scale, and we report CTP scores and Lexiles together to capture both sources of info for members, parents, and students. The Lexiles, in turn, can be used by all stakeholders to understand and track reading levels, as well as personalize the selection of reading materials." (p.1).

Based on the previous academic predictors, it is anticipated that students' reading levels will impact their performance on the after-intervention assessments. Typically, students who are categorized as low-level readers are expected to be outperformed by their peers identified as average or above average readers. For the data set, student reading levels were determined using their Lexile scores from their fall administration of the ERB CTP 4 reading comprehension subtest score. According to MetaMetrics, the following reading Lexile levels encompass mid-year 25% to 75% percentile proficiency reading level ranges for middle students Grade 6: 855L-1165L; Grade 7: 925L-1235L; and Grade 8: 985-1295L (See Figure 8).

Grade	Reader Measures, Mid-Year *25th percentile to 75th percentile (IQR)*
1	BR120L* to 295L
2	170L to 545L
3	415L to 760L
4	635L to 950L
5	770L to 1080L
6	855L to 1165L
7	925L to 1235L
8	985L to 1295L
9	1040L to 1350L
10	1085L to 1400L
11 & 12	1130L to 1440L

Source: https://lexile.com

Figure 8: Lexile reading levels ranges

The researcher linked student assessment data to the student information be able to assign identifying codes. Once the identifying codes were applied, the researcher removed student names. Data collected for this study included demographic information of the participants, reading level and pre- and posttest scores. The data set to be studied included multiple student demographic variables. They include gender, ethnicity, grade level, age, and reading level. To evaluate the effectiveness of the multimedia, active learning intervention between and among the variables and to answer the presented research questions, the data will be coded using each students' identified Lexile reading level; gender will be assigned male = 1 and female = 2; ethnicity will be assigned Asian=1, African American = 2, Hispanic = 3, Caucasian = 4 and, Other (one or more ethnicities) = 5.

Reliability is the degree to which an assessment tool produces stable and consistent results. The Educational Records Bureau (2012) the CTP 4 technical report, the test reliability statistics include: coefficient alpha reliability, the standard error of measurement, and item-total correlations of the subtests. The reliability coefficients were calculated for each grade level by using coefficient alpha. The standard error of measurement (SEM) is the range of scores between participants. The overall CTP 4 test Level 5 reliability coefficient was .84 with an SEM 2.3. The overall CTP 4 test Level 6 reliability coefficient was .83 with an SEM for raw score was 2.4. CTP 4 test Level 7 reliability coefficient was .82 with an SEM for raw score was 2.4.

The third type of reliability for the CTP 4 is item-total correlations. According to the Educational Records Bureau Technical Report for the CTP 4 assessment, the item-total correlation measures the degree to which students who correctly answer test items tend to have higher overall scores than students who answer test items incorrectly. For multiple choice items, biserial correlations, an estimate of overall score and a theoretical, normally distributed variable to determine if the student answers the item correctly.

The total item correlations for the Reading Comprehension sub-tests are Level 5, M=.57, SD=.10; Level 6, M=.53, SD=.12; Level 7, M=.53, SD=.13. The mean scores are consistent between levels, ranging from .53-.57 and standard deviation between .10-.13.

Validity has been defined by the American Research Association as “the degree to which evidence and theory supported the interpretations of test scores entailed by proposed uses of tests” (1999, p. 9). Evidence of validity, specifically content validity, for the ERB CTP 4 assessment references specific portions of the assessment are directly linked to skill outlined in NCTE/IRA (National Council for Teachers of English, International Reading Association) or NCTM (National Council for Teachers of Mathematics) standards. The Content Standards Manual is comprised of sample questions organized by content category and included explanations of correct answers.

Secondly, additional evidence of content validity is provided. By expert review by teachers from independent, private school throughout the country comprised a focus group who determined that test items were representative of the school curricula. While ERB provides several examples of content validity for the CPT 4 assessment, more sophisticated levels of validity evidence such as internal structure and relationship with other measures is not provided.

Intervention

The researcher collaborated with the three science teachers who comprise the middle school science department to determine the specific science vocabulary words included in the study's intervention. During the process of physics vocabulary word selection, the study selected fifty words from the physics book glossary. The criteria for vocabulary words, selected for the study, must meet the critical component of the research intervention - the word must be drawable. As part of the final word selection process, all participating student completed a fifty-word pretest to determine students' current knowledge of words in consideration for the final physics ten item word lists. The fifty-item pretest implemented using Google Forms consisted of physics vocabulary definitions followed by four multiple choice options, three physics vocabulary words and one option of "I don't know." All middle school study participants participated in the vocabulary word selection pretest. From the fifty item pretest results, the twenty most unknown words, determined by incorrect answer responses, were identified and used to generate the two different physics vocabulary lists used in the study, List 1 and List 2. The twenty vocabulary words were listed in order alphabetically, and the words were divided, alternating every other word to create List 1 and List 2.

The instructional interventions, active and passive, were introduced during two separate sessions in middle school science classrooms. To ensure fidelity of implementation, the classroom teachers and the researcher met to review the structures, design, and protocols of the study including the creation of a specific script for the teachers to read regarding the instructions for the intervention. The study participant teachers who lead each intervention recited the correlating script provided by the researcher for each of the strategies, active and passive.

During both interventions, active and passive, the students were allotted thirty minutes to interact with the vocabulary terms based on their assigned task. All students completed both interventions on separate days using two different science vocabulary term lists, List 1 and List 2. Teachers closely monitored the students to ensure time on task. Students participating in the active intervention drew student-generated pictures based on the science vocabulary terms provided. All study participants received a ten-word vocabulary list, including definitions and an 8 x11½" copy paper with a ten box pre-generated grid to guide student-generated drawings. Participants were also allowed to sketch with the instrument(s) of their choice, pencil, pen, colored pencil, and colored markers. For the second portion of the intervention, students shared their science vocabulary term illustrations in small, self-selected groups of two or three students.

During the passive intervention, student participants were instructed to read, copy, and review the vocabulary terms for the duration of the thirty-minute intervention. All study participants received a ten-word vocabulary list, including definitions and a blank piece of wide-ruled notebook paper. Students were allowed to select the writing utensil of their choice to copy the vocabulary terms and definitions from the list of terms.

Procedure

The university's IRB office granted IRB approval for the study. Before teachers and students participated in the study, teachers, students, and their parents, the researcher distributed a form describing the study's parameters. The participants, parents, students, and teachers all have the opportunity to opt out of the study without penalty.

Prior to the study, the three middle school teachers trained on the structures and parameters of each intervention. The essential guidelines for implementation were as follows: 1) adhere to all elements and structure of the interventions; 2) allow thirty minutes for the intervention; 3) read the scripted directions verbatim to the students for each intervention; 4) carefully monitor around the classroom to ensure the students engaged for the entirety of the intervention; 5) during the active intervention, students are directed to create self-generated, unassisted sketches of each of the ten provided science vocabulary terms during the first 15 minutes of the intervention; 6) during the active intervention and after the sketching, students must work in pairs and small groups to share and discuss their drawings for 15 minutes; 7) during the passive intervention, students read, copy and review the ten provided science vocabulary terms; 8) during the passive intervention, students are not allowed to discuss vocabulary or interact with peers; 9) students must complete the digital assessment immediately following each intervention, active and passive; and 10) twenty-four hours later, students repeat the assessment. Using cluster random assignment, class sections of students completed either the active, multimedia intervention or the passive, copy, and study intervention for the vocabulary words on list 1. During the next intervention application using List 2, class sections of students then engaged in the opposite treatment from the first intervention treatment.

Before implementing the vocabulary interventions, the students received instructions to provide clarity on the purpose of the study and to be made aware that the study has no bearing on teacher performance or the students' academic achievement. The students were informed of the purpose of the study and encouraged to generate drawings to enhance their memory of the science terms and to facilitate discussion with their peers. During the passive intervention, students worked independently in their regularly assigned seats. They were provided the list of different science vocabulary terms and their definitions and were asked to read, copy, and review.

The participating classroom teachers conducted both the active, multimedia and passive interventions with each middle school grade level. Using cluster random assignment, a total of fifteen classes, eight engaged in the multimedia intervention while seven participated in the passive instructional model in the first iteration of the intervention. The researcher with the science teachers determined the class sections that received the active, multimedia intervention using the physics vocabulary List 1. Each class section then alternated between receiving the active and the passive vocabulary intervention. The following week, the eight class sections who participated in the active, multimedia intervention while the seven class sections who completed the passive vocabulary intervention received the active, multimedia intervention using the physics vocabulary List 2. Conversely, those students who first received the passive learning strategy received the active, multimedia presentation following the passive intervention.

The students were not allowed to remove any intervention materials or drawings from the classroom. Teachers collected all materials and confirmed that all students completed and successfully submitted the assessment. Students were permitted to leave the classroom during the intervention to use the restroom. Additionally, teachers were instructed to refrain from teaching any of the vocabulary terms selected during the study to maintain the integrity of the instructional strategies implemented in the intervention. The researcher was an observer for all pretest, intervention, and posttest sessions and observed off task behavior by students. Some students participated in off topic discussions during the peer discussion portion of the active, multimedia intervention. The participating classroom teacher quickly addressed off task behavior and discussion, but they were not completely avoidable. Also, the student participants' peer discussions would, at times, stall as students self-determined they were "finished" with their peer discussions; however, student did reengage in their peer discussion when prompted by the classroom teacher.

Data from the assessments and the study variables were entered into Statistical Package for the Social Sciences (SPSS 25) for analysis.

Data Analysis

Based on the four research questions and one sub question, four data variables were analyzed: multimedia vocabulary interventions, reading level, gender, and pretest performance. It is hypothesized that students who used the active, multimedia, drawing and peer discussion, vocabulary intervention learned and retained vocabulary terms presented better than when practicing the passive intervention. Additionally, it is hypothesized that student Lexile level, pretest scores, and gender predict student performance on posttest 1 and posttest 2 for Lists 1 and 2.

Student test data, using the pretest and posttest assessments, were analyzed using a repeated measures ANOVA to test for the between-subject factors of reading level. A $p < .05$ level of significance was used to determine if the hypothesis should be rejected. The effect size was calculated using the partial Eta squared. Before running the analysis, a t-test was conducted on the pretest 1 and pretest 2 data to examine the equivalency of the two groups before the interventions.

Research questions 2 (reading level), 2a (below grade level readers), 3 (gender - female = 1, male = 2), and 4 (pretest performance) were analyzed using a step-wise linear regression was conducted to determine to determine, if any, the influence that 1) reading levels, 2) gender, or 3) vocabulary pretest predict the learner outcomes following the passive and active interventions. An additional paired sample t-test analysis was completed to compare the active and passive interventions using the pretest, posttest 1, and posttest 2 outcomes for students identified as below grade level using the Lexile reading range.

During the entire class period and for the duration of the instructions, intervention, and assessments, the researcher monitored and recorded notes on each of the classroom sessions to ensure fidelity of implementation. The researcher also monitored the intervention implementation to facilitate teacher consistency during the delivery of the intervention, the level of student monitoring and redirection, and the level of student engagement during the intervention sessions.

Summary

Students often have difficulty with retention of nonfiction and content specific science terms, particularly those who are low or less proficient readers. As the United States has strived to improve science achievement test scores both nationally and internationally, there has been a great emphasis placed on STEM and science programming and programs of study to increase student science proficiencies.

This chapter explained the methodology of the study including the study's research questions and design, the instrumentation and data sources, the implementation of the interventions, and the structures for the following data analysis. This study focused on the effectiveness of the multimedia, active intervention on science vocabulary term acquisition and retention with middle school students. This chapter outlined the instrumentation and data implemented in the study including the ERB CTP 4 assessment and the classification of student reading levels using MetaMetric's Lexile Reading Level standards.

This study, conducted with middle school student in science classrooms, introduced two methods of science vocabulary intervention, active, multimedia and passive. Students in grades 6, 7, and 8 were introduced to the two types of vocabulary intervention to determine the effectiveness of the active, multimedia intervention of learner-generated drawing followed by peer discussion on students versus the passive intervention of reading, copying, and studying vocabulary terms. By measuring the acquisition levels of the presented science vocabulary using a posttest following the intervention and the level of retention by conducting a second posttest 24 hours later, the study evaluated the effectiveness of the interventions.

The researcher stored and maintained all data and research materials in a secure location, and all data gathered during the duration of the study, in a password protected file. The results of the study are intended to answer the four research questions and one sub question posed in the study.

The following chapter, Chapter 4 presents the results of the analysis of the data collected in the study including the various data analyses complete with the assessment data. Chapter 5 presents conclusions form the study including interpretations, limitations, implications, and applications of the results.

CHAPTER FOUR: RESULTS

Introduction

This chapter describes the results of the study of the multimedia vocabulary interventions. It includes a description of the study participants, descriptive statistics for the variables of interventions, reading levels, gender, and pretest performance as a predictor of performance on the posttests. Also, the results of the four research questions and one sub question presented in chapter 1:

1) How will the active, multimedia learning strategies of student-generated drawing combined with discussion effect student acquisition and retention of content specific science terms when introduced as a study method in middle school science classrooms compared to passive models of learning: reading, copying, and independently studying science terms based on post-intervention assessments?
2) How will student reading ability, as measured by reading level, following the intervention of active, multimedia learning strategies of student-generated drawing combined with discussion effect student acquisition and retention of content specific science terms when introduced as a study method in middle school science classroom based on post-intervention assessments?
    a) How will below grade level readers perform on post-intervention assessments?
3) How will the active, multimedia learning strategies of student-generated

drawing combined with discussion effect male vs. female student acquisition and retention of content specific science terms when introduced as a study method in middle school science classrooms compared to the passive model of learning: reading, copying and independently studying science terms based on post-intervention assessments?

4) How will student performance on the science vocabulary pretest predict posttest performance following the active, multimedia learning strategies of student-generated drawing combined with discussion and the passive model of learning: reading, copying, and independently studying science terms?

Role of Researcher

The researcher is an employee of the school site selected for the research study as the Director of Academics. Various responsibilities assigned to the director of academics include faculty development, teacher observations, accreditation, licensure, instruction, academic, and curriculum development. Through these job responsibilities, the researcher regularly works with the faculty members and is known by the students in the school. During the academic interventions, the researcher was in the classroom to observe and to provide any needed support for the teacher implementing the passive and active learning interventions. During the entire class period and for the duration of the instructions, intervention, and assessments, the researcher monitored and recorded notes on each of the classroom sessions to ensure fidelity of implementation. The researcher also monitored the intervention implementation to facilitate teacher consistency during the delivery of the intervention, the level of student monitoring and redirection, and the level of student engagement during the intervention sessions. The most students were on-task and fully engaged. The participant teachers, with the researcher as an observer in all intervention sessions, addressed off-task behavior and encouraged students to continue to discuss and review during the implementation of the interventions.

Participants

The school's enrollment in grades 6, 7, and 8 was 270 in the second semester of the 2017-18 school year. Of the 270 middle school students, three students on the science classes opted to not participate in the study. During the study, 58 of the participating students were absent from one or more either pretest or posttest assessment; therefore, the student and their incomplete data set were eliminated from the final data set before data analysis. Of the 209 students who participated in all interventions and assessments, 111 were female, and 98 were male. The ethnicity of the participants in the study was 80.8% Caucasian, 12.44% African American, .96% Asian, 1.4% Hispanic, and 4.3% Other (See Figure 1) closely reflects the ethnicity of the student population enrolled in the middle school (See Figure 9).

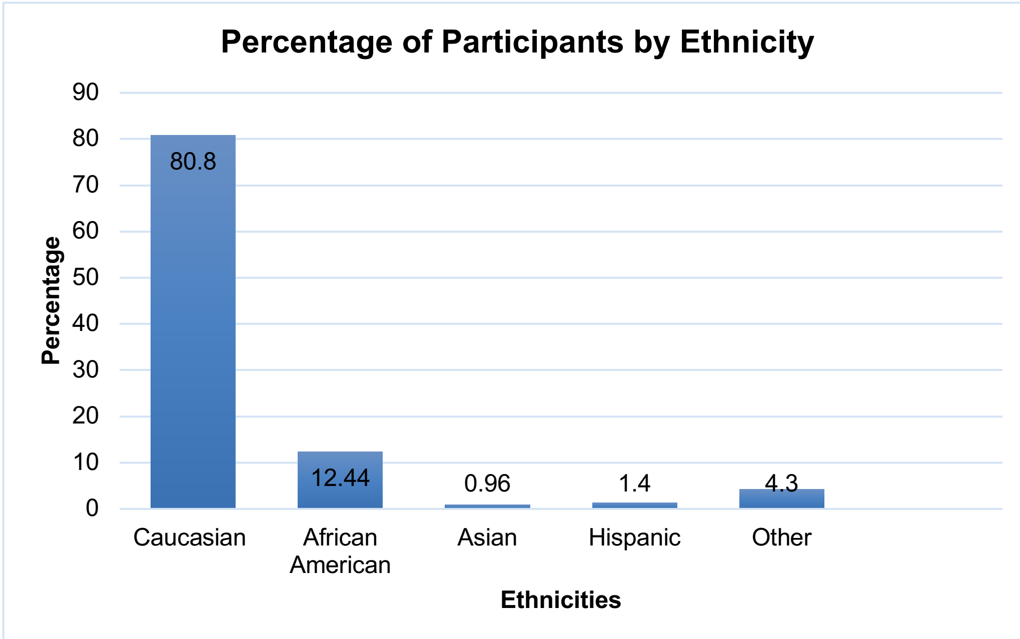

Figure 9: Percentage of participants by ethnicity

Data Screening

Prior to completing the data analysis in SPSS, the data were carefully reviewed to determine that each student participant had a complete data set which includes a pretest and posttest for both science vocabulary terms for List 1 and List 2. Study participants missing one or more of any of the six assessments data points were removed from the data set.

Descriptive Statistics

Reading levels, identified by student reading performance on the CTP 4 ERB, and reported using Lexile levels were used to determine students' reading ability. The CTP 4 assessment outcomes provide a Lexile reading level with student study participant scores ranging from 530L, grade 3 reading level to 1700L, college reading level.

Grade 6 Lexile reading level range is 855L – 1165L. Grade 6 student participant reading levels ranged from 855L, the Lexile grade 6 on grade reading level, through the highest student Lexile reading level, 1600L, college Lexile reading level (see Figure 10). Therefore, based on the Lexile Reading Level scale, all the grade 6 participants are on or above grade level for reading.

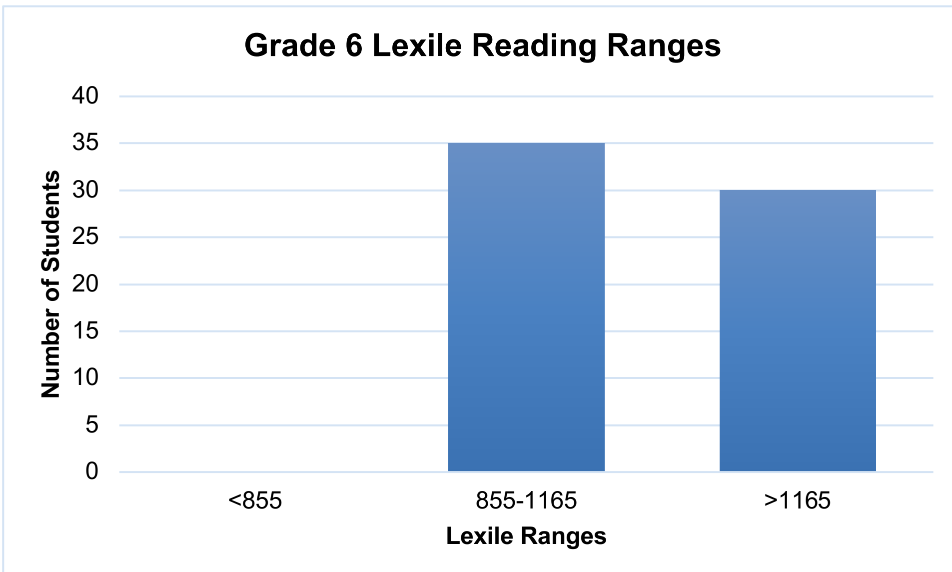

Figure 10: Grade 6 Lexile reading level ranges

Grade 7 Lexile reading level range is 985L-1295L. The grade 7 study participant student Lexile reading level range was 530L-1910L (see Figure 11). Based on the Lexile reading level range for grade 7, six participating grade 7 students were reading below grade level. The remaining grade 7 participants were at or above grade level with the highest performing at a 1910L, college Lexile reading level.

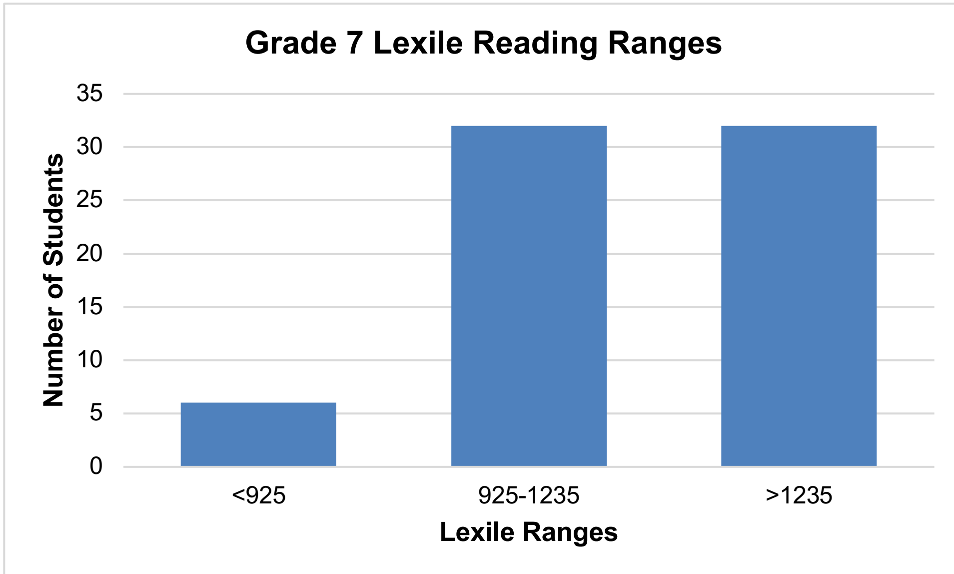

Figure 11: Grade 7 Lexile reading level ranges

Grade 8 Lexile reading level range is 935L-1235L (See Figure 12). The grade 8 study participant student Lexile reading level range was 745L-1885L. Based on the Lexile reading level range for grade 8, seven participating grade 8 students were reading below grade level. The remaining grade 8 participants were on or above grade level with the highest performing at a 1885L, college Lexile reading level.

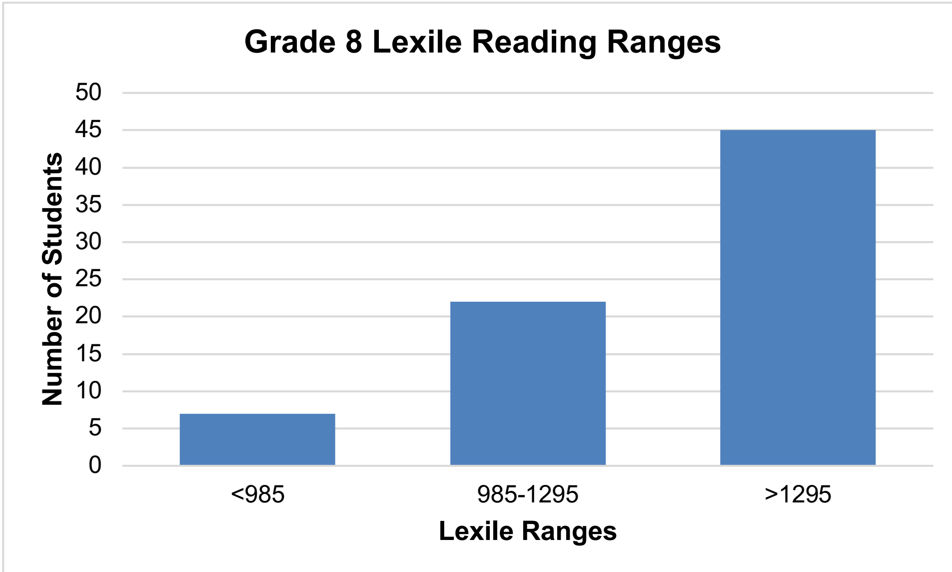

Figure 12: Grade 8 Lexile reading level ranges

Participants Removed from the Data Set

Students who were absent from any portion of intervention series 1 or 2 (List 1, pretest, posttest 1, and posttest 2; List 2, pretest, posttest 1, and posttest 2) data were removed. A total of 59 students were lost from the data set during the study, 13 in grade 6, 18 in grade 7, and 28 in grade 8. Of the 13 grade 6 students six were male, seven were female, 11 were white, 1 African-American, and 1 Asian (See Figure 13). There were no below grade level readers lost. Of the 18 grade 7 students, 10 were male, eight were female, 16 were white, 1 Hispanic, and 1 Asian (See Figure 14). There were no below grade level readers lost. Of the 28 grade 8 students 21 were male, seven were female, 24 were white, 3 African-American, and 1 Other (See Figure 15). There were four below grade level readers lost.

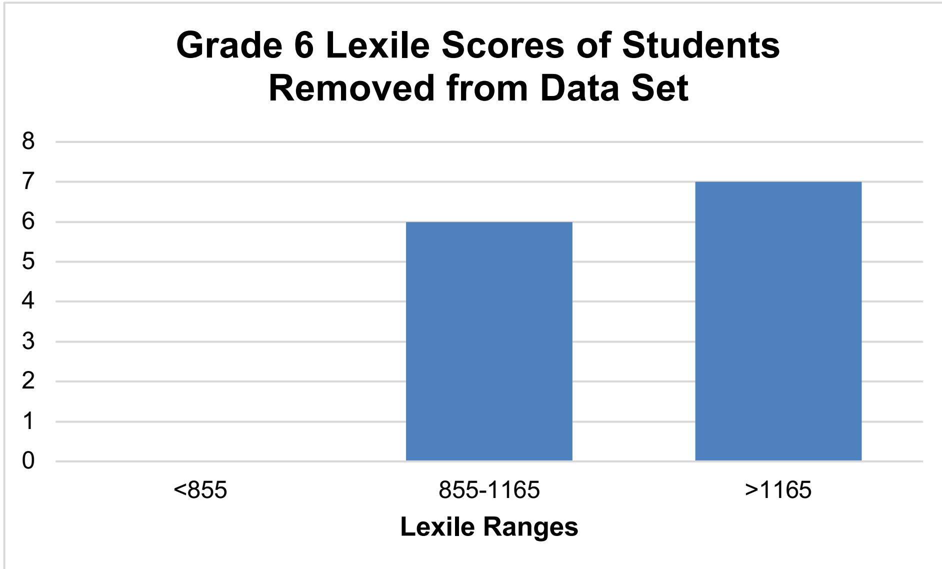

Figure 13: Grade 6 Lexile scores for students removed from data set

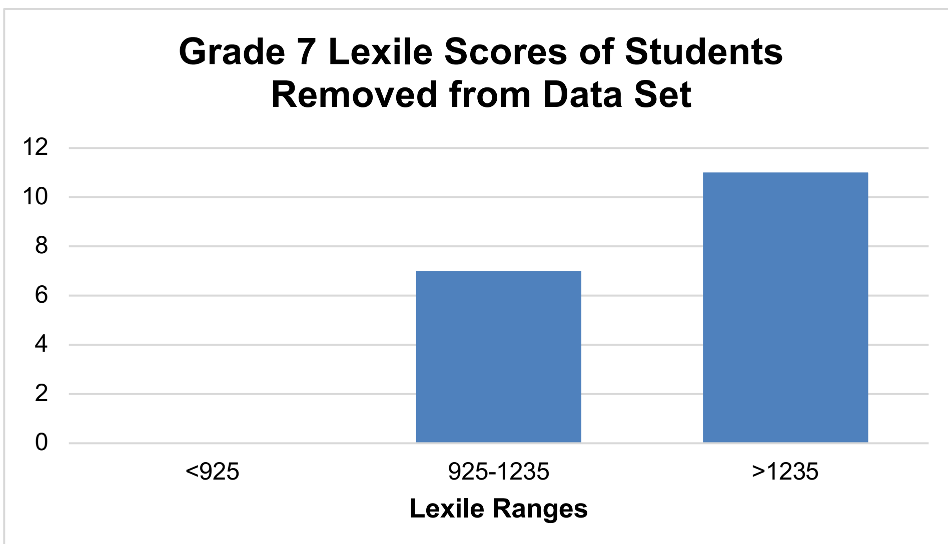

Figure 14: Grade 7 Lexile scores for students removed from data set

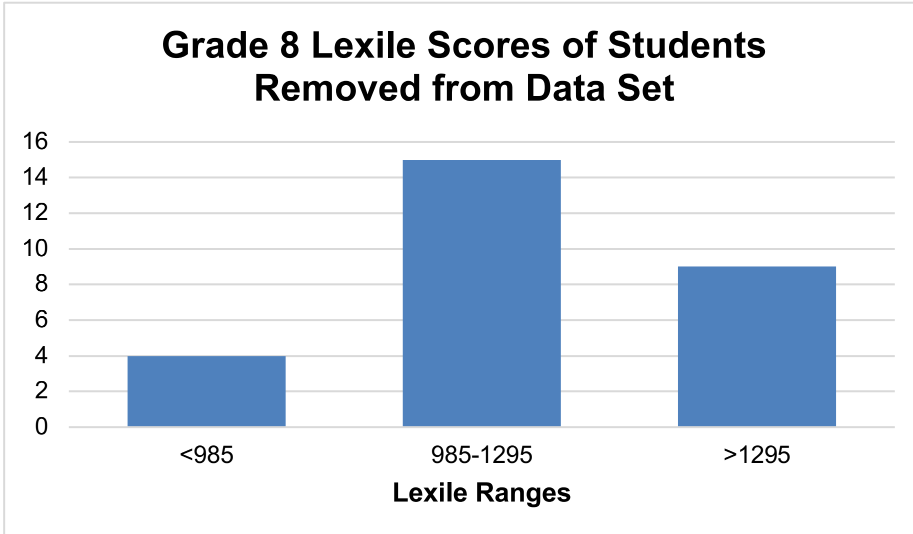

Figure 15: Grade 8 Lexile scores for students removed from data set

Before running the analysis, a t-test was conducted on the pretest 1 and pretest 2 data to examine the equivalency of the two groups before the interventions. The t-test analysis determined the difference between the groups was not statistically significant (pretest 1 $t(207) = .048$, $p = .404$, pretest 2 $t(207) = .702$, $p = .351$). The two groups vocabulary knowledge was equivalent prior to the study. Descriptive statistics for the pre- and two posttests are provided in Table 1.

The mean and standard deviation for List 1 pretest scores for the active intervention were ($M = 3.40$, $SD = 2.22$). The List 1, post-est 1 mean and standard deviation for the active intervention were ($M = 8.08$, $SD = 2.40$), and the List 1, posttest 2 mean and standard deviation were ($M = 7.42$, $SD = 2.81$). Using the following scale .2 small effect size, .5 moderate effect size, and .8 large effect size (Cohen, 1988) pretest to posttest 1 for List 1 ($d = 2.01$) indicates a large effect. Additionally, the effect from pretest to posttest 2 for List 1 administered 24-hours after posttest 1 was also a large effect size, but less than the posttest 1 ($d = 1.58$).

The mean and standard deviation for List 1 pretest scores for the passive intervention were (M = 3.40, SD = 2.06). The List 1, posttest 1 mean and standard deviation for the active intervention were (M = 7.99, SD = 2.80), and the List 1, posttest 2 mean and standard deviation were (M = 7.36, SD = 1.59). The Cohen's d from pretest to posttest 1 for List 1 (d = 1.87) indicates a large effect. Additionally, the increase from pretest to posttest 2 for List 1 administered 24-hours after posttest 1 was also a large effect size, but less than the posttest 1 (d = 1.59).

The mean and standard deviation for List 1 pretest scores for the active intervention were (M = 1.73, SD = 1.31). The List 1, posttest 1 mean and standard deviation for the active intervention were (M = 5.49, SD = 3.19), and the List 1, posttest 2 mean and standard deviation were (M = 4.40, SD = 3.06). The Cohen's d from pretest to posttest 1 for List 2 (d = 1.54) indicates a large effect. Additionally, the increase from pretest to posttest 2 for List 1 administered 24-hours after posttest 1 was also a large effect size, but less than the posttest 1 (d = 1.13).

The mean and standard deviation for List 2 pretest for the passive intervention were (M = 1.89, SD = 1.78). The List 2, posttest 1 mean and standard deviation for the passive intervention were (M = 4.94, SD = 3.22), and the List 2, posttest 2 mean and standard deviation were (M = 3.80, SD = 3.07). The Cohen's d from pretest to posttest 1 for List 1 (d = 1.72) indicates a large effect. Additionally, the increase from pretest to posttest 2 for List 2 administered 24-hours after posttest 1 was also a large effect size, but less than the posttest 1 (d = 0.76). The List 2 posttest 2 active and passive comparisons yield an effect for the active intervention (*d* = 1.13) versus an effect for the passive intervention (*d* = 0.76).

Table 1
Descriptive Statistics for Pre- and Posttests of Active and Passive Interventions

Active Intervention				Passive Intervention			
	M	*SD*	*d*		*M*	*SD*	*d*
List 1 Pretest	3.40	2.22	-	List 1 Pretest	3.40	2.06	-
List 1 Posttest 1	8.08	2.40	2.01	List 1 Posttest 1	7.99	2.80	1.87
List 1 Posttest 2	7.42	2.81	1.58	List 1 Posttest 2	7.36	1.59	1.59
List 2 Pretest	1.73	1.31	-	List 2 Pretest	1.89	1.78	-
List 2 Posttest 1	5.49	3.19	1.54	List 2 Posttest 1	4.94	3.22	1.72
List 2 Posttest 2	4.40	3.06	1.13	List 2 Posttest 2	3.80	3.07	0.76

Research Question 1: Results of Multimedia Strategies

A factorial analysis of variance (ANOVA) was conducted to examine the interaction between the active and passive interventions over time (*N* = 209). The results are displayed in Table 4. The within-subjects comparison showed there is a main effect for time from pretest to posttest for List 1 $F(1, 207) = 411.97$, $p = <.001$, $\eta_p^2 = .67$) and List 2 $F(1, 207) = 145.64$, $p = <.001$, $\eta_p^2 = .41$). The main effect for between-subjects for instruction was not statistically significant for List 1 $F(1, 207) = .01$, $p = .91$, $\eta_p^2 = <.001$) and List 2 $F(1, 207) = 1.01$, $p = .30$, $\eta_p^2 = .005$). The interaction effect, which is the statistic of interest because it explains the combination of time and instruction, is also not significant for List 1 $F(1, 207) = .01$, $p = .99$, $\eta_p^2 = <.001$) and List 2 $F(1, 207) = 2.18$, $p = .114$, $\eta_p^2 = .01$). These results indicate that vocabulary test scores of both groups, active and passive, improved and was not a function of the type of intervention.

Table 2

Results of the ANOVA

Outcome		*Effect*	*F- Ratio*	*p*	η_p^2
List 1	Within-Ss	pre/post	411.97	<.001	.67
		Interaction	.01	.99	<.001
	Between-Ss	Instruction	.01	.91	<.001
List 2	Within-Ss	pre/post	145.64	<.001	.41
		Interaction	2.18	.11	.01
	Between-Ss	Instruction	1.10	.30	.005

Figures 8 and 9 reflect List 1 and List 2 pretest, posttest 1, and posttest 2 scores respectively. The active intervention is represented by the dotted line and the passive intervention is represented by the solid line in both figures. The steep slopes from pretest 1 to posttest for List 1 (See Figure 16) is virtually identical for both active and passive interventions. This graph also illustrates a comparable decline in retention after 24 hours for both groups.

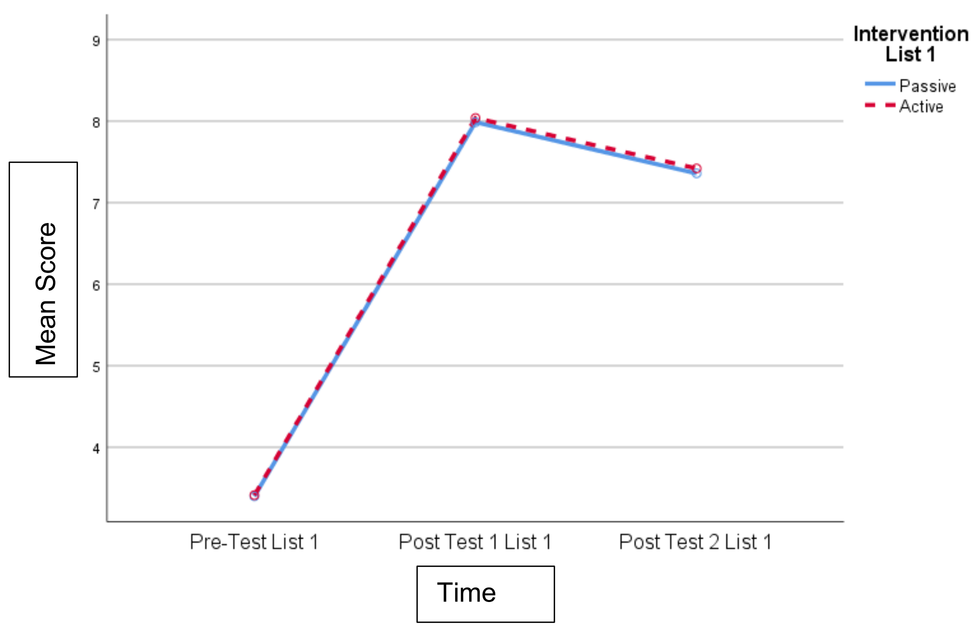

Figure 16: List 1 Active, Multimedia and Passive Intervention Performance

The slope from pretest to posttest for List 2 is slightly steeper for the active intervention (See Figure 17). The slope lines from posttest 1 to posttest 2 are parallel indicating an equivalent decline in retention 24 hours later for both interventions.

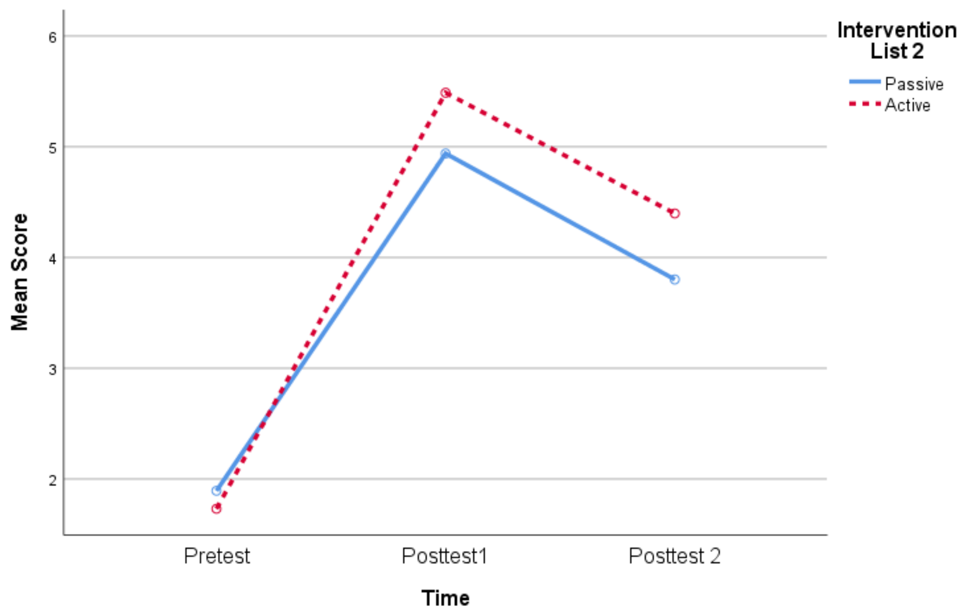

Figure 17: List 2 Active, Multimedia and Passive Intervention Performance

Based on the much higher mean scores for Posttest 1 for List 1 over List 2 for both the passive and active interventions, it appeared that List 1 may be easier than List 2 An examination of the differences in difficulty levels of the lists was conducted. When comparing List 1 and List 2 by word count List 2 terms have longer definitions than the definitions on List 1. More words in the definition may create a greater demand on language, cognitive, and drawing skills. A comparison of List 1 and List 2 based on the mean scores for each list showed the mean for List 1 was of 15.6 words correct and the mean for List 2 was of 12.3 words correct. A mean difference of 3.3 words correct is also an indication List 1 may have been easier than List 2.

Research Questions 2, 2a, 3, and 4: Results of Reading Levels and below grade level readers, Performance of Male and Female Students, Vocabulary Pre-test as predictor of performance

A stepwise linear regression was run to determine, if any, the influence of 1) Lexile reading levels, 2) gender, or 3) vocabulary pre-test performance on the outcomes of the study's interventions. In order to be included in the model, the variable had to be a significant predictor (p value equal to or greater than .05) of the posttest score criterion variable. Any non-significant variable was excluded from the model. The predictor variables were entered into the model in order of their contribution so that the predictor variable that contributed most, based on the r^2, was entered first. The stepwise regression provided two potential models to predict the outcome of the intervention for List 1. Model 1 which included Lexile reading level only, accounted for 22.6% of the variance of students' vocabulary post-test scores. This model states that for every 1000 points increase of student Lexile score the student post-test 2 score will increase by 6 points.

List 1 Model 1 Regression Equation:

List 1, post-test 2 scores = $.363\beta + .006_{(\text{Lexile})}$

List 1, model 2, which included pre-test performance and Lexile reading level, accounted for 29.5% of variance of the students' vocabulary post-test scores, an increase of 6.9%. Gender was excluded from the models because the variable of gender was not a significant indicator of performance on the vocabulary post-tests. This model states that for every 1000 points increase of student Lexile score the student post-test 2 will increase by 4 points and for every 10 points increase in pre-test score the post-test 2 score will increase by 3.78 point.

List 1, Model 2 Regression Equation:

List 1, post-test 2 scores = $.779\beta + .004_{(\text{Lexile})} + .378_{(\text{pre-test})}$

The stepwise regression also provided two potential models to predict the outcome of the intervention for List 2. The regression equation for List 2, model 1 included Lexile reading level only, accounted for 18.8% of the variance of students' vocabulary post-test scores. This model states that for every 1000 points increase of student Lexile score the student post-test score will increase by 6 points.

List 2 Model 1 Regression Equation:

List 2 post-test 2 scores = $-2.935\beta + .006_{(\text{Lexile})}$

List 2, model 2, which included pre-test performance and Lexile reading level, accounted for 21.0% of variance of the students' vocabulary post-test scores, an increase of 2.2%. Gender was also excluded from the models for List 2 because it was not a significant indicator of performance on the vocabulary post-tests. This model states that for every 1000 points increase of student Lexile score the student post-test 2 score will increase by 5 points and for every ten point increase in pre-test score will increase by 2.95.

List 2 Model 2 Regression Equation:

List 2, post-test 2 scores = $-2.814\beta + .005_{(\text{Lexile})} + .295_{(\text{pre-test})}$

The regression analysis indicates that reading level and pre-test performance, represented in Model 2 for both List 1 and List 2 accounts for some of the variance of vocabulary post-test 2 scores, but the vast majority of variance of these scores is not accounted for in these models.

Descriptive Statistics for Below Level Readers

Based on the analyses of the multiple tests, an additional data set was extracted from the full data set identifying student participants with below grade level Lexile scores (N = 13). The Lexile reading ranges of the identified students, in grade 7 are 530L-975L, in grade 8 are 745L-956L. Grade 6 students are not included because there were no below grade level readers in the grade level. In the analysis, rather than evaluate List 1 and List 2, the effectiveness of the active and the passive interventions for students reading below grade level was evaluated (See Figure 18).

Grade 7 Below Grade Level Readers		
Student	Lexile Level	Intervention Order
1	975	L1 Active; L2 Passive
2	670	L1 Active; L2 Passive
3	620	L1 Passive; L2 Active
4	760	L1 Passive; L2 Active
5	885	L1 Active; L2 Passive
6	530	L1 Active; L2 Passive
Grade 8 Below Grade Level Readers		
Student	Lexile Level	Intervention Order
1	745	L1 Active; L2 Passive
2	745	L1 Passive; L2 Active
3	965	L1 Active; L2 Passive
4	840	L1 Passive; L2 Active
5	935	L1 Passive; L2 Active
6	775	L1 Active; L2 Passive
7	900	L1 Active; L2 Passive

Figure: 18 Descriptive statistics of below grade level readers in grades 7 & 8

An additional paired sample t-test analysis was completed to compare the active and passive interventions using the pretest, posttest 1, and posttest 2 outcomes for students identified as below grade level using the Lexile reading range (See Table 3). The means for the active intervention posttest 1 and 2 are higher than the passive intervention means. The means are greater for posttest 1 than posttest 2. The mean for the passive intervention posttest 2 is greater than posttest 1.

Table 3

Means and Standard Deviations for Below Grade Level Lexile Readers

	M	*SD*
Active Pretest	1.69	1.32
Active Posttest 1	5.15	3.31
Active Posttest 2	3.85	2.88
Passive Pretest	1.38	.87
Passive Posttest 1	1.92	1.71
Passive Posttest 2	2.69	1.65

The results of the paired sample t-tests are mixed. The results of the paired sample t-tests shows significant growth from the active intervention from pretest to posttest 1 and from pretest to posttest 2 (See Table 4). In comparison, the results of the paired sample t-tests for passive intervention from pretest to posttest 1 was not statistically significant, but from pretest to posttest 2 was statistically significant. The data include ($N = 8$) participants who completed the active intervention using List 1, the easier list, and the passive intervention using List 2. While the other portion of the participants ($N = 5$) completed the passive intervention using List 1 and the active intervention using List 2.

Table 4

Results from Active and Passive Paired Sample T-test

	t	*df*	*p*
Active Pretest – Posttest 1	3.45	12	.005
Active Pretest – Posttest 2	2.48	12	.029
Passive Pretest – Posttest 1	1.24	12	.237
Passive Pretest – Posttest 2	2.94	12	.012

Summary

This chapter analyzes the student assessment data collected from the implementation of the study's research. Several analyses were completed to evaluate the collected data. Student test data, using the pretest and posttest assessments, were analyzed using a factorial ANOVA. Before running the analysis, a t-test was conducted on the pretest 1 and pretest 2 data to examine the equivalency of the two groups before the interventions.

Research questions 2 (reading level), 2a (below grade level readers), 3 (gender - female = 1, male = 2), and 4 (pretest performance) were analyzed using a step-wise linear regression was conducted to determine to determine, if any, the influence that 1) reading levels, including specifically below grade level readers, 2) gender, or 3) vocabulary pretest predict the learner outcomes following the passive and active interventions. An additional paired sample t-test analysis was completed to compare the active and passive interventions using the pretest, posttest 1, and posttest 2 outcomes for students identified as below grade level using the Lexile reading range.

An additional analysis was completed to delve further into the results of the ANOVA to answer the sub question 2a, how effective are the interventions, active, multimedia verse passive students identified a below grade level readers? Student data, identifying below grade level readers, were extracted from the larger data set and were analyzed by using a t-test to compare the active and passive interventions using the pretest, posttest 1, and posttest 2 outcomes.

A stepwise linear regression was run to determine, if any, the influence of 1) Lexile reading levels and below grade level readers, 2) gender, or 3) vocabulary pretest performance on the outcomes of the study's interventions.

Based on the results described, the following chapter, Chapter 5, the results will be evaluated relating to the literature review and the existing collection of research on the topic.

CHAPTER FIVE: CONCLUSION

Overview

This study was conducted to determine the impact of the multimedia, active vocabulary intervention of drawing and peer discussion versus the passive intervention of copying and studying vocabulary words. The study, for both interventions sessions, included a pretest of the ten vocabulary words used to conduct the intervention. Immediately following the intervention, the student participants completed a posttest. The following day, twenty-four hours later, the student participants completed a second posttest to measure vocabulary word retention. This study was an addition to a series of studies focusing on the impact of multimedia, active vocabulary intervention of drawing and peer discussion versus the passive intervention of copying and studying vocabulary words. Previous studies, (Shore et al., 2015; Thomas, 2017) found a statistically significant difference between the multimedia, active intervention and the passive intervention. Students practicing the multimedia, active intervention performed better than they did when they practiced the passive vocabulary intervention. This current study differed from the prior studies by using middle school student participants and through the implementation of vocabulary pretests to determine the participant vocabulary level of knowledge prior to the interventions.

The study focused on four research questions: vocabulary intervention type, the impact of students' reading levels with a sub question specific to students identified as below grade level readers, gender, and student pretest performance.

A factorial analysis of variance (ANOVA) was conducted to examine the interaction between the active and passive interventions over time. Before running the analysis, a t-test was conducted on the pretest 1 and pretest 2 data to examine the equivalency of the level of participants' vocabulary knowledge based on pretest performance before the interventions. The t-test scores indicated there was no difference between the participants level of vocabulary knowledge on List 1 and List 2 prior to the intervention based on their pretest performances.

The results from the factorial ANOVA showed that the between subjects analysis found no statically significant difference between the two interventions following the instruction. The statistic of interest, the interaction, explains the combination of time and instruction, is also not significant for List 1.

Research questions two, two a, three, and four were addressed when a stepwise linear regression was run to determine if any, the influence that 1) reading levels, 2) gender, or 3) vocabulary pretest performance on the outcomes of the study's interventions. The stepwise regression provided two potential models to predict the outcome of the intervention for List 1. Based on the outcome, student's identified reading level, measured by their Lexile reading level, accounted for 22.6% of the variance of students' vocabulary posttest scores. Next, pretest performance, as an indicator, shows that pretest performance accounted for 29.5% of the variance of the students' vocabulary posttest scores. In response to research question three, gender, the regression indicated that gender was not statically significant indicator of performance on the vocabulary posttests.

While prior studies' findings indicated the greatest influence on students' acquisition and retention levels was the multimedia active vocabulary intervention versus the passive intervention, this study found that the best indicator of student posttest performance was their pretest performance followed closely by their Lexile reading level. The outcomes for List 1 and List 2 were analyzed, and the researcher found little difference between the active and the passive interventions using List 1 words on vocabulary acquisition, posttest 1 results, and retention, posttest 2 results. List 2, however, indicated a slightly elevated difference between the active and passive interventions with the active intervention outcomes outpacing those of the passive intervention with both vocabulary acquisition, posttest 1 results, and retention, posttest 2 results.

To specifically evaluate the effectiveness of the active, multimedia intervention with students identified as below grade level readers, an additional analysis was completed to delve further into the results of the ANOVA. Because the ANOVA data, based on the total participant results, indicated no difference between the active, multimedia and passive interventions, an additional t-test was conducted to answer the sub question 2a, how effective are the interventions, active, multimedia verse passive students identified a below grade level readers? Student data, identifying below grade level readers ($N = 13$), were extracted from the larger data set and were analyzed by using a t-test to compare the active and passive interventions using the pretest, posttest 1, and posttest 2 outcomes. The sample population shows that the active intervention yields statistically significant effect for students identified as below grade level readers. This finding supports prior studies' findings that students identified as on or above grade level are positively affected regardless of the vocabulary interventions, active or passive. In contrast, students identified as below grade level readers, as determined by the Lexile reading scale, show statistically significant levels of vocabulary acquisition and retention with the active, multimedia intervention of student-generated drawing and peer discussion than with the passive intervention of reading, coping notes, and studying independently.

One variable that may have inflated the active intervention outcomes was the combination of List 1 or 2 and intervention type, active or passive. Of the below grade level readers, eight using List 1 terms with the active intervention, while five had the passive intervention. When the treatment was crossed for intervention session 2, eight students implemented the passive intervention with List 2 words, the by correct response item analysis and larger word volume, may indeed be a more difficult word list.

Connections to Previous Literature

There is a vast body of research that emphasizes the importance of instruction that is well planned, prepared, and presented. This study focused on the active, multimedia intervention of learner-generated drawing and discussion versus the passive intervention of reading and coping the vocabulary word definitions. Active learning strategies and student engagement has proven to impact learning and are hallmarks of excellent instruction. Generative learning (Fiorella & Mayer, 2015), including learner-generated drawings (DeJong, 2005; Whittrock, 1990) helps students develop deeper understandings and engages cognition. Additional research found that learner-generated drawings have a compounding positive impact on learner experience and content retention (Shore et al., 2015; Thomas, 2017). The learning strategy of copying notes or information from the board, a textbook or a digital presentation is a passive learning activity (Chi & Wylie, 2014). Van Blerkon et al. (2006) found that generative study strategies are more effective than passive strategies. Research has found that in the hierarchy of study skills and learning strategies, copying is only singularly better than rereading text (Benassi, Overson, & Hakala, 2014).

This study's findings also indicated that student vocabulary acquisition and retention were improved when implementing the active, multimedia interventions; yet the active, multimedia intervention outcomes were not as significant as prior studies when evaluating the whole participant population. In the current study, the outcomes for List 1 indicated no difference between the active, multimedia and passive interventions. List 2 data showed a slighter difference between active and passive interventions. Students who engaged in the active intervention using List 2, outperformed their peers who used the same words but completed the passive intervention.

Additionally, research indicates that for the average learner passive learning strategies are at best ineffective, but for students with reading difficulties passive strategies compound the learning short circuit. Students with reading difficulties struggle to process content when delivered by the passive methods of reading and copying (Freeman et al., 2014). In this study, both performances on the pretest and posttest was closely correlated to the student's reading Lexile level. Thus, students with low or below grade level reading scores were the students who also performed poorly on the vocabulary pretest and posttests. This study found that on and above grade level readers showed similar growth using either the active, multimedia or the passive interventions.

Because a majority of the participant were identified as at or above grade level, the data supported previous studies findings that proficient readers grow regardless of the type of intervention. The most important finding, using the extracted data from the below grade level sample group, were the strong vocabulary growth scores when the active, multimedia intervention was implemented with below grade level readers.

Based in the reading data from the national NAEP (2015, 2017), 64% of students in grades 4 and 8 are performing below the proficiency level and 57% of grade 12 readers fall in the same category. With over half of our nation's school age students, based on the NAEP data, performing below proficient, the most effective instructional strategies that strategically reach below graded level readers must be implemented and include active, multimedia strategies in order to improve both national reading and science scores. Allington found (2012) that the causal analysis of student reading permeance reveals that vocabulary knowledge, or lack thereof, is a crucial variable for students below average or below grade level reading performance, thus tying reading, vocabulary acquisition, and science achievement together.

Research indicates that engaging both visual and verbal channels, multimedia learning strategies improve learning (Mayer et al., 1999; Mayer, 2001; Fensi et al., 2015; Shore et al., 2015; Moreno et al., 2001). Multimedia learning strategies reduce the working memory load which allows learners to prioritize and process relevant information (Mayer et al., 1999).

The classroom teachers provided directions for each intervention, active, multimedia and passive to the study participants. While the directions were clear and specific, the teachers and researcher had no control over a student's self-selected method of reading, copying, and studying during the passive intervention. Research, including the Generation Effect, Slemecka, and Graph (1978), found that learners who produced a word from a cue had better results with word recall that of the learners who merely read the word. Similarly, the Production Effect (MacLeod, Gopie, Hourihan, Neary, & Ozubko, 2010) and production methods, including silently mouthing words to self (McLeod et al., 2010), saying them aloud (Hourihan & MacLeod, 2008), and writing and spelling the words (Forrin, MacLeod & Ozubko, 2012) "improves explicit memory" (McLeod et al., 2010, p. 671). While students participating in the active, multimedia intervention, which included student drawing and peer discussion, were easily observable.

Chi (2009) found that learning occurs when students listen to one another. When two or more students interact (Lehtinen & Viiri, 2014) and actively engaged in a discussion, they both contribute to each other's learning (Chi & Wylie, 2014). However, students participating in the passive intervention with the direction to read, copy, and study may have silently mouthed the words during independent study. This student study behavior utilized may have impacted the outcome by activating increased student engagement level during the passive intervention and could explain the stronger scores for the passive intervention than from prior studies.

An additional area of note, during the creation of vocabulary List 1 and List 2, the two lists were generated from the initial vocabulary word selection pretest where the twenty "least known" words were identified for List 1 and List 2. After the identification of the twenty words, the researcher crafted two lists using an alternating word designation to assign words to each list. The result of this method randomly created List 1 that had words with shorter definitions, while List 2 words had definitions with more words and more robust language. The data from List 2 indicated the active, multimedia intervention had a more significant impact on students' vocabulary acquisition and retention than the passive intervention as indicated in the output data from List 1. It is theorized the active, multimedia intervention positively impacted student vocabulary acquisition and retention with the more language heavy, List 2.

Shore et al. (2015) and Thomas (2017) found that an active vocabulary intervention including sketching and peer discussion in high school students improved vocabulary acquisition and retention. This study followed the research models established in the Shore, Ray, Goolkasian (2015) and Thomas (2017) works but had differing outcomes. The Shore, Ray, Goolkasian (2015) and Thomas (2017) studies compared active, multimedia versus passive vocabulary interventions and found student vocabulary acquisition and retention to be significantly improved when using the active-multimedia intervention than when implementing the passive intervention. However, this study's data, while still indicating that active intervention students outperformed themselves when they complete the passive intervention, did not find nearly as large a spread between the active and passive intervention scores. Two variables may have contributed to the outcome. From this series of studies, this is the only study featuring middle school student participating using the combined active, multimedia intervention of student-generated drawing and discussion. Additionally, this study first conducted a pretest to determine the students' vocabulary knowledge before introducing the interventions and series of posttests. In this study, for the first time the researcher was able to accurately measure how many, if any, the students knew. In addition, there were fewer students who were below grade level reading participating in this study. A prior study showed that students identified as at or above grade level readers had less variance in acquisition and retention assessment outcomes between the active, multimedia and the passive vocabulary interventions than the students participating with the same interventions, but who were identified as below grade level readers.

Also, this study, based on various national and international data sources, analyzed the specific subgroup concern of the gap between male and female science assessment performance. While studies and assessment data have indicated that males outperform females (McFarland et. al, NCES 2017; NSB, 2018; OECD 2007; Poland & Plevyak, 2015), because of the structure of the intervention, the researcher did not anticipate diverging performance outcomes. The regression analysis indicated that gender indeed was not a factor in posttest data because it was not stastically significant. Perhaps the disparity in scores is an indicator of a multifaceted issue, rather than an oversimplification that the female student knowledge base is lacking. While level of knowledge may be a factor, test gender bias may also be a cause for varied outcomes. Also, perhaps since the study participants were middle schoolers, the gender gaps that appear in older students has yet to form. Another reason for the lack of gender discrepancy was due to this study’s concentrated emphasis on science vocabulary tasks the relied heavily on students’ reading and writing ability.

Limitations

As with any study, this study has several limitations that need to be considered. First, this study's student participants were from a large, independent private school that has a rigorous process for admission. Unlike a public school that serves all students who live in the attendance zone, the participant school can select students for enrollment. Because the school has established academic benchmarks for enrollment, the student population is less academically differentiated, with fewer students performing at or below grade level. One could argue the school population is not an accurate representation of a school population at-large.

Secondly, the study's design may present a limitation to the accuracy and validity of the outcomes based on the current design. In this study neither the order of the lists presented to the students nor classes assigned to the active and passive groups were randomly assigned. Randomizing the order of the lists and a Soloman four-group design to randomize all the conditions (lists and intervention) would be a strong study to control for confounding and extraneous factors.

Thirdly, time may have influenced the study's outcomes. Time, pertaining to this study, has more than one application. Time of the school year, the time between interventions may have impacted this study, and time allowed for student-generated drawing during the active, multimedia intervention may have impacted the effectiveness of the intervention. This study, conducted in the last month of the school year, may have been impacted. At this time of year, many schools have special trips and activities; thus, student engagement tends to wane. The other element of time was the time that passed between interventions. Both the active, multimedia and passive interventions, completed within a week of each other, and experienced no testing irregularities. Student performance has yielded different outcomes if they had more time between interventions, but this factor is undetermined. Both groups of students were limited to 30 minutes for the interventions.

Another limitation is the likely difference in the difficulty of the two list of words and their definitions. It appeared that List 1 was easier than list as demonstrated by the mean scores correct for each list. Calculating the item difficulty of each word from the list of 50 initial words, then using this to select and assign words to the two lists would have improved the interpretation of the results of this study.

Additionally, students were permitted a limited amount of time to generated their vocabulary word sketches in order for them to be able to complete the second portion of the intervention, peer discussion within the allotted thirty-minute intervention. Contrary to this studies design where participants' drawing time was limited, researchers suggest that learning outcomes are related to the quality of the drawings and many times, quality drawings require more time to produce (Leopold, 2009; Schwamborn et al., 2010; Van Meter, 2001).

Another limitation may have been the design and structure of the posttest. The posttest design included the ten vocabulary word definitions introduced in the intervention and had a drop-down list of all ten possible vocabulary words as answer choices and in this study there were no distractor words. According to Clay and Root (2001), when writing student test questions, there is a specific format and procedure for effective test items. The design did not place a significant demand on the students to completely commit the vocabulary definition to memory. In theory, students may have been able to guess between the ten choices to make their answer selections.

An additional limitation was the interactions between the students during the active intervention. The active intervention by design encouraged the students to engage and discuss the vocabulary words and their definitions. While this interaction is beneficial and necessary to the study, when two or more students interact (Lehtinen & Viiri, 2014) and are actively engaged in discussion they both contribute to each other's learning (Chi & Wylie, 2014), it becomes difficult to discern if the students remained on task and topic for the duration of the intervention.

The classroom teachers monitored the students carefully and redirected when necessary, but there is no way to ensure that off-task talking did not occur. The researcher was an observer for all pretest, intervention, and posttest sessions and observed off task behavior by students. Some students participated in off topic discussions during the peer discussion portion of the active, multimedia intervention. The participating classroom teacher quickly addressed off task behavior and discussion, but they were not completely avoidable. Also, the student participants' peer discussions would, at times, stall as students self-determined they were "finished" with their peer discussions; however, student did reengage in their peer discussion when prompted by the classroom teacher.

A final limitation was the difference between vocabulary List 1 and List 2 used in the study. While both lists derived from the same grade 9 physics textbook, were identified using the same fifty item pretest, and were generated using an alternating grouping method, List 1 and List 2 differed when comparing the amount of language in each vocabulary word's definition. Therefore, List 2 had more words to read, comprehend, and learn compared to the words on List 1. Based on research, the greater number of words may have created increased cognitive load on the study participants. Additionally a correct item analysis indicated that List 2 was created with lesser known words that those in List 1.

Implications for Practice

The confluence of credible research in the fields of cognitive science and cognitive learning on the topics of student engagement, multimodality content presentation, the Generation and Production Effects, and the importance of multifunction coding to support short-term memory retention is a clear map for teachers to follow to have maximum impact on best instructional practices, teaching strategies, and thus, student learning.

Researcher shows learner-generated drawings positively impact student learning (DeJong, 2005; Whittrock, 1990). Classroom teachers and teacher preparation programs need to implement the proven active teaching strategies based on their positive cognitive impact on students. One area where teachers may need to reframe their thinking is the tendency to view more creative connections for learning as "fluff" or time wasters. However, research indicates student learning outcomes when implementing student-generated drawings during instruction are directly impacted by the quality of the drawings (Leopold, 2009; Schwamborn et al., 2010; Van Meter, 2001). For most learners, excluding artists, quality requires time. In the classroom, effective teachers have limited time for instruction; therefore, there is a sense of urgency to capture every moment of class time for instruction.

One way to maximize instructional time, but to also incorporate drawing and other active learning strategies is to connect classroom instruction to homework assignments. Shifting the vocabulary practice, drawing to homework not only moves classroom assignments to research-based practices, but also influences homework assignments that are predominately passive and traditionally based on worksheet completion, memorization, or copying notes.

Additionally, twenty-first-century learners demand twenty-first learning environments. In today's classroom, research suggests that the "sage on the stage" model might be retired and, in its place, should be classrooms that are learner-centered and learner focused. This paradigm shift initiates new classroom constructs that are characterized by teachers planning and implementing active learning and reflecting on what students need to best support their understandings (Lumpkin, Achen, & Dodd, 2015).

Recommendations for Further Research

Based on the current study's findings that differ from prior studies, additional study with a more academically diverse population may yield different results. While the study did support prior research that active, multimedia vocabulary interventions are more effective than passive interventions for vocabulary acquisition and retention; the data diverged from previous studies regarding the statistical significance between the active, multimedia and passive interventions. Besides, only one study in this series of studies has been implemented with middle school students. Data from a replicative study may yield different results.

Altering the research design to a Soloman four group model, randomizing the lists and interventions will provide a stronger design and strengthen the interpretation of the results.

More research also needs to be conducted with this model specifically with students with diagnosed reading disabilities or with students who are reading below grade level. The regression data in this study indicated a direct correlation between reading Lexile levels and vocabulary acquisition and retention. Further research, explicitly focused on students with reading disabilities and the implementation of active, multimedia vocabulary intentions, may yield more conclusive information regarding the level of effectiveness of the intervention with underperforming reading student populations.

Another consideration for future study is to conduct a study comparing which active, multimedia intervention is more effective, student-generated drawing or peer discussion. As the literature review indicates, studies have been conducted to evaluate the effectiveness of student-generated drawing. Studies have been conducted evaluating the effective need of peer discussions. Studies have also conduced, like this one, which evaluated the effectiveness of combining the active, multimedia intervention of student-generated drawings and peer discussions. Thomas' (2017) combined the strategies and found high rates of effectiveness. The direction of future study is to determine which is more effective – student-generated drawings or peer discussion.

An additional consideration for further study is to replicate the prior studies but to remove the time constraints for student-generated drawing that was implemented in this study. As research indicates, the quality of learner-generated drawings has a positive impact on student learning outcomes (Leopold, 2009; Schwamborn et al., 2010; Van Meter, 2001). Conducting a study that allows for more time during the learner-generated drawing and discussion may have a positive impact on the effectiveness of the active, multimedia vocabulary intervention.

Another research design to consider for future study is to group presented words by concept and then have the participants combine words within one drawing. Not only will the student generate the drawings, but they will, dependent on the implementation by the student, they will also create and organize the information to show relationships and to help to build a more advanced matrices in their schema. It is theorized that this proposed research design will foster more elaborate drawing and create connections that may positively effect vocabulary acquisition and retention. The act of drawing will reduce cognitive load and the more elaborate drawings improve cognition (Schwamborn et al., 2010). With the added layer of connections and relationship between words, an even greater level of cognition may be achieved.

If future replicative studies are conducted, one recommendation is to refine the final step of the word selection process. At the point where the twenty least know words are identified, consider classifying and sorting the words into two categories of ten words each. Form the words into two groups, words with definitions with more language and words with definitions with less language. Then generate List 1 and List 2 by drawing words alternately from the two word grouping. This refinement of the list construction will create lists where words with more language heavy definitions will be evenly distributed between the two lists.

Conclusion

The continued struggle for the nation's schools to bolster science achievement and the cascade of problems resulting from the lack of advancement, from science achievement to national security implications, necessitates targeted interventions based on quality research and effective learner outcomes. The implementation of effective teaching and intervention models are imperative for student growth in science classrooms. Beyond the identification of effective interventions and call for immediate implementation, is the need for teacher development programming to provide teachers with the support, guidance, and coaching they need to make an impactful, long-term change in teaching practice. In order to impact the learning environment, we must change how the teacher is teaching.

Based on the study's findings that active, multimedia instructional strategies and interventions are most imperative and effective for students identified as below grade level readers. As NAEP data indicates (2015, 2017) well over 50% of school aged students assessed were performing below proficient in reading. Allington (2012) connected student reading permeance and vocabulary knowledge, as a crucial variable for students below average or below grade level reading performance.

With the connection between vocabulary acquisition, reading performance, and science achievement and the identification of the most effective teaching strategies and interventions for below grade level readers, it is imperative to change the current teaching models in today's science classrooms. Research indicates that on or above grade level readers will grow regardless of the type of intervention, active, multimedia or passive; however, below grade level readers show more growth when instructed using active, multimedia teaching methods. With over half the country's student body identified as a below grade level reader, the implications of this study's findings and a systemic implementation of active, multimedia instructional practices may have an impact on future national reading and science achievement scores and, thus, the scientists of tomorrow.

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Appendix A:
Vocabulary Selection Pretest

Science Vocabulary Pretest

Read the following definitions and select the correct answer. If you do not know the answer, select "I don't know".

Required

1. **First and Last Name** *

2. **Grade** *
   Mark only one oval.
   - Grade 6
   - Grade 7
   - Grade 8

3. **1) Distortion in an Image produced by a lens.** *
   Mark only one oval.
   - fracture
   - myopathy
   - aberration
   - I don't know

4. **2) Red, blue, and green light. These colors when added together produce white light.** *
   Mark only one oval.
   - additive primary colors
   - secondary primary colors
   - prism effect
   - I don't know

5. **3) Electric current that repeatedly reverses direction, twice each cycle. Usually at 60 cycles per second, or hertz (Hz), in North America, or 50 hertz elsewhere.** *
   Mark only one oval.
   - alternating current
   - direct current
   - ventricular fibrillation
   - I don't know

Appendix B:
Vocabulary List 1

LIST 1	
VOCABULARY TERM	**DEFINITION**
aberration	Distortion in an image produced by a lens
electrostatics	The study of Electric charges at rest
excited state	A state with greater energy than an atom's lowest state
Hooke's Law	The distance of stretch or squeeze (extension or compression) of an elastic material is directly proportional to the applied force
node	Any part of a standing wave that remains stationary
perigee	The point in a satellite's elliptical orbit where it is nearest the center of the earth
postulate	A fundamental assumption
simple harmonic motion	The back-and-forth vibratory motion of a swinging pendulum
spectroscope	An instrument used to separate the light from a hot gas or other light source into its constituent frequencies
time dilation	An observable stretching, or slowing, of time in a frame of reference moving past the observer at a speed approaching the speed of light

Appendix C:
Vocabulary List 1 Pretest

Science Vocabulary Pretest LIST 1

Read the following definitions and select the correct answer.

* Required

1. **First and Last Name** *

2. **Grade** *

   Mark only one oval.

   - Grade 6
   - Grade 7
   - Grade 8

3. **1) Any part of a standing wave that remains stationary.** *

   Mark only one oval.

   - aberration
   - electrostatics
   - excited state
   - Hooke's Law
   - node
   - perigee
   - postulate
   - simple harmonic motion
   - spectroscope
   - time dilation

Appendix D:
Vocabulary List 1

LIST 1	
VOCABULARY TERM	**DEFINITION**
aberration	Distortion in an image produced by a lens
electrostatics	The study of Electric charges at rest
excited state	A state with greater energy than an atom's lowest state
Hooke's Law	The distance of stretch or squeeze (extension or compression) of an elastic material is directly proportional to the applied force
node	Any part of a standing wave that remains stationary
perigee	The point in a satellite's elliptical orbit where it is nearest the center of the earth
postulate	A fundamental assumption
simple harmonic motion	The back-and-forth vibratory motion of a swinging pendulum
spectroscope	An instrument used to separate the light from a hot gas or other light source into its constituent frequencies
time dilation	An observable stretching, or slowing, of time in a frame of reference moving past the observer at a speed approaching the speed of light

Appendix E:
Vocabulary List 1 Student A Copy Definition – Passive Intervention

ABBERATION- Distortion in an image produced by a lens

ELECTROSTATICS - The study of electric charges at rest

EXCITED STATE- A state with greater energy than an atom's lowest state

HOOKE'S LAW- The distance of stretch or squeeze (extension or compression) of an elastic material is directly proportional to the applied force

NODE- Any part of a standing wave that remains stationary.

PERIGEE- The point in a satellite's elliptical orbit where it is nearest the center of the earth

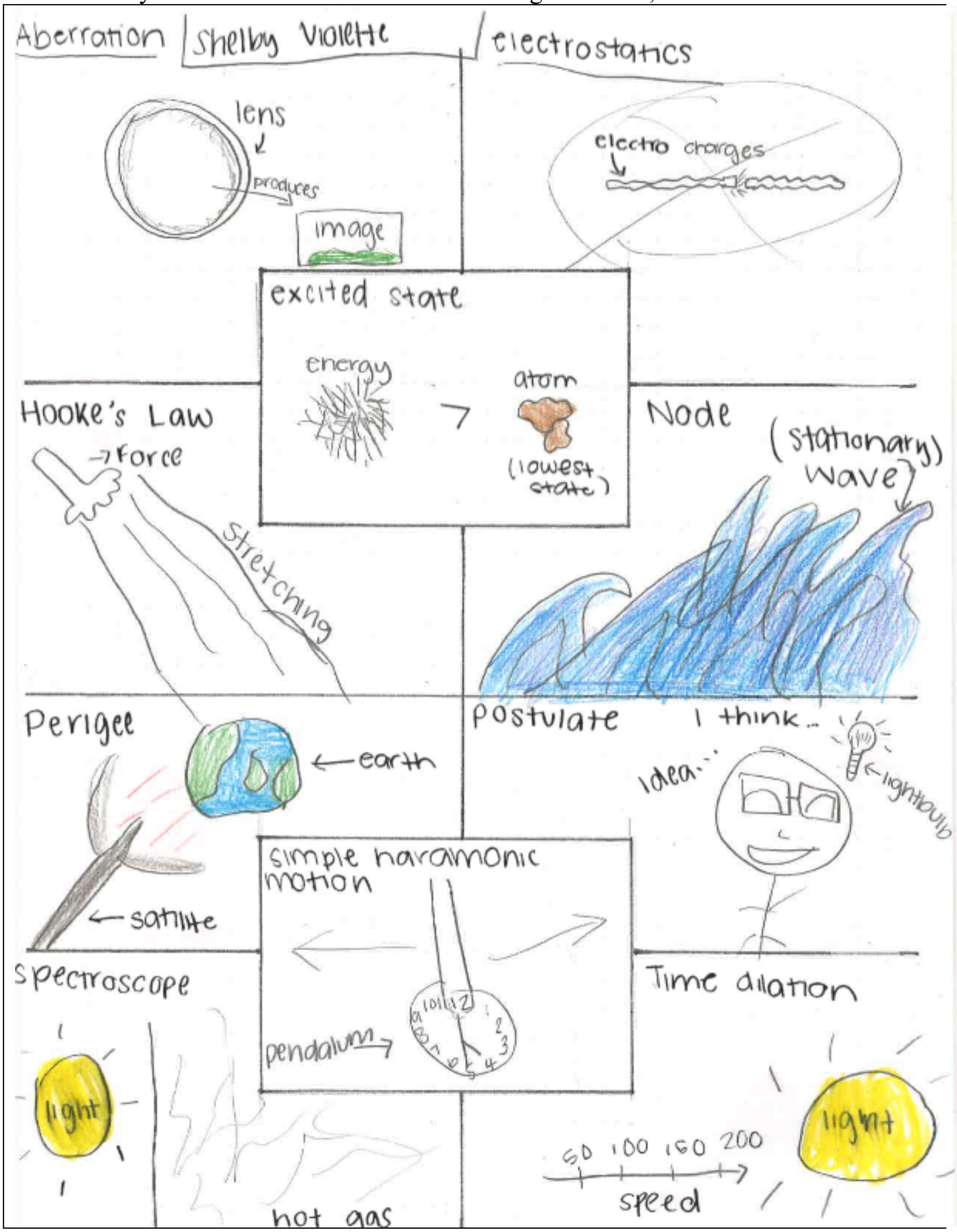
POSTULATE- A fundumental assumption

SIMPLE HARMONIC MOTION- The back-and-forth vibratory motion of a swinging pendulum

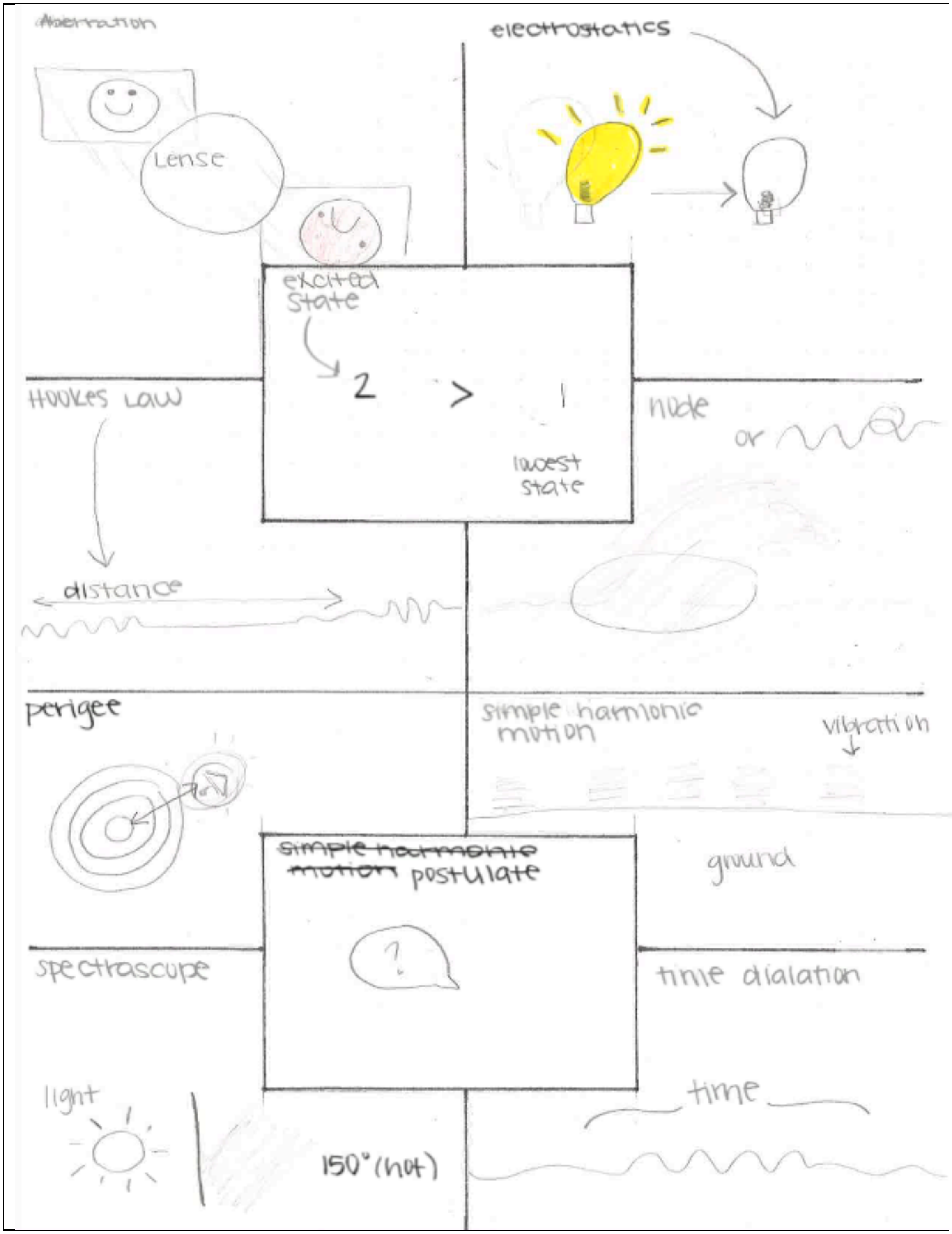
SPECTROSCOPE- An instrument used to seperate the light from a hot gas or other light source into its constituent frequencies

TIME DILATION- An observable stretching, or slowing of time in a frame of reference moving past the observer at a speed approaching the speed of light

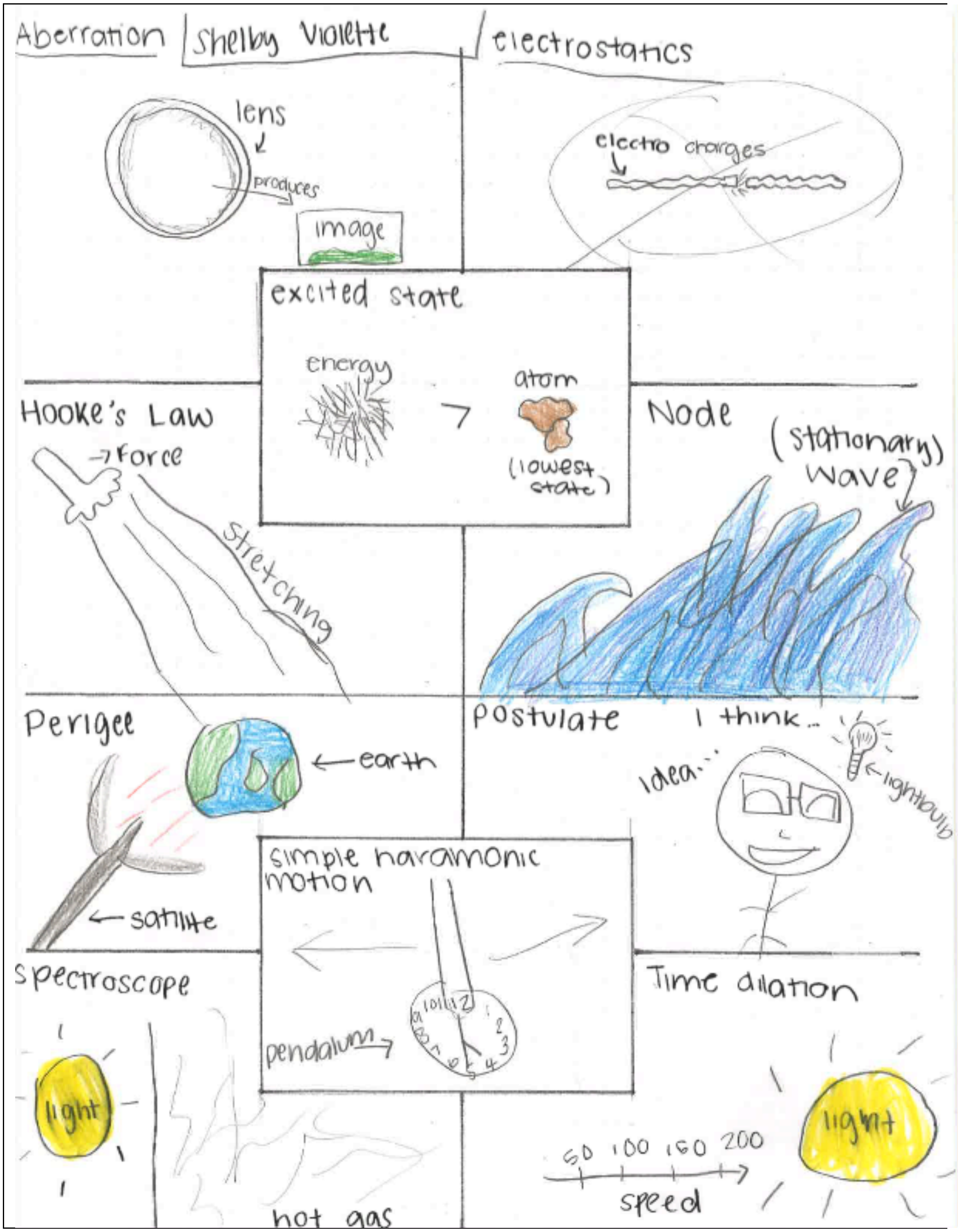
Appendix F:
Vocabulary List 1 Student B Generated Drawings – Active, Multimedia Intervention



Appendix G:
Vocabulary List 1 Student C Generated Drawings – Active, Multimedia Intervention



Appendix H:
Vocabulary List 1 Student D Generated Drawings – Active, Multimedia Intervention



Appendix I:
Vocabulary List 1 Posttest 1

Science Vocabulary POST TEST 1 LIST 1

Read the following definitions and select the correct answer.

* Required

1. **First and Last Name** *

2. **Grade** *

Mark only one oval.

- Grade 6
- Grade 7
- Grade 8

3. **1) The point in a satellite's elliptical orbit where it is nearest the center of the earth.** *

Mark only one oval.

- aberration
- electrostatics
- excited state
- Hooke's Law
- node
- perigee
- postulate
- simple harmonic motion
- spectroscope
- time dilation

Appendix J:
Vocabulary List 1 Posttest 2

Science Vocabulary POST TEST 2 LIST 1

Read the following definitions and select the correct answer.

* Required

1. **First and Last Name** *

2. **Grade** *

   Mark only one oval.

   - Grade 6
   - Grade 7
   - Grade 8

3. **1) An observable stretching, or slowing, of time in a frame of reference moving past the observer at a speed approaching the speed of light.** *

   Mark only one oval.

   - aberration
   - electrostatics
   - excited state
   - Hooke's Law
   - node
   - perigee
   - postulate
   - simple harmonic motion
   - spectroscope
   - time dilation

Appendix K:
Vocabulary List 2

LIST 2	
VOCABULARY TERM	**DEFINITION**
destructive interference	Combination of waves where crests of one wave overlap troughs of another, resulting in a wave of decreased amplitude
entropy	A measure of the amount of disorder in a system
geodesics	Lines of shortest distance between two points in curved space
length contraction	The observable shortening of objects moving at speeds approaching the speed of light
penumbra	A partial shadow that appears where light from part of the source is blocked and light from another part of the source is not blocked
perturbation	The deviation of an orbiting object from its path around a center of force caused by the action of an additional center of force
rarefaction	A disturbance in air (or matter) in which the pressure is lowered. Opposite of compression
sine curve	A curve whose shape represents the crests and troughs of a wave, as traced out by a swinging pendulum that drops a trail of sand over a moving conveyer belt
tangential speed	The speed of an object moving along a circular path
vector	An arrow who's length represents the magnitude of a quantity and who's direction represents the direction of the quantity

Appendix L:
Vocabulary List 2 Student E Copy Definition – Passive Intervention

Destructive Interface - Combination of waves where crests of one wave overlap troughs of another, resulting in a wave of decreased amplitude

Entropy - A measure of the amount of disorder in a system

Gravitational Waves - Lines of shortest distance between two points in a curved space

Length Contraction - The observable shortening of objects moving at speeds approaching the speed of light

Penumbra - A partail shadow that appears where light from part of the source is blocked and the light from a part of another source is not blocked

Perturbation - The deviation of an orbiting object from it's path around a center of force caused by the action of an additional center of force

Rarefaction - A disturbance in air (or matter) in which the pressure is lowered. Opposite of compression

Sine Curve - A curve whose shape represents the crests and troughs of a wave, as traced out by a swinging pendulum that drops a trail of sand over a moving conveyor belt.

Appendix M:
Vocabulary List 2 Student F Copy Definition – Passive Intervention

Vector - an arrow who's length
represents the magnitude of
a quantity and whos direction
represents the direction of the
quantity

Tangential speed the speed of
an object mouhs along a
circular path

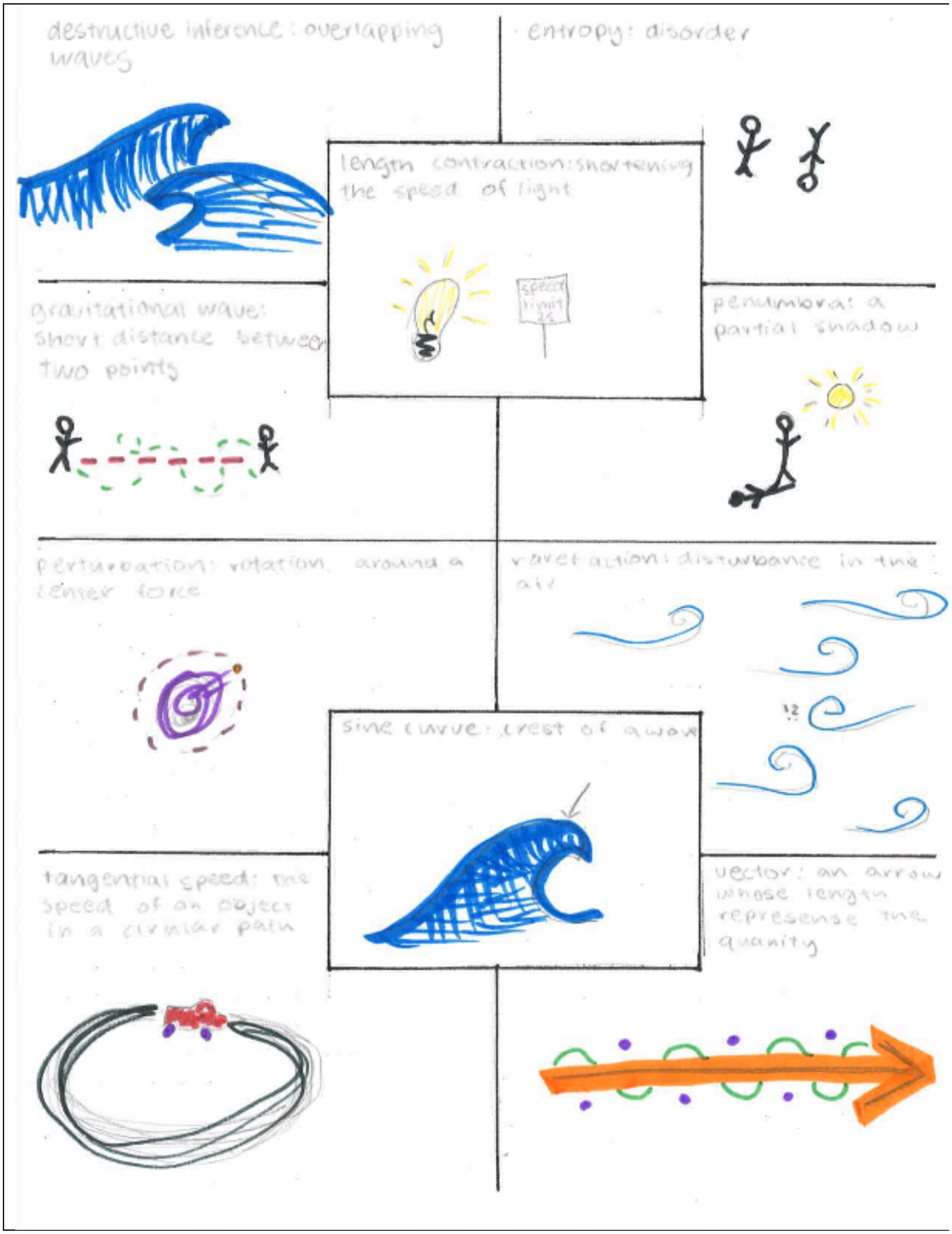
Sine curve A curve whose shape represents
the crep and trough of a wave
as traced out by swinging
pendulum the drop s drop of
sand out s... curves
~~Dil~~

Rarefaction A disturbance in circulation
in which the pressure is ...
Opposite of compression

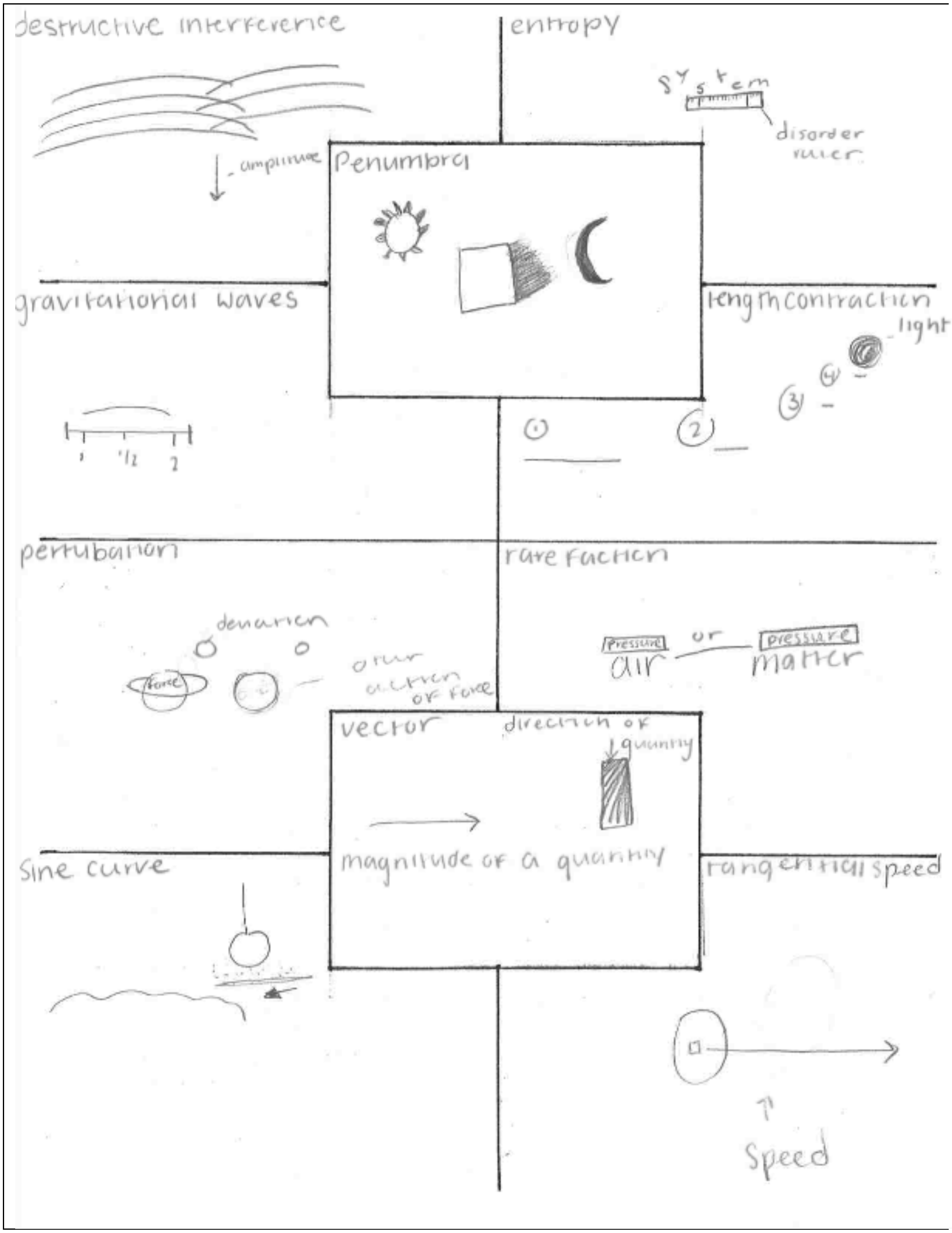
Perturbation The deviation of
an orbiting object from its
path around a center of force caused
by the action of an additional center of
force

Penumbra a partial shadow that
appears where light from part of
the source is blocked and light
from other source isn't blocked

Appendix N:
Vocabulary List 2 Student G Generated Drawings – Active, Multimedia Intervention



Appendix O:
Vocabulary List 1 Student H Generated Drawings – Active, Multimedia Intervention



Appendix P:
Vocabulary List 1 Student I Generated Drawings – Active, Multimedia Intervention

Appendix Q:
Vocabulary List 2 Pretest

Science Vocabulary Pretest LIST 2

Read the following definitions and select the correct answer.

* Required

1. **First and Last Name** *

2. **Grade** *

   Mark only one oval.

   - Grade 6
   - Grade 7
   - Grade 8

3. **1) An arrow who's length represents the magnitude of a quantity and who's direction represents the direction of the quantity.** *

   Mark only one oval.

   - destructive interference
   - entropy
   - gravitational waves
   - length contraction
   - penumbra
   - perturbation
   - rarefaction
   - sine curve
   - tangential speed
   - vector

Appendix R:
Vocabulary List 2 Posttest 2

Science Vocabulary Post Test 1 LIST 2

Read the following definitions and select the correct answer.

* Required

1. **First and Last Name** *

2. **Grade** *

Mark only one oval.

- Grade 6
- Grade 7
- Grade 8

3. **1) The deviation of an orbiting object from its path around a center of force caused by the action of an additional center of force.** *

Mark only one oval.

- destructive interference
- entropy
- gravitational waves
- length contraction
- penumbra
- perturbation
- rarefaction
- sine curve
- tangential speed
- vector

Appendix S:
Vocabulary List 2 Posttest 2

Science Vocabulary Post Test 2 LIST 2

Read the following definitions and select the correct answer.

Required

1. **First and Last Name** *

2. **Grade** *
   Mark only one oval.
   - Grade 6
   - Grade 7
   - Grade 8

3. **1) An arrow who's length represents the magnitude of a quantity and who's direction represents the direction of the quantity.** *
   Mark only one oval.
   - destructive interference
   - entropy
   - gravitational waves
   - length contraction
   - penumbra
   - perturbation
   - rarefaction
   - sine curve
   - tangential speed
   - vector