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

by

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ABSTRACT

DRUSILLA BREWINGTON THOMAS. Using the multimedia strategies of learner-generated drawing and peer discussion to retain terminology in secondary education science classrooms. (Under the direction of DR. REBECCA SHORE)

Student mastery of the academic vocabulary of course content is an important component of learning that content. This research study investigated the combination of two active multimedia strategies within 10 different high school science classrooms, to test for retention of science terminology. The dual process of learner-generated drawings combined with peer discussions were the two active strategies applied to determine if students in high school earth science courses would retain vocabulary terms better than using the passive strategies of quietly reading, copying, and studying the terms by themselves. Through this quantitative study, data were collected and analyzed from 209 high school students to determine if (a) students retained more definitions using the learner-generated drawings combined with peer discussions, compared to reading and copying the terms, (b) males retained more definitions compared to females, and (c) reading levels had an influence on the retention of the earth science vocabulary terms. The study found that there was a main effect of strategy and time. These findings have implications for the selection of instructional strategies by teachers for helping students maximize the retention of complex science terms for all students in classroom settings.

DEDICATION

This study is dedicated to all the teachers who want their students to learn and retain a larger portion of the information the first time it is presented.

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CHAPTER 1: INTRODUCTION

Overview

In January 2002, President George W. Bush signed into law the No Child Left Behind Act (NCLB). Its dual purpose was to educate all children equally and hold schools and teachers academically accountable for the yearly progress of students. All students are required to take assessment tests as a measurement of individual student academic success and with the overall combined scores of students depicting the success of the school. NCLB was a reauthorization of the Elementary and Secondary Education Act (ESEA) of 1965 that provided funds to schools based on the number of disadvantaged students in the school's population to address issues of inequity at the time.

Research studies have shown that despite the large amounts of money devoted to increasing student test scores, particularly in science, there has been little to no growth in test scores (Poland & Plevyak, 2015; NCES, 2009; OECD, 2007). Students take tests such as the SAT® and ACT as a way to determine current academic knowledge and gauge possible readiness for academic endeavors beyond high school. The percentage of students deemed college-ready in science began in 2007 by the ACT. Whereas the SAT® does not test science content specifically, the ACT does. The assessment measures the predicted percentage of students who have a chance of receiving a C or higher in a first-year college level course. Federal funding provided to schools became associated with student learning and increased attempts at determining the effect of federal funds on student achievement.

Each state in the United States spends an average of 1.7 billion dollars trying to measure student success in science and mathematics (Ujifusa, 2012). Table 1 shows the mean science score for high school students who took the ACT has remained virtually the same from 2004 through 2014. The percentage of high school students who are college-ready, (CR), based on science scores has, in essence, remained unchanged over the 10-year span.

Table 1: *Science ACT Performance in the US, 2004-2014 (Poland & Pelvyak, 2015)*

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Av. Sci Score	20.9	20.9	20.9	21.0	20.8	20.9	20.9	20.9	20.9	20.7	20.8
%CR Ready	*	*	*	28	28	28	29	30	31	36	37

* -no data provided

In 2013, ACT lowered the college-ready benchmark that could account for the substantial increase in the percentage of students regarded as college-ready between 2012 and 2013. Nonetheless, the proportion of students prepared for college (based on their performance in science courses) is between 28% and 37%, which means not even 50% of the students assessed by the ACT are ready for college-level courses. Many lawmakers and community members are concerned with the amount of money being spent to improve education outcomes with little to no evidence of improvements.

The sanctions of NCLB have caused concern about student test scores and public perception associated with the type of education offered at some Local Educational Agencies (LEA). Colleges, parents, communities, and LEAs use scores, particularly those from ACT, to evaluate the educational program of a high school. The data collected have caused some agencies to label the lack of science knowledge by students a national security concern.

The shortage of success in educating children in the sciences has caused academic institutions and corporations to generate new ways to draw students into fields that require a rich intellect and a strong foundation in the sciences. Middle and high schools have generated various academies that emphasize science courses. Science, Technology, Engineering, and Mathematics (STEM) programs have become popular ways to create interest in learning difficult courses in science such as chemistry and physics. The National Science Foundation has funded programs focused on teacher training in the areas of science and math to find ways to increase educational outcomes (Foster, Toma, & Troske, 2013). Despite new programs and government spending, science test scores have shown little growth throughout the years (Polanad & Plevyak, 2015; NSF, 2010; OCED, 2007; NCES, 2009). The basic in-class routines and practices need to not only create student interest in science, but also to provide them with techniques and learning methods to help them successfully retain the information presented.

This research study was conducted to explore potentially productive yet inexpensive presentation and learning options for the teacher and the students within a normal classroom environment. A normal classroom environment means all students stay in the room during the intervention, and the setting is not modified to implement the intervention. The teaching technique can be carried out as part of a class lesson.

Models and Techniques of Teaching

Transmission model. It was once standard practice to assume that teachers possessed all the information students needed to master, and students came into the classroom as empty vessels ready to be filled with the knowledge provided by their instructors. The transmission model of education is a traditional teaching method to convey new material to students by presenting the information to them in a teacher-centered, structured format (Jenkins, 2015). The teacher provides the information via lectures or written notes and the students listen, copy, learn, and present the information back in the same format in which it was received to prove learning has occurred (Siegel, 2016). Viewed as the givers and providers of information, teachers usually give information from the front of a classroom, and the students are typically put in orderly rows to sit and receive the material quietly. During this instructional time, there is little to no input from the student except the occasional question. Via the transmission model, students do not usually have much classroom time to practice applying the knowledge, communicate with peers through discussions, or develop creative ways to process the information for themselves. In essence, the teacher is the center of the learning process, not the student.

The 21st-century student no longer enters the classroom hoping to sit and get knowledge from the teacher. Because students have access to computers and other electronic devices, they can access large amounts of information before entering a classroom, but they may not understand the information they find. Hence the teacher is the one who helps explain the meaning behind the material. By contrast, in countries like Australia, Scandinavia, and Northwestern Europe, teachers approach students in classrooms as active learners; therefore, their lessons are typically more student-centered (OECD, 2009). Student-centered lessons focus on how the information is learned and processed by the student. By contrast, the transmission model of education is a teacher-centered process because teachers control the information students receive and how they receive it. They present to the students what they deem relevant information for the course via lectures, textbooks, and notes (Moreo & Mayer, 2000). This process remains the primary method for delivering the essential education curriculum to students throughout much of the world including the United States, despite research showing that the scores in various academic areas, including science, are not increasing.

Cognitive theory of multimedia learning. According to Eckardt, (1993) many studies in the field of cognitive science focus on how the human mind understands and processes the mental task of thinking, remembering, and learning information. The cognitive theory of multimedia learning views the learner as a knowledge builder who actively selects and connects pieces of visual and verbal information to construct knowledge (Mayer, 1997). Instead of being provided with direct instruction that does not focus on teaching the learner how to learn, such as the transmission model, using the multimedia learning method, the learner participates in "discovery learning" in which he/she constructs the rules and relations needed to draw conclusions (Chi & Wylie, 2014).

"Science is a system for exploring, and for innovation. It can fuel our nation's economic growth. It can form a path for our young people in a competitive global marketplace." (DiChristina, 2014, par. 18). According to statistics on science learning, future generations might not be able to understand the importance of our global economy, global innovations, or maintain our leadership as a country in science related areas if recognition of scientific concepts is not increased (Poland & Plevyak, 2015).

Statement of the Problem

It has been found that there is an increase in the retention of material when students engage with the curricular material through active techniques such as practicing, generating a product, or responding based on the information to be remembered (Jacoby, 1978; Slamecka & Graf, 1978; Bertsch, Pesta, Wiscott, & McDaniel, 2007). A combination of drawing and discussion of curricular material creates a multimedia-learning environment (Mayer, 1997; Mayer, 2008; Schwamborn, Thillmann, Opfermann, & Leutner, 2011). Multimedia learning provides students with several formats to become active, engaged learners to better remember their lessons. The active strategies of drawing and discussing the material encourages the learner to participate in the cognitive (reasoning) and metacognitive (higher order thinking) process, and fosters a deeper understanding of the material to be learned (Van Meter & Garner, 2005; Van Meter, Aleksic, Schwartz, & Garner, 2006; Shore, Ray & Goolkasian, 2015).

Several of the research studies cited as foundational in the multimedia knowledge base have used college students and medical students as subjects in their education about multimedia-learning methods. Typically, college students and those who have matriculated to higher levels of learning possess an advanced degree of understanding and intelligence before partaking in the research. The student participants for the current research study were not preselected based on academic abilities or level of intelligence. In fact, they ranged from those with documented learning disabilities to those identified as academically gifted and talented high school learners. Moreover, most of the cognitive science studies with college students were conducted in controlled laboratory settings, usually testing one student at a time.

The purpose of this research is to examine the retention of selected science vocabulary by all learners regardless of prior academic ability to determine if multimedia strategies are effective learning methods in a regular classroom setting. This research will use the multimedia principles of learner-generated drawing and peer discussions/collaborations as learning strategies in high school science classrooms to determine if they provide better retention results to all learners than from individually studying and copying the terms.

Need for the Study

There is a demand for teachers to help students become better, more efficient more engaged learners rather than just passive recipients of knowledge. There is a demand on students to learn more and achieve more at higher levels than in past generations. For example, the number of students in Advanced Placement® (AP) courses has been steadily increasing over the years. AP® courses are college-level courses taught at the high school level that concludes with an AP® exam (College Board®, 2016). The number of students tested has more than doubled over the past decade, and the number of AP® examinations administered have more than doubled during that same time frame. Table 2 shows the annual AP® program participation from 2004 through 2014. It exhibits a steady increase in the number of schools, students, and exams taken.

Table 2: *AP program participation, 2004-2014 (College Board®)*

Year	Schools	Students	Exams
2004	14,904	1,101,802	1,887,770
2005	15,380	1,221,016	2,105,803
2006	16,000	1,339,282	2,312,611
2007	16,464	1,464,254	2,533,431
2008	17,032	1,580.821	2,736,445
2009	17,374	1,691,905	2,929,929
2010	17,861	1,845,006	3,213,225
2011	18,340	1,973,545	3,456,020
2012	18,647	2,099,948	3,698,407
2013	18,920	2,218,578	3,938,100
2014	19,493	2,342,528	4,176,200

These highly demanding academic courses require students to grasp a large amount of information such as facts, vocabulary, and concepts. It is important to find ways for students at all learning levels to be successful at retaining information from the subjects presented within the regular educational environment and not only in a controlled laboratory setting. Students grasping the foundation of information such as basic vocabulary, typically feel encouraged and confident to continue in the learning process. Learning skills that are simple yet effective in a classroom setting, may help students become better problem solvers, test takers, and interpreters of information. The techniques learned could help increase learning from subject to subject and throughout various levels of education. In essence, student academic success could create better learners and a greater number of students pursuing more academically challenging course selections. This study investigated whether teaching students more active strategies to remember information (multimedia) are more effective than the passive strategies of copying and silently studying, which are so prevalent in classrooms today.

Governments, industries, and universities express concern over the need to encourage young people to pursue science and science-related professions because of the role science plays in societal, economic, and global development (Andrée & Hansson, 2014; Poland & Plevyak, 2015). Many careers associated with science are not typically gender- or race- specific. Yet studies show that white males are more likely to become scientists than black females (Andrée & Hansson, 2014). According to Andrée and Hansson (2014), when looking at specific science interests of 15-year-olds from Sweden, young boys show an interest in working with technology and girls show interest in working with people and environmental issues. Middle school girls (5^{th} – 9^{th} grade) at a camp with scientists showed an interest in traveling and working with animals and at nearby beaches (Farland-Smith, 2012). After completing the 1 or 2 years of the required coursework, students from the United States tend to no longer study science-related courses (Farland-Smith, 2012). The study noted that females especially tend to stop taking science courses after only taking courses for a few years (Farland-Smith, 2012). If teachers were able to find ways to help all students become successful at retaining information at the beginning levels of science and keep their interest, the underrepresented population in science courses such as females might become better prepared and increasingly interested in pursuing careers in the sciences. A lack of interest in science is an important issue that begins with the basic retention of terms in science classrooms.

Research Questions

The methods used for this study were grounded in cognitive sciences established as the methods for retaining information in a controlled setting. The following research questions guided this study.

1. How will the multimedia learning strategies of drawing combined with peer discussion affect the retention of science terms when presented as a study method in a high school science classroom compared to passive methods of reading, copying, and studying the terms?
2. How will the multimedia strategies of drawing combined with peer discussion influence the effectiveness of students' performances on assessments measuring the retention of science terms based on students' reading levels?
3. How will females' performances on assessments measuring the retention of science terms compare with that of male students when using the multimedia strategies of learner-generated drawing and peer discussion compared to passively reading, copying, and studying the science terms?

Research Process

The researcher for this study met with teachers at a local rural high school to discuss participation in the study and the course. They decided on earth science classes as it was not used to assess the high school by the state testing agency. This choice allowed the teachers and students the flexibility to deviate slightly from the state-guided curriculum. Earth science was the suggested beginner science course for all students entering high school; therefore, students at this level were less likely to be familiar with the terms presented in this study. Together the teachers and researcher discussed and strategically selected the terms used.

Two units of science terms were chosen to accommodate both learning strategy approaches. The teachers chose 10 science terms associated with “Measurements in Science” (see Appendix A) and 10 related to “Concepts in Science” (see Appendix B). These are terms the students would not have studied yet at their current level of high school science, so there was no expectation of any prior knowledge. The researcher and a university professor reviewed the definitions before being presented in the study. The sponsoring university obtained permission from the Institutional Review Board (IRB), and written permission forms were sent to the parents of all students in the classes of the participating teachers.

The research included one science subject (earth science) but two types of classes; six college preparatory (CP) classes and four honors classes. The teachers decided which of their classes would initially participate in the active multimedia intervention of drawing and discussion, and which classes would be the passive readers and copiers of the information first. This decision was left to the teachers because several had a mixture of both honors and CP courses and they wanted to ensure the same process was not being offered to all honors classes or all CP classes at the same time first so that one unit of words would not feature a specific type of learner. They decided that three CP and two honors classes would participate in the first intervention of peer discussions and learner-generated drawings using the terms from “Measurements in Science.” The remaining three CP classes and two honors classes copied and studied the terms on their own from the handout provided. The next week the three CP classes and two honors classes that participated in the intervention of drawing and discussions were now the subjects of the passive method. They studied the “Concepts in Science” terms by copying and reading the words without interacting with others. The three other CP classes and two honors classes were those where the students participated in drawing pictures and peer discussions unlike the week before when they copied the words and studied them silently. The goal of each student was to retain the information. At the end of both units, all students in all classes had experienced both the passive and active strategies.

Students had 30 minutes for each process. The classes participating in the active intervention drew pictures and discussed within the time frame. Students using passive techniques of reading and copying the terms were also allowed 30 minutes to study the definitions after they copied them.

The assessments used in this quantitative study were identical in wording to the study sheet provided to the students so as not to confuse the learners or incorporate other variables such as interpreting the meaning of the terms studied compared to how the terms were defined on the study sheet (see Appendix E). The order of the vocabulary words on the assessment varied from the order in which the students received them on the study sheet. Participants completed the evaluation on a computer. It included 10 definitions with all 10 terms provided in a drop-down menu for each definition (see Appendix F) so the students could select from a list of all 10 terms for each definition. The students entered their answers using the school-issued computers. Once the students clicked the submit button at the end of the assessment, their answers were graded immediately by the online grading program Floobaroo®. The online assessments were given the same day, during the class period, at the end of the first 30-minute intervention and again the next day immediately at the beginning of class. Neither the students nor the teacher had access to the grades or answers once the student submitted their final answers.

Delimitations

The study included four teachers and 298 students among 10 science classes. Earth science was a course chosen over biology and chemistry because it does not include an End of Course exam which impacts the overall report card grade of the school (Mikulecky, Christie, & Bloom, 2014). Furthermore, all the other science courses, such as chemistry or biology, require more prior knowledge in science. There were three levels of earth science classes taught at this high school: (a) college preparatory (CP) classes, provide students with the required material, and several reviews and remedial lessons, (b) honors classes, in which students learn the necessary information and advanced lessons, and (c) advanced placement (AP) classes, students learn college-level earth science, and they take a different exam at the end of the semester. The AP class was not a part of this research study because of the students' advanced knowledge of scientific terms. Certified teachers with 3 or more years of teaching experience participated in this study.

Students in the chosen classes ranged from high-level to lower-level learners. The typical public classroom contains students with various intellectual levels including those who are performing high enough to be labeled as advanced learners and those who are low enough to be documented as learning disabled. For required courses that count towards graduation, such as earth science, teachers must teach all enrolled students in the course. Students must show mastery of the material on an end-of-course test to receive credit for the course and earn passing recognition by the state (NCLB, 2002).

Limitations

Learners who struggle with recalling prior knowledge may be limited in their capacity to draw upon previous experiences to associate the definition of the terms with images. They are likely to have incomplete, or partial images related to the definitions. Thus, they spend too much time trying to process the correct item to draw. Learner-generated drawings require the person generating the drawings to use rational reasoning to create and organize the drawings based on their prior knowledge (Van Meter & Garner, 2005; Mayer, 2008; Mayer & Johnson, 2008). Irrelevant visuals consume valuable space in the working memory (Clark & Mayer, 2008; Stull & Mayer, 2007; Shore, Ray, & Goolkasian, 2015). The problem of students having limited prior knowledge for adequate discussions of the terms will be addressed in detail in this study.

Students were encouraged to use the full amount of time, 30 minutes, to copy and study terms during the use of more passive practices. Some students copied the words and did not use their time to review or rewrite the terms and definitions during the allotted time. Once the students completed copying the terms one time, they were prompted to continue copying and studying the vocabulary for the remainder of the 30 minutes. There was not much interaction between the students and the teacher during the reading and copying process, so it was possible for the students to become mentally disengaged without the instructor being aware.

Assumptions

There has been an increased interest in enticing girls to enter science-related fields. The targeting of girls for science-associated fields are noted before they reach school age. For example, several companies produce dolls dressed as doctors not nurses, and pictures of girls are used as marketing tools on boxes of science sets such as chemistry and geology. There is also an academic push to develop more female interest to enroll in high-level science courses such as physics, advanced chemistry, and engineering, and whether they are able to retain more definitions using multimedia strategies such as peer discussions and student-generated drawings. Males have dominated the science fields for so long and have predominately been in courses such as drafting, physics, and other higher-level science classes. The expectation for this study is that females, as well as males, will do better with the multimedia strategies.

The assumption is that students with a higher reading level will do well in copying and reading the terms because they have shown the ability to be sound readers and grasp an adequate degree of understanding and comprehension of what they read. Research shows that students with poor reading skills are less likely to comprehend the material (Hawkins, Hale, & Ling, 2011). There is a belief that students with lower reading levels remember more information by relying on pictures and discussions because it allows them to use both visual and auditory methods to acquire information that they cannot grasp through the reading and comprehension process (Shore, Ray, & Goolkasian, 2015).

The multimedia strategy used for this study incorporated the senses of sight through drawings and sound through discussion to more deeply implant the definitions into memory. Using the dual process of vision and hearing helps the learner to implant the information in various parts of the brain. When the students speak about the terms, they use the frontal lobe which houses the abilities of speaking and writing and the temporal lobes used for understanding language, memory, and hearing. When students draw pictures associated with the terms, they use the parietal lobe that interprets signals from vision and hearing, and the occipital lobe that interprets vision involves planning, problem solving, and concentration. Various parts of the brain are actively engaged in the learning process when the multimedia strategies are in use; therefore, the assumption is that the multimedia strategies will render better retention results than those of copying and studying the material. It is assumed students and teachers will be present during every strategy.

Definitions of Relevant Terms

Terms used to define processes and strategies associated with this research.

Active techniques – student-centered strategies that are constructive and interactive; students challenge and critique their concepts and the concepts of others (Carr, Palmer, & Hagel, 2015; Shore, Ray, & Goolkasian, 2015). Students are cognitively engaged in the learning process. In this study, the active techniques are the multimedia strategies of drawing and discussing the scientific terms.

Peer Discussions/Collaborations – social process in which students share and explain information and ideas (Lin, Jadallah, Anderson, Baker, Nguyen-Jahiel, Kim, Kuo, Miller, Dong, & Wu, 2015).

Learning – how the brain, nervous system, and environment of the learner interact to acquire information and skills (Sousa, 2011).

Multimedia Learning – when students receive information in more than one form such as using visuals aids and printed words or written terms translated through discussions (Mayer, 1997; Mayer & Massa, 2003; Mayer, 2008).

Passive techniques – Direct instruction from the teacher (teacher-centered) that often includes the students listening to lectures and coping information provided by the instructor (Shore, Ray, & Goolkasian, 2015; Menekse, Stump, Krause, & Chi, 2013).

Regular classroom – a classroom open to students with various levels of learning and ability, as well as not divided by age, academic ability, or gender. It does not offer special equipment, resources, or teachers beyond what is required to render a basic but complete education to each student. (Rehabilitation Act of 1973, Section 504**)**

Traditional high school – high school that houses grades 9 through 12. Students' ages ranged from 14 to 18.

Summary

Students in earth science classes at a rural high school engaged in two multimedia principle learning strategies, learner-generated drawings, and peer discussions to determine if the techniques helped them retain vocabulary terms better than the passive techniques of quietly reading, writing, and studying the terms by themselves within a regular classroom. Learners were assessed immediately after both study sessions and again the next day upon re-entering the classroom. The information was measured to gauge the effectiveness of the multimedia strategies with high-level and low-level readers compared to passive strategies of reading and copying.

The school environment of the learners was open to interruptions that occur during a typical day of learning. Students were allowed to leave during the intervention for appointments, field trips, and other school related functions where attendance was required. There were some announcements about late buses in the morning and bus changes in the afternoons. Students are typically required to continue to learn and focus even during such interruptions as part of a public-school setting. Any distraction can take away from instructional time; therefore, it is important to find strategies that will help learners learn and retain material while distractions are taking place.

CHAPTER 2: LITERATURE REVIEW

Overview

In 1957, with the launch of Sputnik by the Russians, a growing emphasis was placed on science education in the United States, and this ultimately led to increased funding for education such as through the National Defense Education Act (NDEA) (U. S. Senate Stories 1941-1963, 2015). *A Nation at Risk* (1983) renewed interest in wide-scale education reform, particularly in regards to content, teaching standards, instructional time, and academic rigor in the school system to provide graduates who were inadequately equipped to contribute to a growing and prospering nation. School systems received funding to educate children but initially not to developing teachers to help deliver the information. A shortage of highly qualified teachers has continued while curricular demands have increased both in rigor and content. Unfortunately, many students today are struggling to learn large amounts of information using techniques that are not always engaging. The acquisition of complex vocabulary in science classes has been shown as particularly troublesome for students to obtain, largely due to the infrequency of student exposure to these terms outside of the school setting (Groves, 1995; Yager, 1983). Given how pivotal science education is to global awareness, it is important to find alternatives to lecture, direct instruction, or lecture with recitation to overcome the obstacles associated with learning and remembering science vocabulary.

Through the years, the volume of scientific information students need to learn has increased to the point that many educators have resorted to direct instructional strategies such as lecture, guided notes, or lecture with recitation as the primary ways to provide full curriculum content to their students (Crocco & Costigan, 2007; Betts, 2009).

Students who are unsuccessful at the beginning basic levels of a curriculum are not likely to pursue more challenging, in-depth content within that area. In essence, students who do not master algebra are not likely to pursue statistics and calculus, and those who are not successful at lower levels of science are not likely to enroll in chemistry or physics. These subjects are the foundations for critical areas of research and furthering global and economic growth. One promising approach to helping students understand and retain knowledge in courses such as those in the sciences involves the multimedia principle of visual and verbal learning practices.

When students engage with the material through active techniques such as practicing or generating a product or response based on the information to be remembered, retention of the material increases (Karpicke & Zaromb, 2010; Metcalfe & Kornell, 2007; Jacoby, 1978; Slamecka & Graf, 1978). If students are a part of the learning process, they remember material better than when they are merely bystanders witnessing the process of learning. Talking and drawing provide both verbal and visual behaviors for the students to process and learn information. Therefore, talking and drawing are the two cognitive strategies used during this study to encourage students to actively engage in their learning.

There is a massive amount of material, research, and studies devoted to learning methods. This study focused on the traditional method involving the passive method of reading and copying. The active process of learning used in this study consists of the multimedia methods of peer discussions and student-generated drawings to depict vocabulary terms.

The Framework of Learning

Passive: reading and copying. Some of the standard or passive methods used to teach information to students consists of lectures or information delivered verbally to students. For example, PowerPoint presentations and book reading assignments are methods that allow students to copy the salient points from the traditional textbook or instructional presentation with no active feedback. Strategies such as writing notes from the text more closely resemble the transmission model referenced in chapter 1. In both cases, the learner is unengaged in the learning process. Copying, as an instructional strategy, is a nongenerative strategy in that no manipulation of information occurs (Van Blerkon, D., Van Blerkon, M., & Bertsch, 2006). Students who copy notes verbatim in their entirety are engaging in a passive activity because attention is not focused on any particular part of the notes (Chi & Wylie, 2014). Students can copy notes without being mentally engaged in the learning process. Copying has been proven to be only better than rereading the material. Learners that copy information from their notes to notecards are more likely to benefit from the copying process rather than rereading the content (Bertsch, & Pesta, 2014).

It is possible that students who struggle with reading may have difficulties processing information presented using the passive method of reading and copying terms. Freeman, Eddy, McDonough, Smith Okoroafor, Jordt, & Wenderoth, (2014) discovered, on average, students in passive lecture courses are one and a half times more likely not to pass the course compared to those who learn via engaging techniques (Freeman et al., 2014). A student in an engaging learning environment has a 25% chance of failing the course, whereas a student in a course taught using direct instruction has a 33.8% chance of failing the course (Freeman et al., 2014).

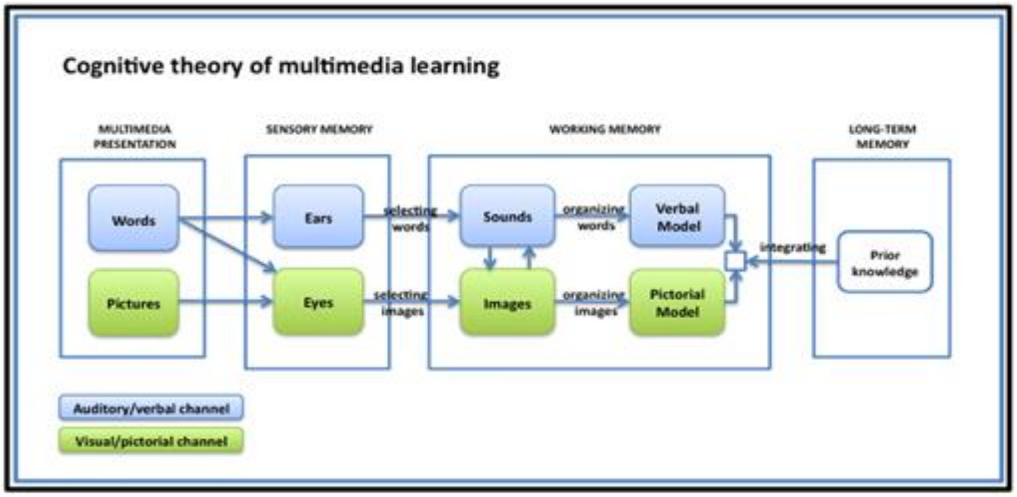
Generative Learning

Generative learning involves using previously learned information to help understand and develop personal meaning to new information (Fiorella & Mayer, 2015). Wittrock (1990) was interested in how learners use background knowledge, thought processes, and imagery to construct meanings for the text. His generative model of learning is based on the premise that learners generate and transfer meaning from one's background and experiences to provide understanding and comprehension of new information. In this view, learning is information by the teacher , in turn, is internalized and processed by the learner. Learning occurs when the meaning is generated through events and experiences (Menekse et al., 2013). Wittrock's model of generative learning is closely associated with Mayer's cognitive theory of multimedia learning. The generative theory of learning is based on generating information; the cognitive theory is based on storing information (Wittrock, 2010).

As part of the generative learning theory, learner-generated drawings encourage learners to engage in productive learning activities that promote deep levels of understanding based on previous experiences (Wittrock, 1990). Connections are made by the learners as they process the information presented in more than one mode such as visual models like pictures, illustrations, or animations as well as in printed test (Marsh, 1997; Leutner & Schmeck, 2014). The current study is based on the cognitive theory of multimedia learning (Mayer, 2001) and generative theories (Van Meter & Garner, 2005; Wittrock, 1990).

Learners in this study generated drawings to connect previous knowledge to understand new information (generative theory). They also engaged in multimedia methods to store or retain the information that has been processed (cognitive theory) to determine if active strategies generate better information retention. Students for this study were defined like those from Wittrock (1990): "the learners became the sources of plans, interests, ideas, memories, strategies…used to select, and construct meaning" (p. 1). Moreover, the students for this study constructed dialogue and visual representation of the meaning they deemed to be associated with each science term.

Cognitive theory of multimedia learning. Multimedia strategies are an effective part of the cognitive load theory. There are people who learn better from visuals such as pictures, and others who learn better from reading words (Mayer & Massa, 2003). The multimedia learning theory uses visual and auditory channels (dual coding theory) as input sources to move information into working memory (Mayer, 2001; Fenesi, Sana, Kim, & Shore, D., 2015; Shore, Ray, Goolkasian, 2015). Dual processing allows the visual learner to draw a picture to represent the terms and allows the readers a chance to read and speak the terms. This way both types of learners can remember and process the new information. Multimedia strategies are based on three assumptions: (a) the idea that people process information differently via two different pathways for visual and verbal material, (b) there is a limit to the amount of information that can be processed at one time in the working memory, and (c) deep learning depends on the cognitive processes of selecting, organizing, and integrating (Mayer, 2001; 2008). Using the mulitmedia allows visual learners and --incomplete sentence ☹



[1]

Figure 1: "Cognitive Theory of Multimedia Learning."

Figure 1 (Mayer, 2001) shows the working memory for auditory learners (top path), which uses sounds and verbal models to store information in the short-term area. Visual learners (bottom path) store information as images and pictures. Reading or listening only provides one pathway to learning, auditory/verbal. Pictures and illustrations also provide a single pathway to learning, visual/pictorial. Combining the two processes within the classroom triggers learning for both types of learners, auditory and visual, and contributes to essential processing that involves reorganizing the information and relating it to prior knowledge for it to become learned/relevant information (Mayer, 2001). Moreno, Mayer, Spires, & Lester, (2001) found when learning is combined with visual and auditory agents (computer-based lesson), more learning occurs, especially for the learner who is a participant rather than an observer.

The strategies used in the study are student-centered because the focus is on how the student is processing the information. A teacher-centered environment focuses on the

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[1] "Cognitive theory of multimedia learning." http://teorije-ucenja.zesoi.fer.hr/doku.php?id=learning_theories:cognitive_theory_of_multimedia_learning

instructor. The importance of the learning process is associated with the teaching process- lecture, notes, or some form of direct instruction provided to the student, not the learning process- how the information is processed and retained by the student (Menekse, et al., 2013). There is typically very little thought, if any, given to providing differentiated instruction to the students so they can be successful in a fully teacher-centered environment.

The multimedia process of dual learning allows the learner to construct images to represent what he/she has processed, and share their drawings and strategies as a discussion with their peers. Students who participate in multimedia learning gather information from spoken words or printed text materials and use visuals such as illustrations, photos, animation or videos to develop their learning (Mayer, 2008). The cognitive theory of multimedia learning is a form of self-regulated learning because learners read the text without pictures, but they construct images mentally or externally as visual representations of the material, helping them retain the information (Leopold et al., 2007; Van Meter, 2001; Van Meter & Garner, 2005). Presenting only a verbal explanation of a lesson does not ensure that all students will understand the explanation whereas the cognitive theory of multimedia learning can stimulate the auditory and visual senses to help most students comprehend new information such as scientific explanations.

Multimedia strategies. There is more than one multimedia learning strategy in which the student is an active part of the learning process. Multimedia strategies do not rely solely on the instructor to provide information for the learner to take in and repeat back when asked. Educators who provide information and do not provide a way for students to interact are creating a passive environment because the students are not engaged or interacting with the learning process (Clark & Mayer, 2008; Fiorella & Mayer, 2015). This setting may include students watching a presentation without being able to explore or manipulate the learning environment (Chi, 2009). The only person engaged in action in a pure direct instructional setting is the teacher; therefore, the inactive or passive teaching process is one where an instructor is the center of learning.

Active learning, on the other hand, has been shown to be multifaceted. Mayer (2015) identified eight strategies he calls “active.” They are summarizing, mapping, imaging, enacting, self-teaching, self-testing, discussions, and drawing. These strategies are designed to equip the learner to activate the appropriate cognitive process during learning and so are labeled active strategies. These eight active strategies are explained below.

The first strategy is the method of summarizing. During this process, students take the provided information and reword or rewrite it in a form that they better understand. Summarizing can be done with any format of information presentation: pictures, animations, slideshows, textbook information, and lectures (Fiorella & Mayer, 2015). Summarizing can occur at any point in the learning process. It can be used to assist with understanding the information while the lesson is being learned, or it can be used to draw closure to the material that has been presented as the learner mentally deletes irrelevant or redundant information. Summarizing does not render consistent results with every subject. It seems to work better with subjects such as social studies and language arts than with science that often contains difficult spatial relationships (Fiorella & Mayer, 2015). Summarizing information is a generative task that suggests the need for prior content knowledge and some training for the learner on how to access the essential content.

The second of Mayer's eight active strategies is mapping. When students map the content of what is to be learned, they organize and process the information in an orderly fashion. They are able to draw a visual road map to compare and contrast information (Fiorella & Mayer, 2015). Maps could take the form of distinct directions depicted with ovals, rectangles, and lines that show relationships with words or concepts. The mapping process causes the learner to pick the key concepts, make, and draw conclusions from the text lesson. The purpose of mapping is to allow the learner to create a spatial representation of key ideas.

Imagining, the third active strategy, is one of the most difficult (Fiorella, & Mayer, 2015). Students are challenged to form mental images of the text material with nothing drawn out or displayed by the learner. In one study, the participants were to select, organize, and integrate the components to put into their mental images (Van Meter & Garner, 2005; Clark & Mayer, 2008). Like most of the strategies, imaging requires training and prior knowledge in order for the learner to execute the task efficiently and proficiently.

Students who perform relevant gestures while learning are retaining information by enacting. This fourth strategy is a process usually found in courses such as drama or dance, but it can also be used in core or academic classrooms. Enacting is a more complex process of self-generated learning because the learner is processing the information beyond what is written or what is provided as a visual representation of the information. They add a range of motion to provide meaning and understanding.

The fifth active strategy is when the learner transfers the information into his or her own words to explain the content of the lesson. Here the individual is learning by self-teaching (Fiorella & Mayer, 2015). This process assists the learner in developing new knowledge by making connections between present information to existing knowledge. It helps the student to identify areas in his/her learning that are missing thereby filling those gaps with contextual information (Chiu & Chi, 2014). The active process of self-teaching allows the student to improve in the learning process by developing his/her own technique for remembering contextual information.

While using the sixth defined active strategy, self-testing, learners respond to self-made practice assessments about previously studied material to improve their learning (Fiorella & Mayer, 2015). Students determine the salient points from the textbook and lectures and design a question and answer format to test their knowledge of the material learned. One of the more common formats is the use of notecards with questions or terms on one side and salient points or definitions on the other. The metacognitive use of self-testing allows the students to enlighten themselves about what they do or do not know so they can focus future efforts on the material that was not previously mastered (Roediger III, Agarwal, McDaniel, & McDermontt, 2011).

The present study combined the remaining two active learning strategies: peer discussions and student-generated drawing. The students carried out both strategies simultaneously. They used the dual process of listening and discussing (peer discussions) and mentally and physically generate drawings to gather and remember information through peer discussions and visually (student-generated drawings).

Peer discussions. The production effect is an established principle in the cognitive science literature that indicates that people remember terms they read aloud more effectively than terms they read silently (Forrin, MacLeod, Ozubko, 2012; Hassall, Quinlan, Turk, Taylor, & Krigolson, 2016). MacLeod et al., (2010) referred to the production effect as speaking a word out loud during study rather than silent reading, which can improve explicit memory. An extensive amount of research (since Jacoby, 1978) has been conducted to propose that the act of saying scholastic material aloud can significantly increase the prospect of remembering the information once it is presented again. A large amount of research on the production effect has shown several various formats of the production process including silently mouthing (MacLeod, Gopie, Hourihan, Neary, & Ozubko, 2010), saying the item out loud (Hourihan & MacLeod, 2008), singing (Quinlan & Taylor, 2013), and writing or spelling (Forrin, MacLeod, & Ozubko, 2012). Students in this study did more than just read words and mentally digest definitions. They were more fully engaged in the learning process by discussing the terms and drawings.

Having students communicate verbally in order to help each other understand the information to be learned is not a new concept, yet for generations, many teachers have insisted students work quietly within the classrooms. Recent research shows that when students listen to each other speak, learning can take place (Chi, 2009). When students are actively engaged in learning they often discuss their thought processes with other students or their instructor. Peer-to-peer discussions are classified as interactive if both parties contribute constructively to the learning process (Chi & Wylie, 2014). Students exchanging information within the classroom can be referred to as small group discussions containing two or more learners (Lehtinen & Viiri, 2014), collaborative reasoning (Lin et al., 2015), or think-pair-share (Bonwell, 1997). The active mode occurs when learners engage in generating ideas that go beyond the to-be-learned information such as problem solving or engaging in dialogue that involves constructive behavior such as asking and answering questions with a peer or defending an argument (Fiorella & Mayer, 2015).

In a classroom setting, students are more likely to have discussions among themselves when the teacher does not give sustained, direct instruction. Discussions with peers are often moments with the least amount of direct control by the teacher, but they can be some of the most inquisitive and mentally developing times for student learning. When students have the freedom to discuss and incorporate the information they have obtained, they generate a better understanding of the content (Fiorella & Mayer, 2015).

Drawings. “The Report of the Committee of Ten” (Eliot, 1894) discussed how the older methods of lecture and recitation had been shown to be inadequate for college and high school learners especially in the area of science. Students, particularly those studying science, should be allowed to see, touch, and make their own inferences as part of the effective learning process. This report shows that lecture is not typically an acceptable teaching method for all subjects, for all students, at every stage of learning (elementary through college). The report emphasizes that truly effective teaching is a process that addresses the individual needs of the student.

Instructors in medical schools stress the use of pictures and illustrations in order to promote and assist students’ understanding of the copious amounts of material that must be mastered. For example, asking students to produce illustrations as opposed to listening to verbal instructions about the material has shown to be beneficial for students who must recall detailed information associated with anatomy (Balemans, Kooloos, Donders, Van der Zee, 2016; Schwamborn, et al., 2011). Difficult science courses that require much retention in higher academia stress the use of student illustrations.

Drawings have been shown to be a more enjoyable way for students to express themselves and retain important information while learning (Shore, Ray, Goolkasian, 2015). There are four ways to use drawings. According to Fiorella & Mayer (2015), the function of drawings can be

- Decorative – appealing illustrations that fill space,
- Representational – simple illustrations that portray a single element in the lesson (such as a drawing of the shape of a neuron in a lesson on how neurons work),
- Organizational – map-like illustrations that depict the locations of elements within a system (such as a line drawing of neuron and its parts with each part labeled in a lesson on how neurons work),
- Explanative – causal-chain illustrations that explain how a system works by showing how a change in one part affects a change in another part (such as a series of frames showing the steps in how a neuron fires in a lesson on how neurons work).

There are various types of drawings and various levels for instructional use. Drawings can be generated using the following levels (Fiorella & Mayer 2015):

- Unsupported – with no direction of help,
- Guided – with learners given training in how to produce drawings and/or being told what content to include in their drawings,
- Partial – with learners asked to complete a partially drawn illustration,

- Supported – with learners being given an author-provided illustration and asked to make comparisons between their drawing and the provided drawing.

The students in this study generated drawings that were generally unsupported but based on the science terminology presented. The function of their drawings was representational: the learners constructed images associated with the terms studied that they determined were meaningful to them.

Learning by drawing involves the learner creating an image by hand or with a computer to represent the content being studied (Van Meter & Garner 2005; Leutner & Schmeck, 2014; Schwamborn, Mayer, Thillmann, Leopold, & Leutner, 2010). Drawings are visual representations of the written content that provide meaning to the learner doing the drawing. For this study, the drawings did or did not appear identical or share a physical resemblance to the definitions the drawings depicted. Students were free to draw upon their own knowledge and experiences to make a connection with the information being studied and the image they wanted to use to represent the material. In sum, the learner-generated drawings in this study were pictorial representations constructed according to the definitions of the given terms, the learners' knowledge, and their peers' feedback.

Researchers have established that by drawing, learners are no longer passive consumers of information and knowledge; in contrast, they are involved in the rational thinking process of choosing, forming, and assimilating the content into a format that has personal meaning (Schmeck, Mayer, Opfermann, & Pfeiffer, 2014; Schwannborn, Mayer, Thilllmann, Leopold, & Leutner, 2010). During the learner-generated drawing process, a deep level of understanding occurs when students are encouraged to participate in forming an internal representation of the material to be learned (Wittrock, 1990; Schwamborn et al., 2011).

Recent Studies

Several multimedia studies were conducted with learners using instructional support such as cut-outs, figures, prompts, or images. In one study, 196 ninth-grade students were instructed to read a text about the chemical process of doing laundry and to draw pictures associated with the text (Schwamborn, Mayer, Thillmann, Leopold, & Leutner, 2010). The control group was instructed only to read the text that explained the chemical process of doing laundry. The students in the drawing group used drawing prompts that included a selection of images of the necessary elements for interpreting the lesson including a partially predrawn background as part of their paper-pencil image (Schwamborn, Mayer, Thillmann, Leopold, & Leutner, 2010). Results showed students who learned using images retained more information than those who learned from text-only. This study showed that providing drawing instructions for drawing prompts was more effective compared to a text-only control group that received neither prompts nor drawing instructions. This research compared drawings to the text-only control group using computer-generated images, but it did not show the results of full student engagement such as students generating their own images and the effects of class peer discussions.

Two other studies investigated retention of information while using prompts as the drawing strategy. Schmeck, Mayer, Opfermann, Pfeiffer, & Leutner (2014) introduced drawing prompts to eighth-grade students to teach them about influenza.

They were provided a text to read, a predrawn background to use to incorporate images, and pictorial elements within the ledger to use. The researchers compared three groups of learners: (a) those who only read the content and did not have drawings of any kind, (b) those that constructed learner-generated drawings with prompts, and (c) those who were provided author-generated drawings to compare to their self-made drawings. Those who generated their drawings and those who generated drawing plus the author-generated picture group scored significantly higher than the control group who only read the material. The study also revealed that having students draw pictures during the learning process is more effective than providing pictures of the material.

Van Meter, Aleksic, Schwartz, & Garner (2006) compared prompts and learner-generated drawings among fourth- and sixth-grade learners who read the information about birds' wings. The studies conducted by Van Meter, et al. (2006) about the drawing of birds' wings and Schmeck, et al. (2014)'s study about images to teach about influenza have shown that students in drawing groups outperformed students in the unsupported drawing groups. The groups used for the current research study were unsupported in that they generated drawings to represent the information to be learned without the use of prior visual aids.

Leopold, Doerner, Leutner & Dutke (2015) divided high school students into four groups. The text-picture group (1) was instructed to read the text and view the pictures. The read-group (2) was directed to read with no pictures provided. The integration-group (3) received a text with pictures and asked to make notes beside the corresponding parts of the picture. The fourth group (the separation group) was also asked to make notes that corresponded to the picture, but they were instructed to write beside the picture, not next to the corresponding parts of the picture. The text-picture group (1) did as well as the group that was instructed to label the picture (3), which showed the multimedia effect is a stand-alone process that does not need an overabundance of input and direction from the instructor. Leopold, Doerner et al. (2015) showed instructions distract students from making reference connections. The active method used for the current research also involved teachers not providing a plethora of feedback and directives so the drawings and discussion sessions of the students would only indicate the students' interpretation of the material.

Previous strategies were based only on texts and instructor-provided illustrations presented in a textbook, but computers are becoming a more accessible learning device within the classroom. Thus, some research has been devoted to drawing strategies involving computers. Schwamborn, Thillmann, Opfermann, & Leutner (2014) used computer-based text to investigate learning by using different forms of pictures to determine if they contributed to improving the recollection of science material. Ninth and tenth graders used the "drag and drop" method to draw pictures associated with surface tension. The results showed computer-based pictures resulted in higher retention on transfer and drawing tests.

PowerPoint presentations are a commonly used method for presenting learning visuals to students. Using medical students, the effects of information retention were studied by having a group read and study PowerPoint images. A second group read, studied the PowerPoint images, and drew and labeled the images to be learned. The study showed retention of knowledge several weeks after the initial intervention by students who drew and labeled their drawing when compared to the nondrawing group. This suggests that actual drawings can be used as a way to improve long-term retention of information (Balemans et al., 2015). The study shows students from a specialized group of learners such as medical students can successfully retain information from learner-generated drawings, but it does not incorporate the verbal method of processing information through the use of collaboration.

While the aforementioned studies noted a marked improvement in student memorization of information when using multimedia/ drawing strategies, some studies show no results or mixed results when students were asked to generate drawings. Leutner, Leopold, & Sumfleth (2009) provided tenth graders with material from their science textbook about water molecules. Students were instructed to read the text and either provide a mental image of the content while reading, draw pictures on a sheet of paper representing the content, or imagine and draw while reading. The results showed that creating mental images increases comprehension and learning when not disturbed by drawing pictures on paper, but when the learners generated their own images, they seemed to focus more on creating images instead of learning the information.

Although the previous studies did not mention any form of successful strategy associated with gender, results on standardized tests have been noted by gender. It has been documented/observed? (ACT®, 2014; OECD 2007) that there is a difference in science achievement by gender. Males perform better than females on standardized tests in the area of mathematics and science (Buddin, 2014). That females do not pursue careers in science as much as males has concerned many and caused a recruitment of women in science. Through this research, the researcher analyzed data to determine a performance based on gender.

Prior studies noted some difference in results based on the students' academic abilities. Shore, Ray, and Goolkasian provided the results of students with good reading levels compared to those that were not strong readers. Good readers should be able to master vocabulary better than low readers because good readers can depend upon their ability to grasp information due to higher verbal skills (Shore, Ray, & Goolkasian, 2015). Their results showed that better readers were better at the retaining information. The researcher for this study followed the lead of researchers Shore, Ray, and Goolkasian (2013, 2015) by considering students' reading level as a potential variable. It was expected that low-level readers would especially benefit from peer discussions and generative drawings to grasp the science terms.

Summary of Literature Review

The multimedia principle is a combination of verbal and pictorial material that can be used to help students learn more effectively (Mayer, 1997, & 2008). For example, when a scientific text is illustrated with images representing the information being discussed or described, students can better comprehend the information regardless if it is written or displayed in a multimedia-learning environment (Leutner, Leopold, & Sumfleth, 2009).

Multimedia strategies require the learner to be able to select, organize, and integrate information, resulting in a more active learning strategy than reading and studying alone. The reviewed literature shows the effects of learner-generated drawings with learners at various levels in controlled settings. The learners in these prior studies had only processed the information visually or verbally but not both. In contrast, the current research combined the dual process of visual and verbal multimedia strategies to determine if the two strategies combined would be beneficial in a regular learning environment.

The second research question involves retention of science definitions based on the reading proficiency level of the student. Students who are proficient readers were expected to be able to actively select and connect pieces of visual and verbal information to construct knowledge needed to retain the science terminology presented in this study. The researcher expected the peer discussion and student-generated drawings to be beneficial to those who struggled with reading proficiency.

The third research question involved retention of information by gender. Standardized assessments show a significant difference in scores by gender. ACT® (2014) noted that males outscored females in math and science and females outscored males in English and social science. Various studies associated with cognitive development have proposed females are more apt to be successful with words and in social settings (Sax, 2006; Bonomo, 2010). The multimedia strategy of peer discussion provides a verbal platform to enhance the learning style of female students.

Contribution of This Study

Active, constructive, and interactive student-centered strategies were used to determine retention of information when compared to passive strategies (e.g., copying notes and reading from textbooks). Learners are considered active when their involvement engages them beyond what is being presented such as writing verbatim notes and underlining (Fiorella & Mayer, 2015). The passive mode takes place when learners receive information without engaging in the learning process such as listening to a lecture without providing input or any form of interaction. Active does not necessarily mean interactive (Chi, 2009), but the students in this study were discussing the science terms; therefore, they were active and engaged.

This study investigated the active process of students engaging in dialogue and generating images to depict science vocabulary terms to determine whether the techniques were more effective than the passive process of reading, copying, and studying terms individually. Images produced by the students were representational drawings as defined by Fiorella and Mayer (2015). This study contributes to the established research by (a) using students who have not been selected by intelligence or ability, (b) being carried out in a classroom setting during normal instructional time, and (c) using materials normally afforded to learning such as paper and pencils.

Journals and books included in the literature review were found using the computerized databases Educational Resources Information Center (ERIC), Google Scholar, ProQuest, psychology information (PsycINFO), and EBSCO. Information was located by searching keywords or terms associated with multimedia learning, the generative drawing principle, and the cognitive theory of learning.

CHAPTER 3: METHODOLOGY

Overview

Students are required to learn and retain substantial amounts of academic or curricular information to progress through their years of K-12 schooling. It can be a daunting task for students to remember the required dates, formulas, names, and academic vocabulary needed to be successful in school each year. Educators consider the development of the ability to learn and apply tactics that will eventually become regularly used cognitive skills as a major educational goal for learners (McNamara, Jacovina, Snow, & Allen, 2015; Lengenfelder, Chiaravalloti, & DeLuca, 2007). This chapter provides the detailed methods and procedures used to explore the impact of active multimedia methods of learner-generated drawings and peer discussions on student achievement.

For this study, a quasi-experimental design was selected to establish how the implementation of multimedia strategies using discussions and drawings (active) compare to silently reading, copying, and studying (passive) on selected science terms in a regular high school classroom setting. Upon submitting all the proper materials to the UNC Charlotte Institutional Review Board (IRB), this study was approved by the IRB Committee.

The quasi-experimental design used is appropriate for this study because the terms used for the students to learn were not in earlier chapters of the curriculum for the course chosen; therefore, the results measure initial exposure to the terminology at the high school level. The teachers chose terminology from areas they had not yet covered with the students in the class. Furthermore, the curriculum from previous grade levels did not include terms from areas not yet covered; therefore, the assessments recorded the student's reactions to the active learning process compared to the passive process.

A synthesis of previous research related to the combined multimedia strategies of drawings and classroom discussions reveals there is little research on the retention of information in a high school science classroom using these combined methods. This quantitative research examined the hypothesis that when students actively use engaging strategies as part of remembering in-class science vocabulary, they retain more information when compared to less engaging techniques such as silently reading and copying terms. A popular inference is when students assimilate information using visual and auditory channels they will retain more information over reading and writing terms.

The cognitive theory of multimedia learning explains the processing of information through the visual and the verbal channels within the brain. For the active strategy group, the science terms will be processed in working memory using sound and images. As students discuss their images using their prior knowledge to explain the reason for their drawings, the definitions become stored in their long-term memory.

Research Design

A quasi-experimental crossover research design was used to examine the effectiveness of the multimedia effect on retention of science vocabulary. Before the intervention using multimedia strategies, classrooms were assigned to either receive the intervention first or serve as the passive group that first copied definitions from the textbook and then silently studied them. Five classes used the active multimedia strategy of drawing and discussing their pictures and the definitions first, and five classes copied the terms as their first strategy. Both the active and passive methods were allotted the same amount of time, 30 minutes, to alleviate a variation in assigned time as a factor towards performance. All students took their first online assessment of the vocabulary terms immediately following each strategy. They received their second evaluation on the terms the following day.

The next week the classes switched strategies using a different set of 10 new science terms. The classes that participated in the active multimedia strategies in the first week then copied the terms and silently studied them in the second week. The terms for the first week were titled “Measurements in Science” (see Appendix A). The teachers cover the units of measurement later in the curriculum. The terms for the following week, “Concepts in Science” (see Appendix B), consisted of terms associated with a list of concepts students learn as part of the curriculum. Each set of terms had a different group of 10 key terms. The day after participating in the assigned strategy, all the students took the online assessment (see Appendix D), which measured retention of the studied material. Students were assessed immediately following the 30-minute strategy session.

The grading scale for students ranged from 0 to 100. A student who received a score of zero or 100 was not an outlier. Students who struggled with terms and required longer periods of time to grasp information could score zero on the assessments. A student who was able to grasp information quickly could obtain 100. Thus, zeros and 100s were scores received by some students.

Population and Sampling Procedure

This study took place at a rural high school in south central North Carolina. The school is one of 12 high schools in the sixth largest school district in the state. This traditional public school has approximately 1350 students with class sizes averaging between 25 and 30 students, and the school's location is about 30 minutes outside of a major urban city. The area around the school was once open fields and locally owned businesses that, within the past 5 years, have been replaced with several franchised businesses. Although the school has some upgraded facilities, it still retains most of its original 1960's appearance.

The subject group belonged to an education system that offers primarily face-to-face courses as well as online courses through the school system's virtual high school at no cost to the students. Students can also qualify to take courses at the local community college if they meet certain grade point average (GPA) requirements by the time they are juniors or seniors. The 12 high schools in this area have varying levels of socioeconomic support. The high school in this study serves students in grades 9 through 12 from diverse socioeconomic statuses and ethnicities. White students make up 65% of the student body with the remaining 35% of the student body divided among African Americans (14.8%), Hispanics (12.3%) and all other ethnicities (7.9%). Approximately one-third of the students qualify for free and reduced lunch, and about 10% of the students receive special education services. This school district has a one-to-one initiative, which means that upon enrolling in grades 3 through 12, all students are elible to receive a laptop instead of textbooks. Parents may choose not to allow their child to have the device, in which case teachers provide assignments using alternate methods. Because this study required the use of laptops, a fully charged class set of laptops were in the room on assessment days, just in case a student forgot to bring theirs to school.

The school is on a traditional school year schedule beginning in late August and ending in mid-June. The academic year is divided into two semesters: a fall semester that runs from August until January, and a spring semester that begins in January and ends in June. The length of each semester is 90 days. There are no summer sessions as part of the academic school year, and there are no early morning courses or evening courses. However, students may take extra courses or advanced courses online through the state or the local online high school while still enrolled as a student in the brick and mortar school.

The initial pool of students considered for this study consisted of 298 pupils in the earth science courses. The final number of participants was 209 students enrolled in 10 earth science classes. The course was selected for two reasons behind it (a) it is the most basic science course offered at the high school level, and (b) the End of Course assessment does not affect the school's academic efficiency. The students within this study ranged from 14- to 16-years-old and varied in learning ability from academically and intellectually gifted (AIG) to having a learning disability. Students had the option not to participate in the study.

The two Caucasian females and two Caucasian male teachers who took part in the research were licensed instructors in the area of science; each possessed 3 or more years of teaching experience. Two of the teachers had taught in other states before coming to teach in North Carolina. The educators and students received an incentive for participating in the study. The teachers received a $100 stipend, and the students who participated had the privilege of getting a pass that could stand in the place of a homework assignment. Students not involved in the research also had a chance to earn homework passes based on other class assignments.

Instrumentation and Source of Data

The dependent variable is the percent of correctly identified science vocabulary terms presented on the research study assessments. There were several meetings with the teachers and the researcher to select the terms to be used in the study. Content validity was established by asking the teachers to choose words from the school's science textbook to ensure there was 100% agreement among the four teachers that each item represented an important concept for the students. The teachers worked together to choose the terms and provide the definitions. Ten terms associated with a "Measurements in Science" unit and 10 associated with a "Concepts in Science" unit were the sources for the vocabulary. The science department chairperson reviewed all the terms and definitions to provide additional verification of their accuracy to convey the construct under study.

The retention test was immediately administered after the students participated in the 30-minute active or passive learning strategy and was administered the following day to measure the students' retention of the terms after 24 hours. The students took the assessments on the school-issued computers. To perform the evaluations, the students typed in the URL address that was given as part of the directions on the page provided to the teacher (see Appendix C). The link opened the test for the students on their classroom computer (see Appendix D). Once linked to the test site, the student typed in their name and his/her teacher's name. The name of the student taking the test recorded automatically; however, student names were removed from the data once the identifying codes were in use. The assessment directions instructed the students to select the vocabulary term from a drop-down menu that best described the definition given. There were 10 definitions to match each of their science vocabulary terms.

The assessment appeared as a long sheet of paper on the computer screen. The definitions were numbered 1 through 10, and the terms were listed in a drop-down menu under each definition using the exact definition provided during the intervention. The participants were instructed to match the correct word with the correct definition and to close their computers when they had completed the task. The definitions and word choices were shown on one screen to eliminate the need for students to click through multiple screens. Once submitted, the assessment tool recorded the date and time the evaluation ended, the duration of the assessment, each answer given by the student (including no answer), and the number of correct responses. The addition of gender and ethnicity of the students happened at a later date. The independent variables were gender, type of classes (honors and college preparation), and reading levels. The reading levels came from English scores the students received on their state assessments in a prior year recorded by the school district.

Learning Strategies

The intervention occurred during two regular classroom sessions. Teachers had written instructions given to them to use as a script to explain the process to the students. There were two sets of instructions for the active and passive strategies. The students were given computer links to the assessments following the interventions (see Appendix C). Implementation fidelity, the accuracy with which the teachers carried out the interventions, were recorded by the researcher and noted by the teachers conducting the study.

When the students were a part of the passive group, they received instructions to read and copy the vocabulary until the allotted time ended. When the students were in the active group, they generated pictures and discussed the terms as they worked in pairs or groups to discuss their illustrations. Since there were two units of 10 science terms, every student was a participant in both the passive group for one unit and the active intervention group for one unit. The teachers in both groups monitored the class to ensure the students were on task. At the end of the 30-minute allotted time, all students' handwritten terms from the passive groups and drawings from the active groups were collected.

The learners were allowed to group themselves to provide some level of comfort while implementing a new learning technique. The strategy of peer discussion centered around a drawing related to definitions was a new technique and putting students with new peers while encouraging a new style of learning was found to increase pressure and stress on the students. Peer acceptance and inclusion is important to teens and preteens. The researcher advised the students to focus on the learning process and not on who the members of their groups were, thus trying to impress group members shouldn't be a concern during the peer discussion process.

Procedure

At the beginning of the study, the teachers and parents signed an informed consent document that described the study and their rights as research participants. The four teachers received training on how to implement the active and passive strategies and how to access the online examination for the assessment of each one. The teachers were instructed to monitor the students during the vocabulary activity for both the active and passive groups to make sure (a) conversations were related to the vocabulary in the intervention groups, (b) vocabulary terms were copied at least once by every student in the passive group, and (c) no discussions about the vocabulary was allowed in the passive groups. The teachers received instructions not to assist students in the drawing process. Teachers were told to remind students they were to draw their pictures so the drawings would help them remember the definitions for the terms and to talk with their peers for advice and guidance. The students had knowledge of the experimental purpose of the study and procedures they were to follow before the study. Students were instructed to keep the intervention materials in the classroom. They were not to take the words, drawings, or anything associated with the science unit vocabulary home to study.

Students who participated in the passive group first were presented with the first 10 vocabulary terms to copy and study for 30 minutes. The passive group of students remained in their usual classroom seats to copy and review the terms. Some students sat at desks in rows; a few others were around the room at lab stations at their assigned seats depending on the teacher's classroom setup. Students in the passive group were not allowed to move about to other desks or lab stations nor communicate in any way.

The groups receiving the active intervention worked in pairs or small groups to draw and discuss the terms. Immediately following each 30-minute strategy session, the students logged onto the URL using their school-issued computers and took the vocabulary assessment. The next day, upon entering the classroom, each student took the same vocabulary assessment on the computer. This concluded unit one of the study.

The following week the students were presented with the second 10 vocabulary terms from "Concepts in Science" to study for 30 minutes, but the strategies switched and the process repeated. In other words, if Teacher A, asked students to copy and review the terms associated with the "Measurements in Science" first, they then directed the students to draw pictures and engage in peer discussions the following week for the terms related to "Concepts in Science." Teachers were instructed not to teach any of the terms related to the study while the study was underway, this was to ensure that it was the effectiveness of the strategies themselves being examined and not teacher effectiveness.

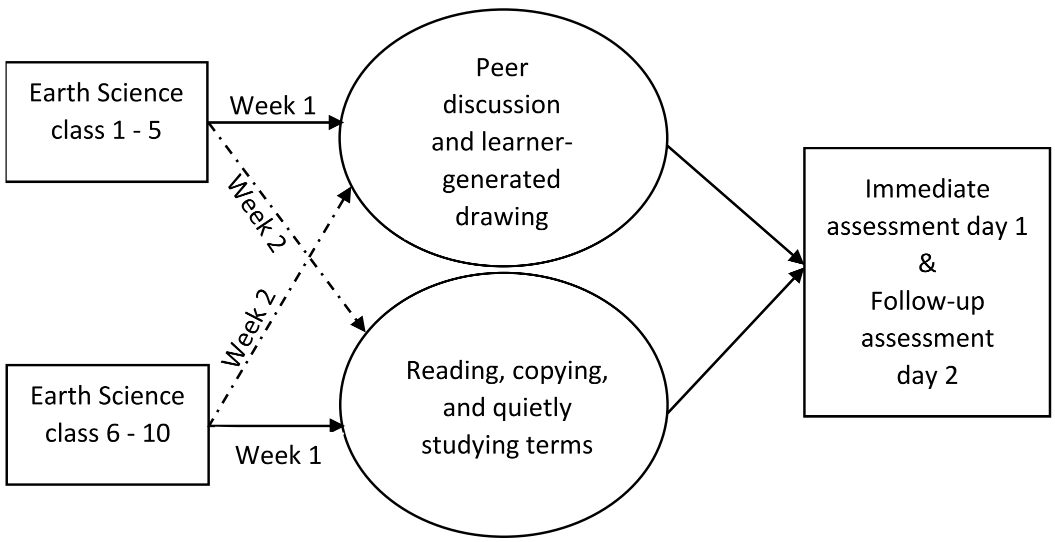

Figure 2: Assessment procedures.

Data entered in Statistical Package for the Social Sciences (SPSS) software were used to filter the results and shield the identity of the faculty and students involved in the research. The teachers had a coded letter according to their last name, and the students had a coded number according to their last names.

Data Analysis

Several student characteristics and demographic variables, such as gender, ethnicity, class type, age, and reading level figured in the data set. Science courses often require the students to be able to read and sound out words that often do not show up in any other academic disciplines. One hypothesis of this research study predicts that students identified as poor readers could learn and retain a greater amount of the required terminology using the multimedia techniques of peer collaborations and student-generated drawings. Reading levels have been associated with comprehension of the information, that is, the higher the reading level, the greater the degree of comprehension of the information read. The state identified reading levels were used to classify the reading standards of the students. Level one and two readers made up the low-level of readers; level 3 indicated the medium- level readers, and level four and five readers were the high-level readers.

This information was used to determine if the effectiveness of the strategy relates to the educational reading level of the student. Gender and ethnicity were assigned categorical scores: gender (ex. male= 1, female = 2); ethnicity (ex. Asian =1, African American = 2, Hispanic = 3, Caucasian = 4, and mixed (one or more ethnicities) = 5). In order to answer the research questions, there was an examination of the relationships between and among variables. Data came from measures associated with the students' previous state exam scores and the results.

ANOVA calculated the between and within factors. A $p < .05$ level of significance was used for all analyses in the study to determine if the hypotheses could be rejected or accepted. The effect size was calculated using the partial eta squared.

Role of Researcher

The researcher in this study was also an assistant principal at the school that served as the setting for this study. The participating teachers and some of the students were at least slightly familiar with the researcher. The instructors and the learners were made aware that the research had neither a bearing on the teachers professionally, nor on the students academically. The researcher acted primarily as an observer during the implementation of the strategies.

To ensure confidentiality and teacher confidence, the learners and instructors could not confer the results. The results were collected and re-coded so as not to use the real names of the students and teachers. The researcher later coded the information to protect the identity of the students and the teachers. The information was maintained in a password-protected database. The information provided to the students was in English, which was the native language for most of the participants. All students and teachers were aware their participation was voluntary and they could withdraw or miss any part of the intervention without penalties.

The assessments were graded using the program Floobaroo@. The researcher entered questions and correct answers into the grading program that provided each student with an overall grade for each test. The data input process was designed so there was no bias associated with scores of particular students or teachers.

Summary

Students struggle to learn and retain science vocabulary. The amount of money devoted to increasing science scores on standardized tests has been substantial but has not produced much change in performance. Students are in need of methods to help them retain the complex scientific information that, in turn, can help them in other subjects as well.

The researcher carefully assessed the data to evaluate the results to determine if the multimedia-learning strategies improved the retention of information for the readers at various levels, and also to see if the students had an overall increase in the rate of retention of science vocabulary based on the strategies. The researcher also created tables, spreadsheets, graphs, and charts as needed to show the results of the research. Representation of these figures and tables are in chapter 4. The information was collected and maintained in a safe and secure location throughout the study to protect the identity of the teachers and subjects.

CHAPTER 4: RESULTS

Overview

Prior research concerning learner-generated drawings has shown promising results for students in a controlled learning environment such as testing one student at a time in a lab. However, the typical science classroom contains 25 – 30 students with various levels of understanding and comprehension. The average science classroom has various disruptions that do not occur in a controlled setting. The site for this study was not completely isolated from outside interference. For example, others who were not part of the activity could enter the setting while the intervention was occurring, participants in the study were allowed to leave the classroom during the intervention, and other disturbances occurred such as announcements over the intercom. These occurrences were part of the experimental environment indicative of a nonclinical learning setting. The purpose of this research was to (a) determine how will the multimedia-learning strategies of drawing combined with discussion affect the retention of science terms when presented as a study method in a high school science classroom compared to passive methods of reading, copying, and studying the terms, (b) determine how the multimedia strategies of drawing combined with peer discussion influenced the effectiveness of students' performances on assessments measuring the retention of science terms based on students' reading levels, and (c) determine how females' performances on assessments measuring the retention of science terms compared with male students when using the multimedia strategies of learner-generated drawing and peer discussion compared to passively reading, copying, and studying the science terms.

This chapter describes the results of the intervention. The error bars in each graph represent the standard deviation. The first section of the chapter provides the data collection method. The second section describes the population sample. The third section provides the descriptive statistics for the variables. This chapter concludes with a summary of the results.

Data Collection Method

A total of 298 students were enrolled in the 10 earth science classes during the spring semester of 2015. Test scores were analyzed using ANOVA with a repeated-measures general linear model to test for the between-subject factors of reading levels, gender, and the order of the strategy. The order of the strategy was assessed to determine if the students scored differently by participating in the passive strategy before the active strategy or if the students scored differently by taking part in the active strategy and then the passive.

The repeated-measures general linear analysis was also used to test for the within-group effects of the learning strategies: the multimedia strategy of learner-generated drawings with peer discussion, and the more common method of learning by reading and copying while studying. The *F* tests reported include the Greenhouse-Geisser correction to protect against possible violation of the sphericity assumption, and Type III sum of squares to adjust for the varying number of subjects in each of the reading levels. If the p-value is greater than 0.05, the null hypothesis will be rejected (Creswell, 2014), .

Sample Population

Of the 298 students enrolled in earth science courses, 89 students were not present for all four assessments. Several students left the class during the intervention for various approved reasons. A few arrived late to class and thereby were unable to participate. The data used to calculate the results of the study did not include the information of students that were not present for all interventions and assessments. Of the remaining 209 participants, there were 109 males and 100 females. The students within the study represented diverse ethnic groups. The percentages were 63% White, 12.0 % African-American, 14.4 % Hispanic and 10.6 % of the remaining population of students were from other ethnic groups or were a combination of multiple ethnicities. Figure 3 indicates the sample population of the research by ethnicity, and Figure 4 shows an adequate representation of the actual student body population of the school by ethnicity.

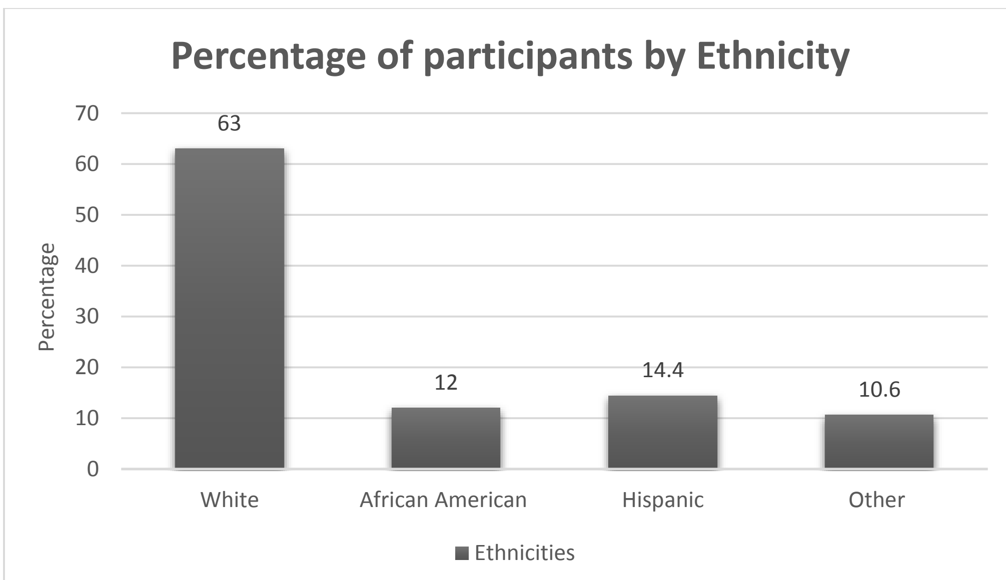

Figure 3: Percentage of participants by ethnicity.

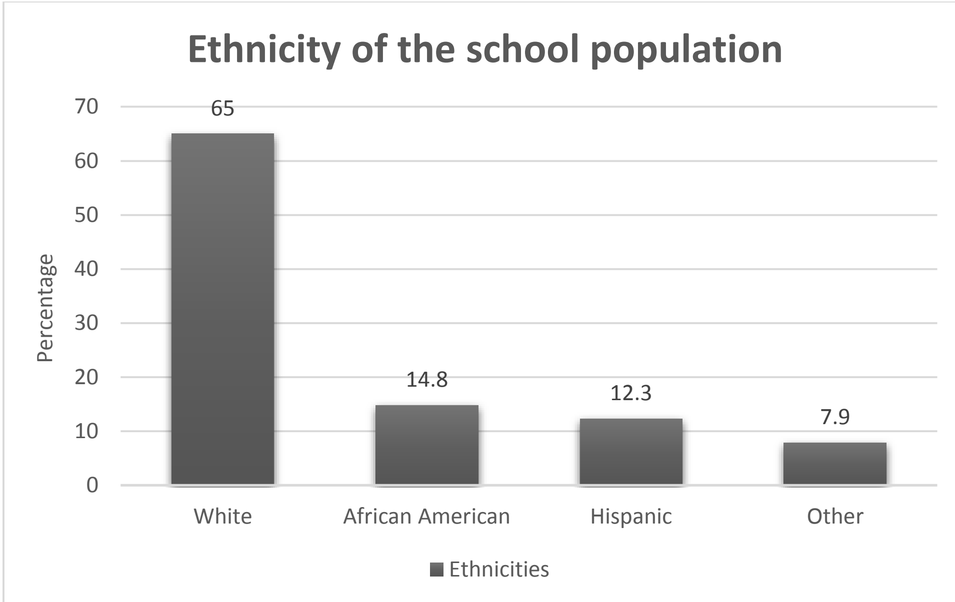

Figure 4: Percent population of the school by ethnicity.

The data were screened and analyzed with SPSS. The screening process was used to isolate missing values, determine statistical significance, and indicate effect size. The assessments were graded using an online program called Floobaroo®. Using this program to grade the assessments prevented human error that can occur and cause the grading of the assessments to occur incorrectly.

Descriptive Statistics

The reading levels used as the initial baseline to identify the group categories were the summation of information students received on the North Carolina End of Year test in the area of reading. The scores from the North Carolina End of Year test were used to indicate a proficiency level in reading. Students were assigned a number based on their level of proficiency in reading ranging from one to five. A level one score indicated the student was well below state-determined proficiency in reading, level two was below proficient, level three was at proficient, level four was above proficient, and level five represented a student that scored well above proficiency in reading.

There were not enough participants in each of the separate levels to show five different categories of readers (Figure 5); therefore, they were combined and categorized as two distinct levels of readers as shown in Figure 6. Readers coded as average and below were combined as a group of students to form the category of lower-level readers for this study. Level four and five combined as a unit generated the category of upper-level readers that indicates above grade-level proficiency in reading. Forty-three students did not have reading level data for various reasons such as insufficient data from previous standardized assessments. Some students were new to the state and did not have the reading level information as part of their enrollment data, and others did not have information entered at the time of this study.

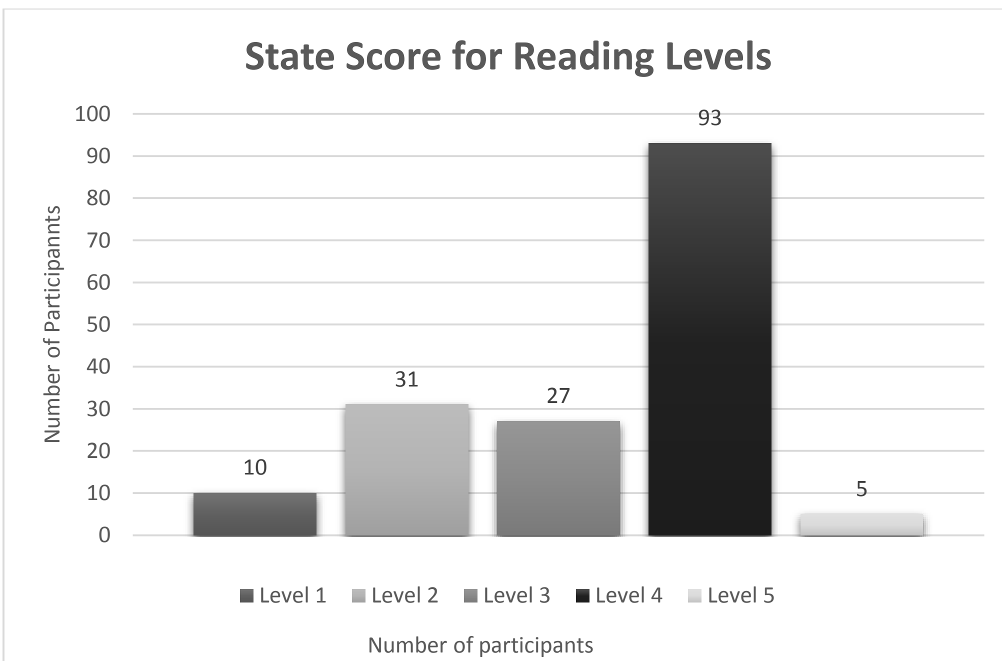

Figure 5: State reading level score and number of participants.

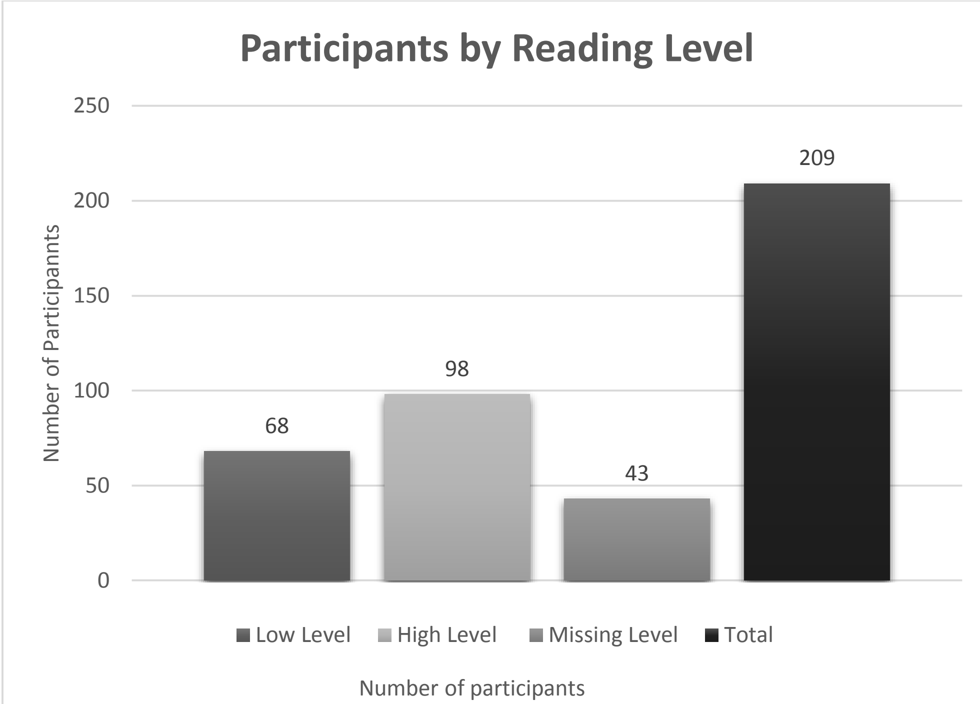

Figure 6: Reassigned reading levels.

Research Question 1: Results of Multimedia Strategies

How will the multimedia learning strategies of drawing combined with discussion affect the retention of science terms when presented as a study method in a high school science classroom compared to passive methods of reading, copying, and studying the terms?

Comparison of Strategies. An analysis of variance (ANOVA) was conducted to examine the relationship between active and passive strategies (n=209). The effect of the active multimedia strategies was very significant, F (1,207) =59.79, p < .001, $\eta_p^2 = 0.22$. Eta squared indicates 22% of the variance is related to the strategies used. Students performed better on the assessments after they drew a picture to show a visual of the vocabulary term and then discussed their pictures with their classmates. These results were important because of the significantly low p-value and the value of eta squared. The results showed students maintained a higher level of retention when using the active multimedia strategies. When they used the passive method to learn, students scored a mean difference of 13.2 points less than those who used the active strategies. Table 3 displays the means and standard deviations of the two strategies.

Table 3: Mean & Standard Deviations for Research Question 1

Variable	*n*	*M*	*SD*	*SE*
Multimedia – Active Strategies	209	75.1	24.1	1.67
Copying/Studying – Passive Strategies	209	61.9	26.0	1.8

Comparison of Active and Passive Strategies Over Time

There was an interaction that resulted in lower performance on day 2 for the students who learned the definitions by using the passive strategies as indicated in Figure 7. The data indicates there was a variation in the active and passive strategy from day 1 to day 2 that is not statistically strong, but it is still statistically significant, $F(1, 207) = 4.16$, $p=.043$, $\eta_p^2 = 0.02$. Eta squared shows that 2% of the variance is related to the active strategy compared to the passive strategy over time. Students who participated in the active strategies retained more terms day 1 compared to students in the passive group. Students who drew pictures and discussed terms, the active strategy group, also retained more definitions 24 hours later compared to the passive strategy group that read and copied definitions.

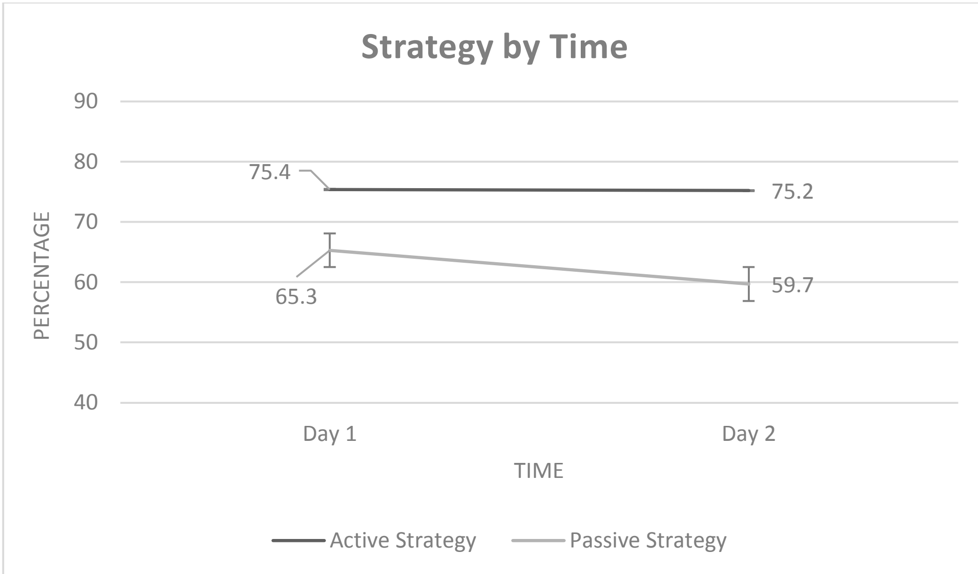

Figure 7: Strategy by time.

There was not a three-way interaction of strategy by gender by time, meaning the results were not statistically significant to show the strategy affected the students per gender the next day, [$F(1, 158) = .001$, p = .98, η_p^2 <.001].

Strategies by order. The order in which the students received the learning strategies was also found to be significant, $F(1, 207)$ =43.87, p < .001, η_p^2 = 0.18. The strategy by order accounts for 18% of the variance. Those who received the active strategy first (designated as Order 1 in Figure 8) retained more words during the initial intervention compared to students who generated drawings and carried out discussions as the second order of intervention. Figure 8 shows students who read the material and copied the information as the initial intervention received a mean score that was lower when compared to the active strategy mean score the following week.

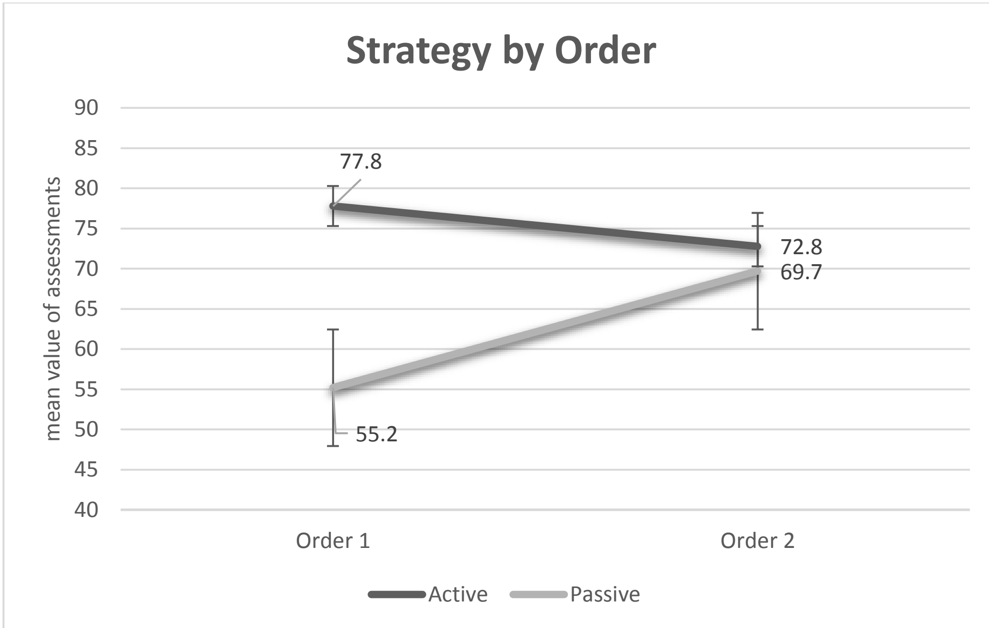

Figure 8: Strategy by order.

The students who carried out peer dialogue and drew for the first week, received a higher score using the passive strategy the second week compared to students who used the passive strategy without first being exposed to the active strategies. The group that received the passive strategies of quietly studying and writing terms as the initial intervention had a mean score lower than the score they received when they worked actively by generating drawings and having discussions with their peers. Figure 9 represents the type of strategy provided to the students, the order in which the strategies were carried out, and the mean average assessment score received associated with the strategy.

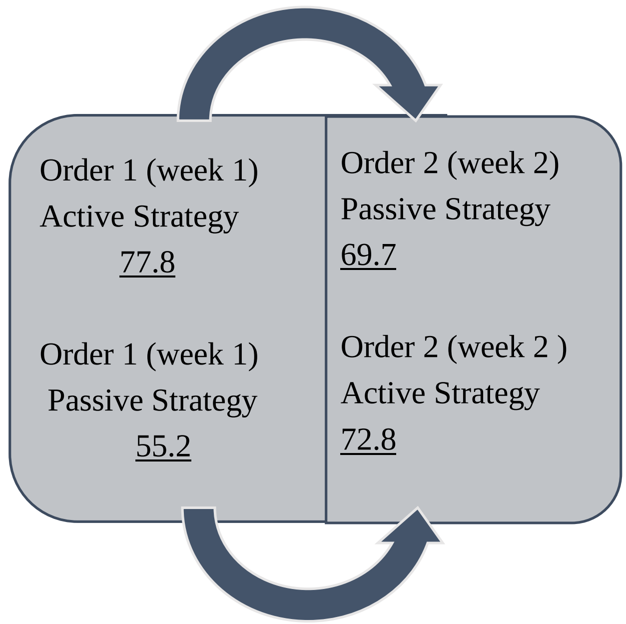

Figure 9: Flow chart of mean average of weekly strategies.

Research Question 2: Results of Reading Levels

How will the multimedia strategies of drawing combined with peer discussion influence the effectiveness of students' performances on assessments measuring the retention of science terms based on students' reading levels?

Reading levels were used to analyze data as follows: lower-level reader to upper-level readers by strategy and overall lower-level students were compared to upper-level students over time. A total of 166 students had identifiable reading level scores provided by the NC End of Year 8^{th} grade English exam and 43 were without reading level scores. The results provided in this section include the students with identifiable reading level scores from the state.

Using Pearson Chi-square, the overall reading levels of 85 males and the 81 females was computed. The results, $\chi(1) = .330$, $p = .566$, indicates there is no statistically significant association between gender and reading level. The number of male upper- and lower-level readers closely matched the number of upper- and lower-level female readers. There is not a statistically significant different amount of high or low readers per gender. The descriptives in Table 4 identify the proficiency of the students by reading level and gender.

Table 4: Descriptive Statistics of Reading Proficiency Levels: Nominal Scaled

Variable	*n*	%
Gender		
Males	85	51.2
Females	81	48.8
Lower-level readers		
Males	33	38.8
Females	35	43.2
Upper-level readers		
Males	52	61.2
Females	46	56.8

Reading Level by Time. How students performed over time was determined by initially comparing low-level readers to higher-level readers and again after 24-hours. The data analyzed the results of the student's assessment performance without considering the strategies individually. Figure 11 reveals that lower-level readers show more of a loss of information from day one to day two. Upper-level readers show no loss. Using ANOVA, the effect for reading level by time $F(1, 158) = 5.92$; $p = .016$, $\eta_p^2 = 0.036$, indicates this is a significant interaction that accounts for 3.6% of the variance. It shows students with low reading scores did not retain as much information the following day as those with higher reading levels.

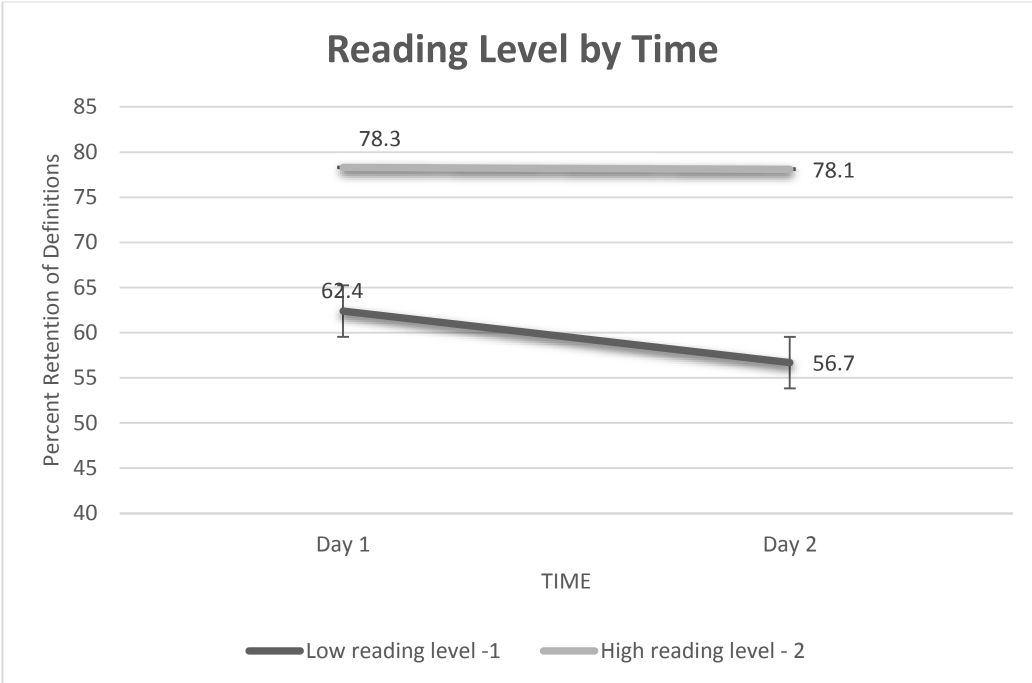

Figure 10: Lower-level readers compared to upper-level readers over time.

The results indicated the strategies did not show a statistical difference for students with different reading levels [$F(1, 158) = .98$; p = .325, $\eta_p^2 = 0.006$]. Thus, the strategies did not show a significant difference for lower-level readers compared to upper-level readers.

Research Question 3: The Performance of Male and Female Students

How will females' performances on assessments measuring the retention of science terms compare with male students when using the multimedia strategies of learner-generated drawing and peer discussion compared to passively reading, copying, and studying the science terms?

The data was assessed by comparing the male and female mean scores for the active and passive approaches to retention of science terms. The data were initially evaluated to distinguish how males and females performed on the assessments that were given. The overall results were then compared using those from the day 1 and day 2 assessment scores. Time is an independent variable that indicates when students took the assessments. The reading levels were used to analyze data as follows: the amount of information retained by each gender after 24 hours, comparison of males' and females' retention of definitions over a 24-hour time frame, upper-level male readers compared to upper-level female readers. Because reading levels were used to compare the male and female students as lower- and upper-level readers, the results for questions 2 and 3 overlap.

Time by Gender. The results were further investigated using ANOVA by combining all lower- and upper-level males and comparing the mean difference to the combined results of the lower- and upper-level females over time. The effect for reading level indicates this is a significant interaction. Table 6 illustrates that female students show a mean loss of 0.3 points from the initial assessment to the second day of testing.

Table 5 indicates mean and standard deviations for research question 3. There was a main effect of time by gender interaction, $F(1, 158) = 4.95$; $p = .028$, $\eta_p^2 = 0.030$, with a variance of 3%. Male students did not perform as well as their female counterparts in the initial testing sessions. Subsequently, as shown in Figure 17, there was a decrease in their average score from day 1 to day 2. Male students show a decrease in their assessment score 24 hours after the initial assessment. There was no loss of information for the females. From the results provided, the hypothesis is rejected because the results indicate there is not an increase in the retention rate of males over females.

Table 5: Mean & Standard Deviations for Research Question 3

Variable	*N*	*M*	*SD*	*SE*
Males day 1	109	69.1	23.3	2.23
Males day 2	109	63.7	26.5	2.54
Females day 1	100	71.5	18.9	1.89
Females day 2	100	71.2	22.1	2.21

Lower-level readers by gender over time. Table 6 indicates the mean performance on the retention tests by gender and reading level proficiency. Low-level female students remember almost the same amount of information when the average score from day 1 was compared to the average score of day 2 regardless of strategy. The male students identified as low readers recalled far less information the second day when they were presented with the repeated assessment. Females retained 14 points (a gain of 22%) more terms when tested the following day compared to the males. Results in Table 6 indicate that the males and females initially retained different amounts of information during the first day of assessment and the gap increased after 24 hours According to the results, females retained more information the second day. Males who were identified as low-reading students remembered less than half of the words they were presented with during the first day. Females identified as low-reading students did not show an increase in remembering terms, but they scored almost the same on the second day as they did originally, showing almost no loss in information.

Upper-level readers by gender over time. The male and female students who were proficient readers performed well (above a passing grade of 70) on the initial assessments and the follow-up tests the next day. There was a negligent amount of information loss between day 1and day 2 by either gender as indicated by the mean values, standard deviation, and standard error in Table 6. The ANOVA results [$F(1, 158) = 4.90$, p= .028, $\eta_p^2 = 0.030$], indicate reading levels, student gender, and the time of the assessments to be significant in the study. The results account for 3% of the variance.

Table 6: Mean & Standard Deviations of Students by Gender Over Time

Variables	*M*	*SD*	*SE*
Lower-level readers			
Males day 1	60.4	34.6	3.31
Males day 2	49.7	37.8	3.62
Females day 1	64.3	33.1	3.31
Females day 2	63.7	36.2	3.62
Upper-level readers			
Males day 1	77.8	26.9	2.58
Males day 2	77.7	29.5	2.83
Females day 1	78.7	28.4	2.84
Females day 2	78.6	31.0	3.10

There were subfindings from the statistical analysis of the data. The subfindings are statistical information revealed as a result of the using ANOVA to analyze the assessment results. They were the order of the terms after 24 hours and the variable time.

Order of the terms after 24 hours. Using ANOVA, vocabulary over time was significant $F(1,207) = 4.77$, p = .030, $\eta_p^2 = 0.023$. The statistical data of eta squared show that the order of the terms was 2.3% of the variance. The order of the terms over time represents the results of eah set of vocabulary terms from day 1 compared to 24 hours later. The students were given two separate sets of terms. Without taking into consideration any specific strategy, the average assessment score for the first set of terms, “Measurements in Science,” was (*M* =66.9) on day 1. The assessment mean average for the terms of all students after 24 hours was (*M* =61.8). The following week the students received the second set of terms, “Concepts in Science.” The mean average of all students using the second set of terms for day 1 was (*M* =72.9), and the mean score 24 hours later was (*M* =72.3) for day 2. The mean data results show students retained more terms from the second set of science vocabulary terms compared to the set they were given the first week.

Time. The data was looked at more closely to determine if the assessments overall resulted in a higher retention of information after 24 hours. Time was also a significant factor, $F(1, 207) = 7.20$, $p = .008$, $\eta_p^2 = 0.034$. There was a measurable difference in retention after 24 hours of receiving the initial strategies. Students remembered less information the second day of assessment (*M* = 67.1, *SE* = 1.70). Students retained more of the definitions after the initial intervention of the strategies (*M* = 69.9, *SE* =1.49). Time was significant, but it was 3.4% of the variance.

Summary

The reason for this study was to determine if strategies implemented in science classrooms using active visual and verbal methods of drawing and discussion would help students retain science terms better than mentally processing the definitions by copying and silently reading them. There were a series of analyses related to the outcomes to demographic characteristics, and there were not statistically significant results such as strategy by gender and order by gender. Results were analyzed using multivariate

ANOVA with a view to determine if there was a difference in retention by gender, a difference in retention by reading level, and to determine if there was a difference in retention by strategy. The results indicate that the multimedia strategies have a measurable impact on remembering science vocabulary over the passive strategy of copying and reading in a classroom setting.

CHAPTER 5: CONCLUSION

Overview

This chapter examines the results of this study and how it may contribute to the existing literature about the multimedia strategies of learner-generated drawing and peer discussion in a classroom setting. A summary of the results for each of the three research questions is provided. The chapter concludes with suggestions for contributions to further studies, limitations of the study, implications for practice, and suggestions for future research. The research inquiries addressed in this study were: (a) how will multimedia-learning strategies affect the retention of earth science terms when presented as a study method in a high school science classroom compared to passive methods of reading, copying, and studying the terms, (b) how will the multimedia strategies of drawing combined with peer discussion influence the effectiveness of students' performances on assessments measuring the retention of science terms based on students' reading levels, and (c) how will female students' performances on assessments measuring the retention of science terms compare with male students when using the multimedia strategies of learner-generated drawing and peer discussion compared to passively reading, copying, and studying the science terms?

Research Question 1: Evaluation of Methods

How will multimedia learning strategies affect the retention of earth science terms when presented as a study method in a high school science classroom, compared to passive methods of reading, copying, and studying the terms?

Cognitive literature refers to the active process of learning as a practice that is engaging and will result in an outcome of understanding and remembering the information provided. The passive strategy of rehearsing or repeating words is passive because it involves less active practices that in turn provide fewer learning opportunities and potential for remembering the subject (Chi, 2009). Learner-generated drawings allow the learner to construct pictorial representations to improve learning of content (Van Meter & Garner, 2005; Van Meter et al., 2006). As the results of this study indicate, a clear difference between retention of science terms can be achieved in a typical high school science classroom when using the multimedia strategies of learner-generated drawing and peer discussion.

Comparison of strategies. The active multimedia strategies of drawing and discussion produced beneficial results associated with learning in a regular science classroom setting compared to passively copying and studying terms. Students who were engaged in the active multimedia strategies remembered more terms than students who only read the terms and copied the definitions. The mean of the data showed students who incorporated the vocabulary as mental images and heard the terms discussed, retained more vocabulary than those that did not receive the intervention. The results also show while there was a minor loss of information for the active state of the learners, the mean difference of active over passive strategies for the students showed an increase of 13.2 points 24 hours after being introduced to them.

Peer-discussions allow students to help each other because each person contributes information to the discussion. The dialogue within the groups is constructive learning that allows the participants to generate knowledge beyond what is provided. Peer dialogue enables the learners to argue and defend ideas, challenge and criticize thought processes, ask and answer questions about each other's images, and thereby generate knowledge and information beyond the definitions to be learned (Chi, 2009). During the process of learner-generated drawings, students construct the images they deem to represent the definitions of the words they were learning. The pictures drawn by the student represent the interpretation of the student. Most of the images vary from student to student within a class, but they were still correct representations in the mind of the one constructing the image. Students were not provided with any indication of right or wrong images, so they sometimes expressed strong opinions as to which image was correct. For example, Appendix G shows Student A used more complex images to represent definitions for "Measurements in Science", compared to Student B (see Appendix H), who used very simple sketches to represent terms. The drawings were relevant to the student who generated the drawing, so both students were correct in their interpretation.

The active multimedia strategies of learner-generated drawing and peer discussion have shown to be a more beneficial learning tool for students than quietly studying and copying terms. There was an increase in vocabulary retention overall for all learners when using the active strategies. This study supports the use of learner-generated drawing and peer discussion as learning strategies for remembering science definitions in a science classroom. The findings of this study agree with prior research on the benefits of learner-generated drawings (Van Meter, 2001; Van Meter, Aleksic, Schwartz, & Garner, 2006). Thus, the hypothesis that students will retain more information using the multimedia strategies of learner-generated drawings and dialogue between peers to embed the meaning of the terms into memory was accepted.

Comparison of active and passive strategies over time. The active and passive strategies were assessed immediately after the interventions and again the following day when students entered the room. When students processed information visually by drawing pictures and also verbally by discussing their drawings and definitions, students received an initial mean score (M = 75.4, SE = 2.05), and 24 hours later, students scored virtually the same score (M = 75.2, SE = 1.91). Essentially, after 24 hours, students maintained the information learned from the initial day after using the active strategies.

Students who quietly studied and copied definitions as a method to remember terms had a mean score of (M = 65.3, SE =1.97) as their initial score immediately following the passive study method. This score was 10.1 points lower than the score students obtained when using the active strategies as their initial study method. After 24 hours, students who participated in the passive strategies received a mean assessment score that was lower than the score students received from their initial evaluation after immediately completing the passive strategy. The score shows a 5.6 mean value decline in information from the assessment mean score that occurred the previous day.

When teachers present students with new terms to learn, they usually have several days to go over them with their students. Students are given several days to learn the terms before an assessment occurs. Students for this study were given the strategies and then assessed immediately after the strategies. They received no other interventions and were assessed again the next day. The expectation was that students would remember fewer terms the next day after receiving no further intervention after the initial strategies were introduced. The students using the passive strategy showed a greater decline on the mean score after 24 hours compared to students using the dual strategies of drawing images and discussing terms with peers. The results strengthen the hypothesis that students would retain more information using the multimedia strategies of learner-generated drawing and peer discussion to embed the meaning of the terms into memory.

Strategies by order. Strategy by order compares the results of students according to the order in which they participate in the strategies. In chapter 4, Figure 8 shows the order of the strategies was statically significant. The results were surprising because order by strategy was not expected. Learners who received the passive strategy after the active intervention the previous week did better than students who used the passive strategy as the initial intervention week 1 (Figure 9). The researcher did not anticipate the order of the strategy would make a difference for the participants.

The results raised the question why the second set of passive mean scores were 14.5 points higher than the first group of students who started with the passive strategy. It is possible that students who used the active strategies as an initial process to learn the terms the first week may have retained some of those strategies to use the second week during the passive strategy session. Students who received the active techniques first could have remembered how to make visual models in their minds and could have had the ability to mentally imagine and reason through images that would represent the words they were now asked to copy. Therefore, it is possible that even though they were copying the terms and reading silently, the students who had drawn pictures and discussed the terms during week one, now possessed the skills to integrate learning beyond the given directions. It can be expected that using mental imagery will foster comprehension (Leutner et al., 2009). Fiorella and Mayer (2015) discussed imagining as one of the eight multimedia strategies used to help learners to better retain information.

Students who experienced the active technique as the second method of learning terms were learning the active process for the first time, and thus they did not have the experience to implement the strategies until the second week; therefore, their initial passive scores were based only on reading, writing, and studying terms for the allotted time.

When looking at the order by time results, several factors had to be considered. By the second week, students knew they had to learn a given set of terms during a given amount of time, and they knew they were going to see those words on the assessment with the same definition as the ones they were copying. Although the strategies to learn the information were different, the process had a sense of familiarity the second week versus the first week when every step of the process was unknown. The familiar process could have caused the students to be more relaxed with the process of learning and processing the terms.

In conclusion, the mean passive scores for the first group of students show higher results than for the second group of students who initially used the passive strategy to learn definitions. The first group of students might have mentally formed images to help them remember science definitions (strategies they learned the first week). Furthermore, the words were not pretested for complexity or difficulty. The terms could have possessed a higher level of difficulty in week 1 compared to week 2. Thus, the results of strategy by the order are statistically significant, but they may not conclusively render a sound interpretation of the information provided. In other words, the data indicates students in group one remembered more terms from the initial passive strategy in week 2 compared to the initial passive scores obtained by group two. Moreover, group one students scored higher using active strategies compared to group two students, but because the level of difficulty of the terms could have been a factor, and the possibility students might have used active techniques during the passive session, the results are not conclusive based on this one piece of data.

Research Question 2: Interpretation of Reading Level Results

How will the multimedia strategies of drawing combined with peer discussion influence the effectiveness of students' performances on assessments measuring the retention of science terms based on students' reading levels?

Reading level by time. Students who possessed upper-reading level skills retained the same amount of information day 1 and 2 (Figure 10). Lower-level readers again showed a loss of information over time. Overall, time and reading level were significant for those with low-level reading skills and the data indicates lower-level readers did not retain their initial amount of information over time. Only the upper-level readers retained their initial amount of information, but because they were skilled learners, it cannot be conclusively stated that the multimedia strategies or passive strategies increased their retention of the vocabulary terms. The initial assessment mean value for those with low-reading levels was 15.9 points less than the initial assessment mean value of upper-level readers. By day 2 the gap had grown to a 21.4 point deficient between the assessment scores of lower-level and upper-level learners. Thus, students deemed proficient readers retained more science terms than lower-level readers.

Research Question 3: Evaluation of Gender Performance with Terms

How will females' performances on assessments measuring the retention of science terms compare with male students when using the multimedia strategies of learner-generated drawing and peer discussion compared to passively reading, copying, and studying the science terms?

Time by gender. When students were tested in the same environment under the same conditions, the results showed that males exhibited a difference in information retention that varied greatly from that of the females within the same setting regardless of strategy. These findings were statistically significant, but there were other factors to consider before it could be determined that the information was relevant. In this study, females scored higher than males on the assessments, but the differences may not be associated with the learning strategies. Males and females respond differently to situations that involve conversation. Females acquire verbal skills and language earlier than males and this might have been beneficial for the female students during the peer discussions (Ginger, 2003). Males are expected to be better skilled at creating and gathering information from images and spatial processing (Cahill, 2005; Lenroot & Giedd, 2006; Sax, 2006; Bonomo, 2010). Females acquire more vocabulary words, speak earlier during growth and development, and have better-spoken communication skills than males during early stages of maturity (Sax, 2006).

It has been noted that girls are born with a sense of hearing that is exceedingly more sensitive than boys; especially if the sound is of a higher frequency (Ginger, 2003; Sax, 2006). Girls also have a different visual perception than boys. Girls tend to draw more-detailed images associated with people and faces, boys' spatial vision is better developed thus they tend to be better at drawing objects (Sax, 2006). Most of the science terms in this study were associated with objects; therefore, males could be expected to have an advantage for the multimedia-learning strategy of drawing.

Mayer (2015) suggested that students could be trained to determine how much detail should be put into a drawing and coached on how much time to take for drawings prior to implementing this process as part of the learning practice in the educational setting. The drawings for this study did not have to be elaborate or extremely large to depict the concept or the idea to be learned. The images only needed to be understood by the generator of the drawing to support the dictionary meaning the figures represented.

The hypothesis that males would do better using multimedia strategies was rejected. According to previous research on how the brain learns, the outcome of the assessments could be associated with the learning styles and brain development of the genders and not due to the strategies. Thus, the effect of the multimedia-learning strategies in this study was significant between the genders, but it cannot be conclusively stated that the active strategy was more beneficial for one gender over the other.

Lower-level readers by gender over time. Being able to comprehend is the process of relating text to one's memory, knowledge, and experiences (Wittrock, 1990). In order for students to perform well on the assessments, they had to retain the definition of the terms. The ANOVA results indicate the lower-level readers struggled to retain definitions from day 1to day 2. Lower-level males decreased below a mean score of 50. This means lower-level male readers retained less than 50% of the terms after 24 hours. Students with low-reading skills were not able to grasp the terms based on a specific strategy.

Lower-level males retained less information than lower-level females. Prior research suggests academic achievement affects retention (Edens & Potter, 2001). In their study 68% of the females improved their scores on the posttests compared to 32% of the male students, and high performance on the posttests was also largely attributed to the academic level of the students.

Upper-level readers by gender. Teachers are responsible for growing the academic skills of their students and trying to bring less proficient learners up to proficiency often with limited funding or resources. Educators are also expected to differentiate teaching techniques to communicate learning for all their constituents. Often, in a public classroom, the skilled learners will be in the same class as those that require extra help and resources. Students who have a higher level of proficiency are deemed as better readers, better at comprehension, and as better learners overall. Thus, learners with higher proficiency skills in reading would be expected to perform better on assessments compared to students who possess lower proficiency skills. Students who have a higher skill level for reading are able to compensate for a lack of background knowledge about science (O'Reilly & McNamara, 2007; Morgan, Farkas, Hillemeier, & Maczuga, 2016).

Order of the terms aftter 24 hours. Students scored noticeably lower the first week using the terms "Measurements in Science" in comparison to the second week when they used the terms "Concepts in Science." The terms were not assessed for difficulty before this study. The teachers chose words that they knew had not been taught in their classes before this assessment. The level of difficulty was considered when the teachers met to choose the vocabulary terms, but they were convinced that because the words were terms they would eventually cover, the terms would not be too difficult to use for this study. The data indicates the second set of terms (vocabulary 2) were easier to master.

Time. All 209 students were presented with terms during the initial intervention and were immediately tested on day 1 and retested the next day. Once the intervention was over and the assessments completed, the teacher had approximately 45 minutes of remaining class time. The teachers taught the lesson they had planned associated with their curriculum for the day that did not include the units tested after the strategies. Students had to refocus their attention on the teacher at the end of each assessment. There was no time to process the new definitions or the strategy. The next day, students entered into their science classroom after listening, studying, reading, doing worksheets, and other reinforcement strategies provided by the teacher to help them learn the material taught for the day. Once the bell sounded to begin class, the students immediately took a second assessment on the terms they had received and practiced for 30 minutes in class 24 hours earlier. Thus, having to wait 24 hours to see any of the terms again without any studying of them outside the first assessment was a factor as their grades showed a decline in mean score overall from day 1 to day 2.

Limitations – Passive Setting

Conducting a study with a class of 25 to 30 teenagers in their regular classroom of instruction lends itself to several circumstances that are controllable in a more confined location such as a research lab. For example, some students who were instructed to read and study silently were seen mouthing the definitions to themselves. The production effect is based on students learning information by saying it aloud *or* mouthing it (Castel, Rhodes, & Friedman, 2013). No matter how much it was emphasized that silent study meant learners were to study in their head and on paper, some students appeared to resort to mouth movements occasionally to try to remember a particular term or definition.

Because the students were not talking out loud or posing a significant distraction to others, the teachers or researcher did not continuously addressed the issue. This study was done in a regular classroom to determine if the active strategy would be a more beneficial method over the passive strategy of studying and copying the terms. For a silent study session conducted by a teacher in their classroom setting, students mouthing definitions without sound would not be an issue to address and would be considered as a passive learning method.

For courses in all subject areas embedded with basic foundation vocabulary and skills, teachers often give priority to directly instructing information over developing critical thinking skills (Killian & Bastas, 2015). Such classes often use lectures, direct instructions, worksheets, and vocabulary as ways to introduce new or complex material.

Limitations – Active Setting

When the students participated in the active multimedia strategies, they picked their partners for peer discussions in classes that had an uneven number; students were allowed to have three students to a group. Again, there were factors that were difficult to control for a research study, but they would be typical and acceptable for a learning environment at the high school level. Those who worked in pairs in seating arrangements that faced each other were eager to show their drawing and have peer discussions with the group in front of them or behind them. This caused some chatter and talking among the students. Student-generated drawings and peer discussions seemed beneficial because each time a student interacted with another student to discuss the meaning of the term in comparison to a drawing, their actions reiterated the word and the definition. The cognitive process of learning by vision and sound reoccurred each time students interacted over the terms. In the discussion and debriefing with the teachers, some expressed this setting also made for a loud and active classroom and made some teachers feel uncomfortable as if they were not in complete control of their class.

Limitations – Interactions

Chi (2009) defined being interactive as not ignoring what others have to contribute when working together. When there are 25 to 30 students in a class, it is difficult to make sure that all are engaged and attentive to each other during the peer discussion portion of the strategy. Students should be coached on the proper etiquette of group discussions, such as making eye contact with the speaker, making some acknowledgment to what the person said during their discussion or explanation time. The teacher must also be patient and realize the student-drawn pictures may lead to conversations that are irrelevant to the terms being learned.

Occurrences happen in an environment that is not structured, isolated, or controlled compared to a research lab. Not all students wanted to work in small groups or in pairs for the interactive strategies. A few preferred doing the activity alone, or they did not want to work with others or talk to others. Again, this situation requires the teacher to establish rules to ensure students are not ridiculed for their interpretive drawings or their reasoning during the discussion process. Consequently, the assignment of student pairs is recommended. Teachers should always make their learning environment a safe and secure place to share information.

Limitations – Definitions

There is a standard format and procedure for writing test questions for students (Clay & Root, 2001). A definition should not have any parts of the word being defined within the definition. For this study, the teachers elected to take the longer definitions from the textbook and carefully rewrite them into a shortened format according to the way they would present the terms to their students while maintaining their meaning. Shorter terms were provided because of the various academic abilities of the students within the CP classroom setting. One teacher stated, "If the definitions are too long, my students will not try to learn them."

Some of the definitions used provided examples of how the terms could be represented with images, and regardless of the learning levels of the students, the teachers made sure they would be able to show (draw?) some images. The teachers stated they would decipher the terms in this manner for their students in a regular learning environment to make learning easier. Some students copied the terms and examples that were within the definitions (see Appendix L). Others were reluctant to write definitions verbatim that were provided as shown in Appendix I in which the student used a slash mark (/) to represent the words "or" and also the word "and." Long terms that included examples were shortened to only the term without writing the example. This example supported the teacher's concern that some students were not inclined to write lengthy information associated with the definitions. The study was conducted using actual teachers and their students; therefore, it was imperative to carry out the process they would use in their classes. It is possible that because the definitions were made so basic or simple for reading purposes, students with upper reading level skills moved quickly through the terms.

Implications for Practice

Teachers typically spend considerable amounts of time preparing a lesson before they initially teach it to students. The teacher makes sure they have a clear understanding of the material themselves so they can explain it and answer possible questions. In addition, they research the lesson so they can have relevant examples to help explain a new topic. They also take copious notes following the lesson and the teacher retains the original materials so the next time the topic is taught the process is not as time-consuming. Teaching the active multimedia strategies of generative drawing and peer discussions should also be well planned and thought out. It is suggested that the teacher provide the list of words and definitions to the students and give the students specific instructions such as guidance on the size of the images they are to draw. Teachers should also instruct students that their images should not be too abstract, and they must relate back to the true definition of the word.

Enforce time limits. Student generated images should have enough details to show meaning to the student, but students should not spend so much time forming details that they miss the purpose of the activity. However, some researchers suggest that the quality of the drawing is directly related to learning outcomes (Leopold, 2009, Schwamborn et al., 2010; Van Meter, 2001). Drawing pictures takes time, but when the process is compared to how much information is retained versus copying definitions, this study shows it is worth the extra effort by the students. It may be beneficial to start students on the process in class and let them continue their images for homework. They can still conduct peer discussions the next day as a review of the terms at the end of the lesson. A prior study showed that students preferred drawing pictures to copying and would likely be more willing to complete them for homework over copying definitions (Shore, 2015).

The results of this study show active learning have clear advantages over silent reading and copying as a study method for science terms. As with any other new process or new idea introduced to students in the classroom, the teachers must provide carefully monitored and guided instructions. Learner-centered classrooms can be more productive for the students when the teacher spends time creating, implementing, and assessing the proper learning strategies for their students (Lumpkin, Achen, & Dodd, 2015). In order for teachers to be comfortable with active multimedia strategies, they must give specific and clear directions about the tone of the class, and they should set reasonable noise level expectations. The normal speaking voices of 25 to 30 high school students can get very loud very fast. Therefore teachers have to keep this in mind when establishing what is a reasonable level of noise for their learning environment.

Learners must also understand they should have a meaningful drawing to best help them with recall, but they should not be overly concerned with details. Student D showed very few details in the drawing associated with the definition (see Appendix J). Student D also drew large, simple images. Student A drew several pictures that matched the terms according to how they were defined (see Appendix G). Student E used a drawing for the term “force” (see Appendix K) that seemed to show no reference to its textual meaning. These varying examples of student-generated pictures are not incorrect, and the teacher must be willing to let the students’ knowledge and creativity guide them during the generative drawing process. The teacher acts as a coach to (a) keep students aware of the time constraints, (b) contain the noise level during the process, and (c) keep students on task and focused as they share their student-generated drawings with others in the room.

Future Study

The demand by parents, the community, and others for teachers to help produce better learners with limited resources can be a daunting and stressful task for educators. This study has shown that instruction that makes the learner more actively involved in the learning process can be more beneficial for the retention of complex science terms than the methods of copying, reading, and studying alone. However, teachers need more information about how to effectively implement active strategies in their classes. Thus, more research should be conducted using students in a regular classroom setting particularly at the high school level to test additional active multimedia strategies or combinations thereof.

There were students who drew simple pictures and wrote only part of the definition. It could be very beneficial to know if the reading level of the student was associated with the pictures they generated. Did they draw simple pictures because that was the extent of their prior knowledge or was there some other reason? Several students expressed the desire to color their drawings. Would allowing students to add color increase the level of retention? How many colors would be considered enough? Would the cognitive process decrease because of the extra details?

Have the additional pressures of the recently implemented End of Course state assessments affected how teachers teach information to students who are enrolled in courses such as science? Do teachers shy away from “nonconventional” methods of teaching state assessed courses? If so, why? Is it because they do not know how to successfully implement active strategies such as the multimedia strategies of peer interactions and student-generated drawings? Is it because such activities generate a higher volume of noise in the classroom and are viewed negatively by the administration or other teachers? It would be beneficial to investigate teachers' perceptions of levels of difficulties or ease in implementing various multimedia strategies. This study has shown that actively engaging students in the learning process has shown positive effects on retention. Teachers usually take several minutes a day to review or reteach terms, and when that time is factored in, active learning strategies should take no more instructional time and resources than traditional methods. Why are more multimedia strategies not used more often in the educational setting? Are these strategies being taught to those who plan to become teachers? Future studies could investigate the extent to which colleges of education are teaching cognitive strategies such as multimedia strategies. This study has opened up several questions that could help provide a deeper understanding of the relationship between multimedia strategies and retention.

This researcher recommends that educators relinquish their perception that classrooms must be orderly and quiet in order to create a space to experiment with more active learning strategies in their classrooms. This researcher further recommends that all teachers periodically incorporate active learning strategies into their curriculum. Teachers should be willing to participate in more nontraditional methods in order to increase student learning and retention of information.

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APPENDIX A: "MEASUREMENTS IN SCIENCE"

Scalar – A physical quantity or magnitude that can be described completely by its amount such as the words "temperature," "distance," or "speed."

Pascal – The metric unit of pressure.

Watt – The metric unit for power such as a 60-watt light bulb. A house uses so much electricity it is measured in kilowatts.

Acceleration - The rate of change of velocity of a moving object over a specified period of time (such as a car going from 0 miles per hour to 60 miles per hour in 5 seconds).

Quantum – The smallest amount of energy that can be absorbed or emitted by an atom.

Velocity – The distance traveled by an object in a particular direction per unit of time such as a baseball pitch.

Luminosity – The total amount of energy radiated into space each second from the surface of a star.

Vector – A quantity described both by size and by direction.

Magnitude – A unit of measurement for size or greatness.

Oscillation – The back and forth motion of an object from its resting position, such as a swinging pendulum.

APPENDIX B: "CONCEPTS IN SCIENCE"

Diffusion – The random mixing of two objects, such as food coloring in water.

Dispersion – The effect of spreading colors of light into a spectrum.

Energy – The ability to do work or cause change, such as fuel which causes a car to move.

Exothermic – A process in which heat is released by the system, such as a fire in a fireplace.

Free Fall – The motion of an object as it moves towards the Earth when no other force except gravity is acting on it, such as a boulder going over a cliff.

Force – A push or pull on an object.

Half-life – The amount of time it takes for a substance to lose half its' radiation.

Isochoric – A process in which volume remains constant, such as the amount of soda in a 2-liter bottle.

Inertia – The tendency of an object to resist change in motion, such as starting or stopping a big truck.

Power – The rate of doing work, such as a 60-watt light bulb versus a 100-watt light bulb.

APPENDIX C: TEACHER DIRECTIONS

Handout terms and paper to students. The active classes will draw images to help them remember the definitions. Students may discuss their images in groups of two or more. They are not to write the definitions. They are to draw images and discuss them as they see fit. Students have 30 minutes to carry out this activity. They will take an assessment at the end of the 30 minutes. The retest will follow the next day.

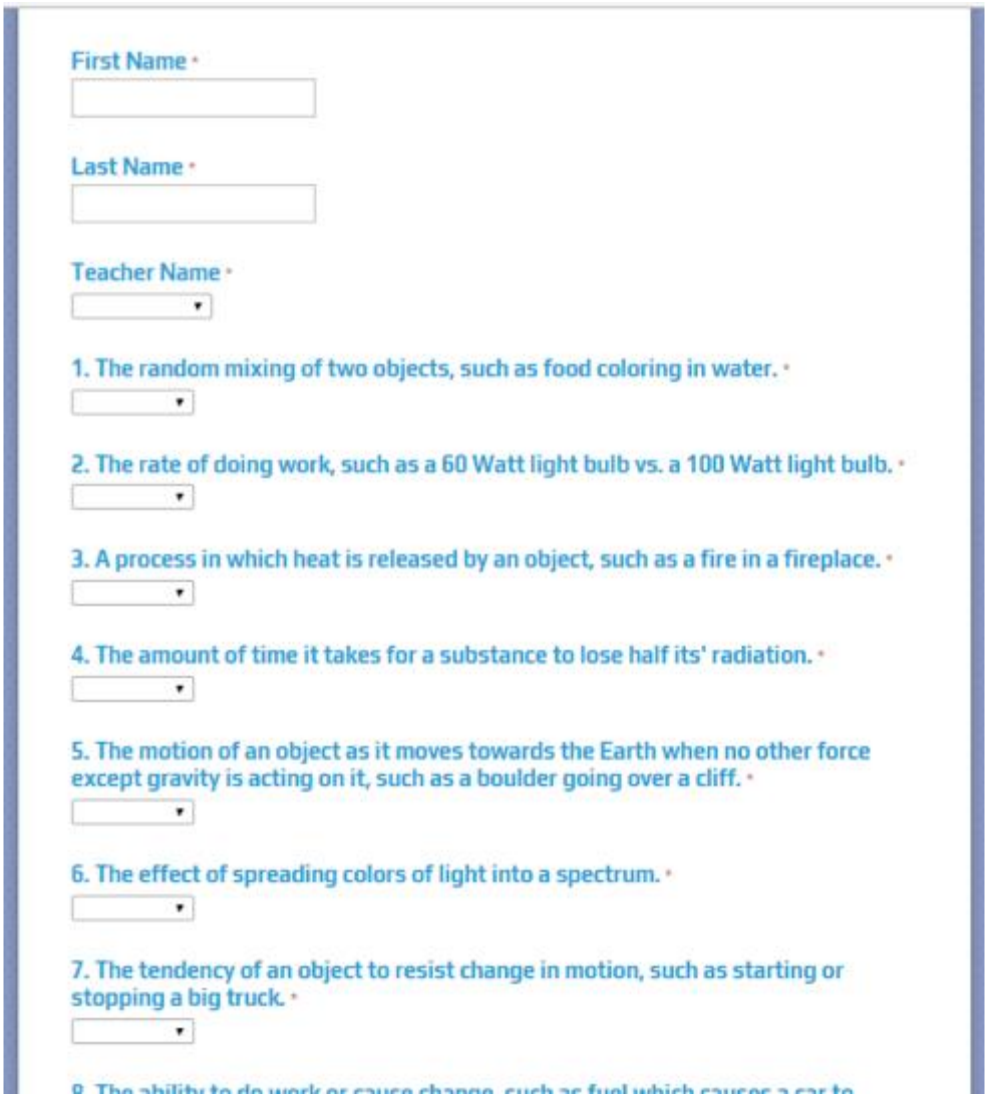
The passive classes will copy the definitions and study them for the entire 30 minutes. They may rewrite the terms over and over for 30 minutes or write them once and study. Students are not allowed to talk to each other or ask assistance from the teacher. They will take an assessment at the end of the 30 minutes. The retest will follow the next day.

The links below are case sensitive. They should be typed in "as-is" (they do not need https: or www.) The words in parentheses describe the image on the header so you can tell if students are in the correct location. Notice that the Day 1 links are google links (goo.gl/) and the Day 2 links are bitly links (bit.ly/).

Make sure you are using the correct link for each class and/or day.
Day 1
Pictionary/Active link for the terms: Measurements in Science - goo.gl/mZM1Gb
(town hall)
Dictionary/Passive link for the terms: Measurements in Science - goo.gl/mtJQ7p
(science lab)

Day 2
Pictionary/Active link for Measurements in Science - bit.ly/1CWKEfM
(fish)
Dictionary/Passive link for Measurements in Science - bit.ly/1JI5JQF
(woods)

APPENDIX D: IMAGE OF ASSESSMENT SCREEN PROVIED TO STUDENTS "CONCEPT IN SCIENCE



First Name *

Last Name *

Teacher Name *

1. The random mixing of two objects, such as food coloring in water. *

2. The rate of doing work, such as a 60 Watt light bulb vs. a 100 Watt light bulb. *

3. A process in which heat is released by an object, such as a fire in a fireplace. *

4. The amount of time it takes for a substance to lose half its' radiation. *

5. The motion of an object as it moves towards the Earth when no other force except gravity is acting on it, such as a boulder going over a cliff. *

6. The effect of spreading colors of light into a spectrum. *

7. The tendency of an object to resist change in motion, such as starting or stopping a big truck. *

8. The ability to do work or cause change, such as fuel which causes a car to

APPENDIX E: IMAGE OF ASSESSMENT SCREEN PROVIDED TO STUDENTS "MEASUREMENTS IN SCIENCE"

First Name *

Last Name *

Teacher Name *

1. A physical quantity or magnitude which can be described completely by its amount such as the words "temperature," "distance," or "speed." *

2. The metric unit of air pressure. *

3. The metric unit for power such as a 60 watt light bulb. A house uses so much electricity it is measured in kilowatts. *

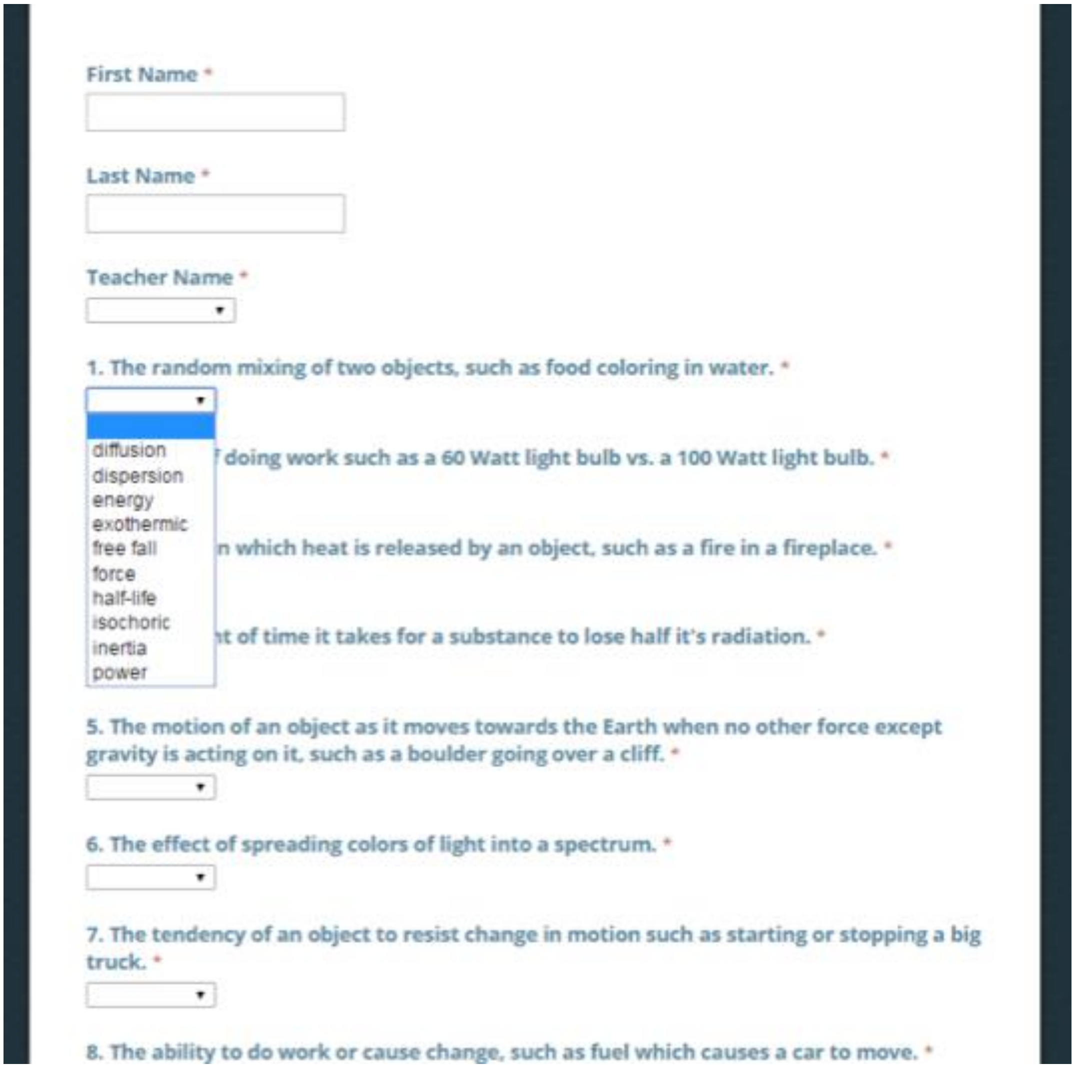
4. The rate of change of velocity of a moving object over a specified period of time (such as a car going from 0 miles per hour to 60 miles per hour in 5 seconds). *

5. The smallest amount of energy which can be absorbed or emitted by an atom. *

6. The distance traveled by an object in a particular direction per unit time such as a baseball pitch. *

7. The total amount of energy radiated into space each second from the surface of a

APPENDIX F: DROP DOWN MENU OF ONLINE ASSESSMENT



First Name *

Last Name *

Teacher Name *

1. The random mixing of two objects, such as food coloring in water. *

diffusion
dispersion
energy
exothermic
free fall
force
half-life
isochoric
inertia
power

f doing work such as a 60 Watt light bulb vs. a 100 Watt light bulb. *

n which heat is released by an object, such as a fire in a fireplace. *

nt of time it takes for a substance to lose half it's radiation. *

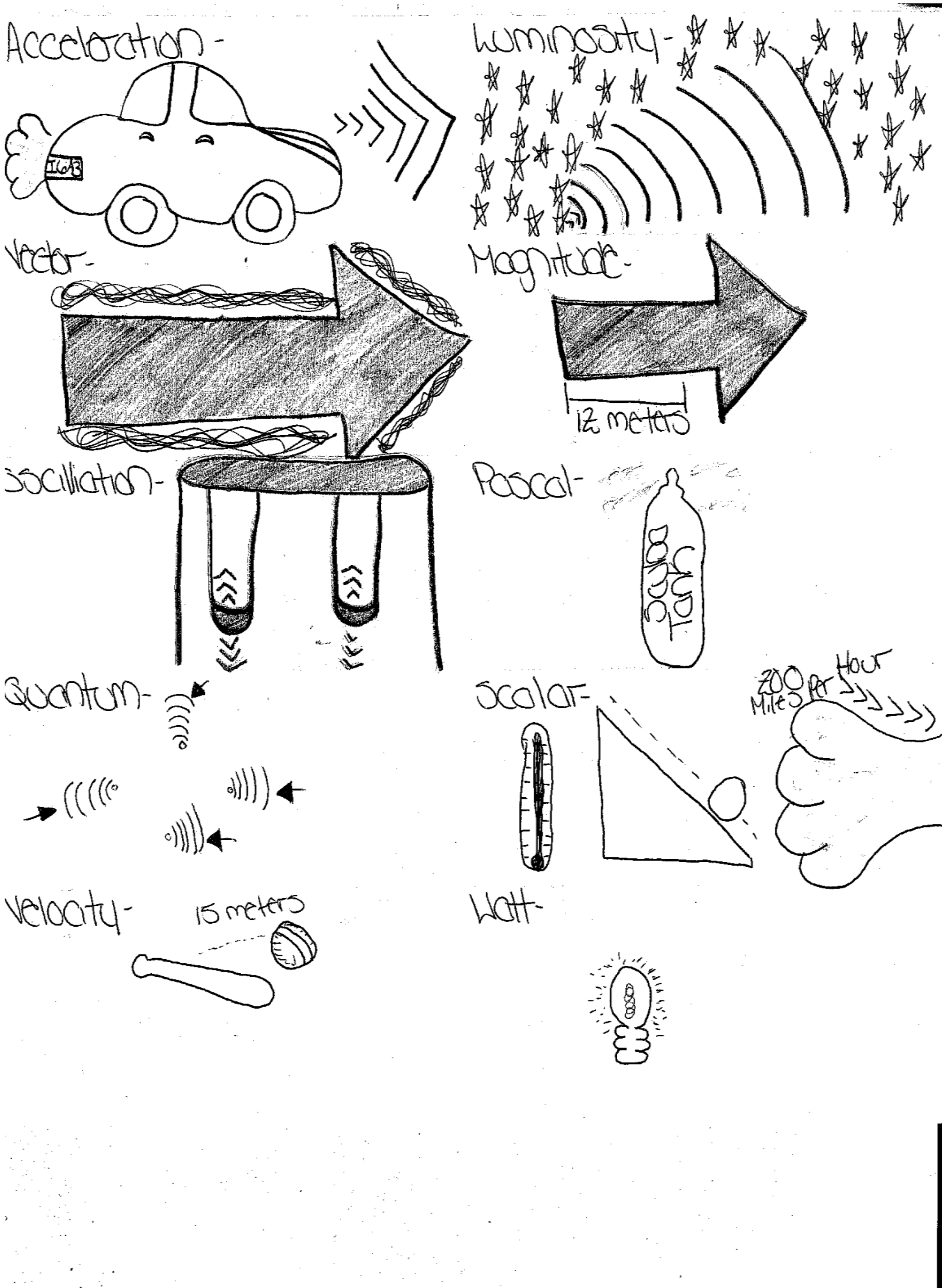
5. The motion of an object as it moves towards the Earth when no other force except gravity is acting on it, such as a boulder going over a cliff. *

6. The effect of spreading colors of light into a spectrum. *

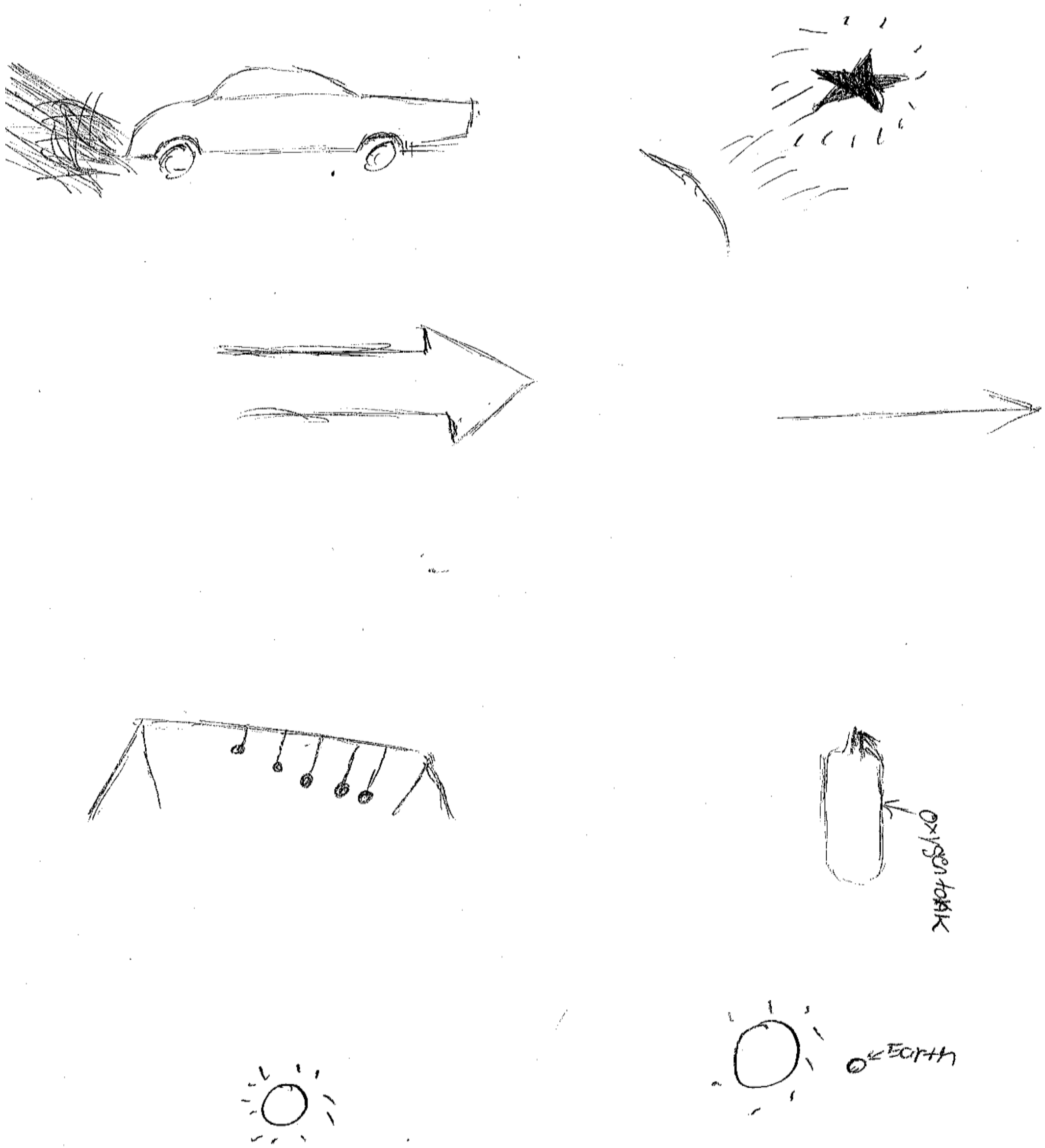
7. The tendency of an object to resist change in motion such as starting or stopping a big truck. *

8. The ability to do work or cause change, such as fuel which causes a car to move. *

APPENDIX G: STUDENT-GENERATED DRAWINGS FOR "MEASUREMENTS IN SCIENCE" (STUDENT A)



APPENDIX H: STUDENT-GENERATED DRAWINGS FOR "MEASUREMENTS IN SCIENCE" (STUDENT B)



APPENDIX I: STUDENT DEFINITION FOR

"MEASUREMENT IN SCIENCE" (STUDENT C)

Acceleration- rate of change of velocity of a moving object over a specified period of time

Luminosity- total amount of energy radiated into space each second from the surface of a star

vector- a quanity which is described by size/direction such as an arrow.

Magnitude- size of measurement of a vector such as the length of an arrow

Oscillation- back/forth motion of an object from its resting position

Pascal- SI unit of pressure/stress

Quantum- smallest amount of energy which can be absorbed/emitted by an atom

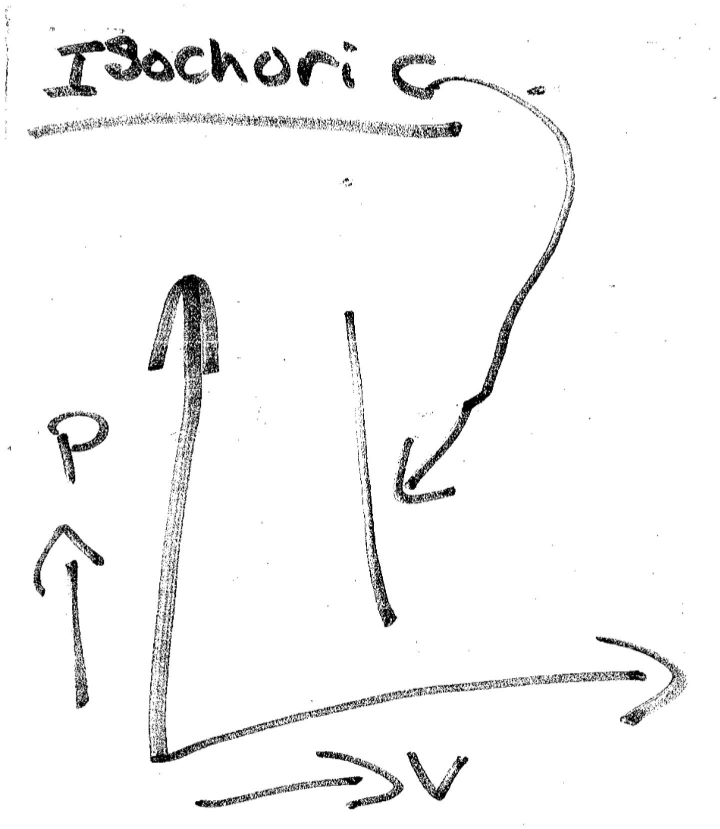
Scalar- physical quanity/magnitude, described by its amount such as words, "temperature", "distance," or "speed".

Velocity- distance traveled by an object in a particular direction per unit time

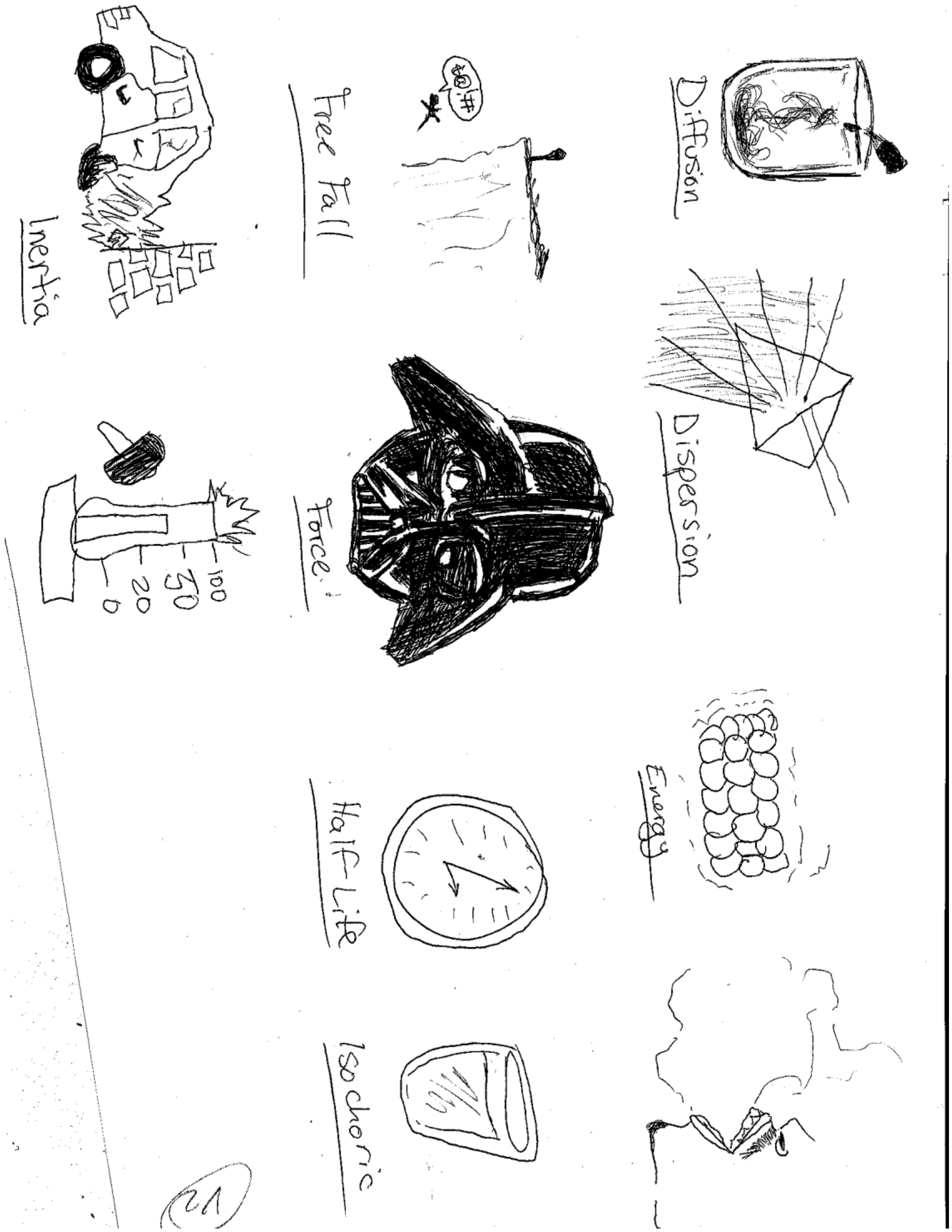
Watt- metric unit for power such as 60 watt lightbulb.

APPENDIX J: STUDENT GENERATED DRAWINGS FOR

"CONCEPTS IN SCIENCE" (STUDENT D)



APPENDIX K: STUDENT GENERATED DRAWINGS FOR "CONCEPTS IN SCIENCE" (STUDENT E)



APPENDIX L: STUDENT DEFINITIONS FOR "CONCEPTS IN SCIENCE" (STUDENT F)

Diffusion - random mixing of two objects
Such as food colouring in water.
Dispersion - The effect of spreading colours
of light into a spectrum.
Energy - ability to do work or cause change.
Such as fuel which causes cars to move
Exothermic - Process in which heat is released
by the system, fire in a fireplace.
Free Fall - motion of an object as it moves
towards Earth when no other force
except gravity is acting on it, such
as a boulder going over a cliff.
Force - push or pull on an object
Half-life - Amount of time taken an isotop
to lose half its radiation
Isochoric - process which volume remains
constant, such as the amount of soda
in a 2L bottle
Inertia - tendency of an object to
resist change in motion, such as
starting/stopping a big truck
Power - rate of doing work, such as
a 60W bulb VS a 100W bulb.