

THE EFFECTS OF THE 5E LEARNING CYCLE ON STUDENT
INTEGRATION OF SCIENCE VOCABULARY

by

Shari Lynn Generaux

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Shari Lynn Generaux

July 2014

DEDICATION

Thank you to the MSSE faculty and staff for the support, suggestions and encouragement over the past few years. I am grateful to my capstone committee of John Graves, Peggy Taylor and Sean Griffin for their advice and support. Thank you to the all my peers in the program who spent much of their valuable time peer editing sections of my paper. Thank you to Sue, for taking care of the house, the dogs and us, but more for having enough strength to never give up on me. Thank you to my administrators, faculty and staff at Elmhurst Community Prep, for their support and encouragement. Finally, thank you to my students who were willing to try new things, offer feedback, and who without a doubt have made me a better teacher.

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ABSTRACT

Teachers at Elmhurst Community Prep have been using a traditional approach to teach vocabulary to middle school students for the past 5 years. This strategy involves frontloading terms and definitions using a worksheet which requires students to record each word and definition and then create a sentence and image prior to interacting with the content. The expected outcome of strategy was to support students who were reading below their grade level. Data from classroom assessments and state testing showed that 8th grade students continued to struggle reading text, worksheets and assessment questions. However, on occasions when inquiry instruction was used, student assessments scores increased. The purpose of this study was to determine the effect of the 5E Learning Cycle on 8th grade physical science students' ability to use vocabulary on written assignments, discourse and assessments. Students were given an opportunity to engage and explore content prior to the introduction of vocabulary. Students also time to interact with vocabulary through practice and interactive games on the computer. Pre-treatment and post-treatment data was collected using student assessment data, student notebooks, written assignments, teacher observations and surveys. The results of the study show most students made gains in their academic performance. Whole grade level data, from classroom assessments, showed a gain of 5% for both male and female students. However, the data also revealed that African American females gained 11% on assessment scores and Vietnamese females gained 8%. Another notable gain, of 7% was identified among female English Language Learners. In addition to improved student performance on assessments, students' opinion and engagement with vocabulary improved. The results of this study suggest that inquiry based instruction does improve students ability to use and engage with vocabulary with the greatest gains among female students.

INTRODUCTION AND BACKGROUND

The image of an urban school is often thought of as having a relatively high poverty rate, high proportion of students of color, many students identified as English Language Learners (ELLs), and low high school graduation rates. In addition to being considered high needs, urban classrooms are often described as having high student to teacher ratios. In an effort to eliminate the pressures of overcrowded classrooms and poor academic performance by students, the Oakland Unified School District, in California, underwent a major transition by opening several small middle schools in 2004. The purpose of this movement was to increase learning opportunities for all students. This was accomplished by reducing the size of the student population at the newly created small schools. For each grade level there was to be no more than 120 students enrolled. Elmhurst Community Prep (ECP) was founded in 2006 as one of Oakland's small schools (Murphy, 2009).

ECP has approximately 360 students in grades 6 through 8 with a diverse population of students in each grade level. Thirty-one percent of ECP students are African American, 65% are Latino, 2% are Pacific Islander, and the remaining 2% are white or multi-ethnic. English Language Learners (ELL) make up over 50% of the student population, 11% have been identified as having disabilities, and over 90% of the students and their families qualify for free and reduced lunch (Oakland Unified School District, 2013). All ECP students are placed into class cohorts. Most of the cohorts consist of approximately 30 students. Students remain in their class cohorts for each of their core classes; English, history, math, and science. After lunch, students transition

into new classes, including one advisory class and a variety of general elective classes such as art, music and physical education. Grades 7 through 8 are located in the main building on campus, while the 6th grade is located in a separate building. There are currently 119 students enrolled in 8th grade. Female students make up 51% of the 8th grade population, while males make up the remaining 49%. Latino students make up 65% of the students and 28% of the students are African American. Pacific Islanders and others make up the remaining 7% of students (Table 1).

Table 1
8th Grade Demographics

Ethnicity	Percentage of Females (N=61)	Percentage of Males (N=58)
Latino	34	31
African American	12	16
Pacific Islander	2	1
Other	3	1

All 8th grade students are required to take physical science, which is divided into units of introductory physics and chemistry. Inquiry instruction is introduced during the first week of school. The next several weeks are dedicated to setting up class norms and expectations, as well as proper use of science equipment in an effort to get students comfortable with laboratory investigations and activities. After classroom behavior and a positive learning environment have been established, students are introduced to specific content through a series of units that include experimental design, structure of matter, chemical reactions, motion, forces, and astronomy.

Twice a year all students take a computer based reading assessment called the Scholastic Reading Inventory to determine their grade level performance. Student scores for this assessment are maintained in a Google spreadsheet that is available to all

teachers. According to SRI data, from Fall 2014, over 60% of 8th grade students are reading below their grade level. Approximately 15% of students are reading at grade level while over 20% are above grade level (Figure 1).

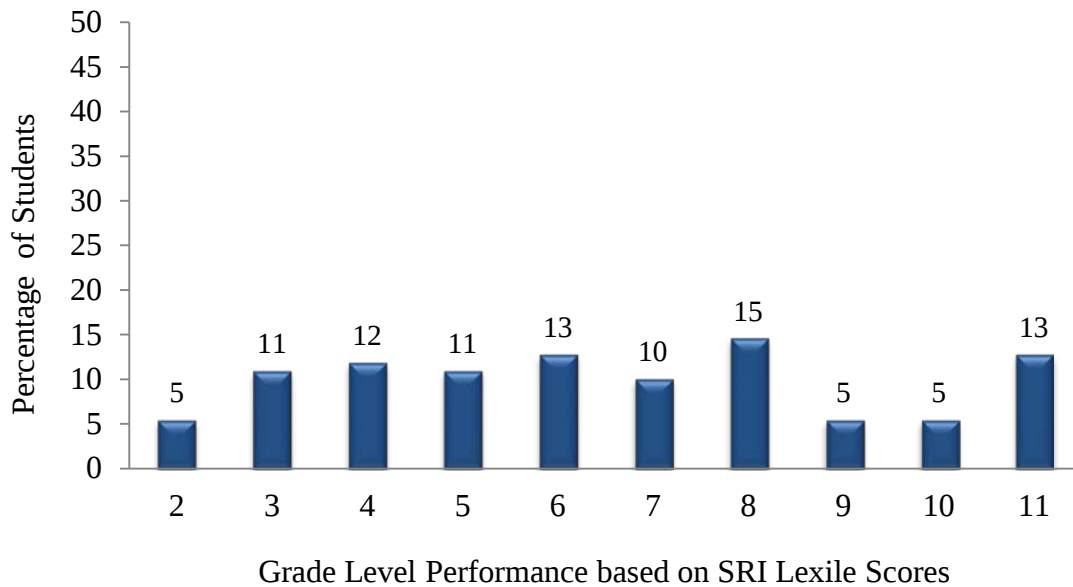


Figure 1. Student Reading Inventory for 8th grade, (N=110).

Four years ago, ECP teachers were introduced to a new strategy for teaching vocabulary. It was believed that student literacy and academic performance could increase if students had a better understanding of vocabulary. It was required that all teachers frontload new vocabulary for new content using the same strategy. The expected outcomes of strategy were that students would comprehend written text better if they knew the meaning of the word prior to learning content and students would be able to make more connections to content if they knew the meaning of the word first. Teachers agreed to use a Vocabulary Template as part of their regular instruction (Appendix A). In a typical vocabulary lesson, students record the definition of a new word onto their worksheet. Then the teacher provides an example of how to use the word in a sentence.

Next, students are asked to create their own sentence using the new word. Lastly, students create an image of what the meaning of the word might look like.

After four years of using the Vocabulary Template, several trends began to emerge in the classroom, including 1) students have difficulty creating sentences using unfamiliar new vocabulary words; 2) students have difficulty drawing images that represent the word; 3) students seldom use vocabulary to support verbal explanations; 4) students use vocabulary incorrectly or not at all on written assignments; and 5) students make little or no connection to content. On several occasions last year inquiry instruction was used prior to introducing vocabulary. Midway through the lesson, new vocabulary was introduced. It was observed that students began using vocabulary more accurately and more often to explain the concepts they had learned. Student scores on the unit exams also showed gains when compared to previous year's results.

Vocabulary comprehension is a key component to a student's academic success. Whether the student is reading a textbook, directions on a worksheet, or questions on a standardized test, they must know the meaning of the word in the context in which they read it. Requiring students to write definitions and create sentences, prior to learning the material, may not be an effective strategy to introduce new vocabulary to students. In addition, students who are reading at grade levels far below their peers have even greater challenges with understanding and using vocabulary. Ultimately, this investigation grew out of several challenges including 1) the ineffectiveness of the Vocabulary Template, 2) student engagement with vocabulary, and 3) student inability to accurately use new vocabulary. The purpose of this study was to answer the question, *How will inquiry instruction affect student use of vocabulary on assessments and written assignments?*

CONCEPTUAL FRAMEWORK

Today United States urban science classrooms are filled with students from varying socioeconomic environments, gender, cultures and ethnicities. Once in the classroom, many of these students face a variety of academic challenges. In addition to learning content, students must learn the vocabulary associated with the content. Students arrive in classrooms with a range of prior knowledge and skills (Rupley & Slough, 2010). Many teachers are not sufficiently prepared to handle the diverse learners such as struggling readers, ELL and second language learners in their classrooms (Feldman & Kinsella, 2005). Content area instruction must be modified to meet the needs of these learners based on their abilities (Gomez & Madda, 2005). In addition to ELL challenges, teachers must also address summer vocabulary setbacks that face many African American students in low-income urban school settings (Lawrence, 2009). The role of the science teacher has changed in recent years to include both content and literacy (Johnson, 2005).

Many teachers still utilize traditional instructional strategies for delivering vocabulary. Historically, teachers have used a method called front loading, or direction instruction, to introduce new vocabulary to students prior to teaching content. Students are required to record words and definitions, then memorize the definitions (Rupley & Slough, 2010). However, studies have shown students do not learn vocabulary when they simply look up and record the definitions to words. In fact, looking up words in the dictionary, figuring out the meaning from written context, and unplanned vocabulary instruction are often limited (Feldman & Kinsella, 2005). However, one study by Kinloch (2010) showed that front loading can be a successful strategy when there is a

reduction in the number of words. During the study, students were introduced to three new words each Monday. The word, part of speech, synonyms, definition and two original sentences were recorded into a vocabulary notebook. All students, from gifted to special education, showed an increase in use of new vocabulary on written assignments and discourse. In addition, several studies have shown that the combination of front loading new vocabulary and inquiry instruction promoted student understanding of new vocabulary (Kinloch, 2010; Wilhelm, 2013).

The task of identifying which words, and how many, should occur prior to introducing new vocabulary to students. This requires careful preparation and thought. Teachers must carefully analyze text and plan which words will have the most impact on students (Dugan, 2010). Words must be chosen that are important, in context to what the student is learning now and in the future, and lead to learning other words (Feldman & Kinsella, 2005; Wilhelm, 2013). In addition to deciding which words to teach, how to teach words has also changed. There are numerous strategies to teaching and building academic vocabulary. Students become motivated to learn new vocabulary when they are curious and engaged with the words they are learning (Dugan, 2010). The most recent shift in vocabulary instruction is the use of technology in the classroom. In a recent study Putnam and Kingsley (2009) used weekly use of podcasts to introduce vocabulary. Although the author did not discuss any academic growth in student use or understanding of vocabulary, he did note that there was an increase in student engagement with the new vocabulary.

New vocabulary words can be taught to students through direct and indirect methods. Indirect methods are typically student driven whereas direct methods are

teacher centered. Indirect methods, such as word walls, provide visual support for vocabulary acquisition. On the other hand, direct methods of vocabulary instruction include graphic organizers and word journals, where students complete words, synonyms, definitions, examples and sentences (Feldman & Kinsella, 2005; Wilhelm, 2013). This type of instruction often requires front loading of vocabulary by the teacher prior to content instruction and exposure to text. Feldman and Kinsella (2005) found that struggling readers and ELL benefit from this type of instruction. This type of instruction is often referred to as a "sheltered" model. In this model, teachers deliver content and language concurrently with an emphasis on vocabulary, phrases and sentence stems (Lee, Quinn, & Valdes, 2013). There is little or no other exposure to words other than the use of a graphic organizer. However, for this type of strategy to be successful, these students should also have multiple exposures to words using a variety of strategies (Feldman & Kinsella, 2005; Marzano & Pickering 2005). Whether a teacher is using an indirect or direct method to teach new vocabulary, the strategies used should be differentiated and modified to best fit the needs of students (Dugan, 2010).

Even with various instructional strategies, a student's background knowledge is a major factor in his or her ability to learn science vocabulary (Rupley & Slough, 2010). In addition to prior knowledge, the student may lack the literacy skills for their current grade level resulting in a greater challenge to learn vocabulary. Through carefully designed instruction and intervention, students can increase their science vocabulary (Lesaux, Harris, & Sloane, 2012). Even students with moderate to severe learning disabilities show academic gains from vocabulary instruction (Scruggs, Brigham, & Mastropieri, 2010). Using a variety of strategies to teach science vocabulary can result in

increased student connections, understanding, and confidence in their own abilities.

However, implementing new strategies can be difficult for both the teacher and student.

Students may resist new strategies that are not familiar to them, and teachers must take time to identify which strategies to use and, accordingly, write lessons to incorporate them (Nixon, 2012). In order to meet the needs of all types of learners in the science classroom, instruction must be modified and a variety of strategies should be used (Gomez & Madda, 2005; Wallace, 2012). One such strategy that has evolved over the past 50 years has replaced traditional teaching strategies, for science and focuses on student processing skills and reasoning.

In the 1970's, Robert Karplus introduced the first learning cycle model based on Jean Piaget's Constructivism Model (Constructivist Learning Cycle, 2013). His cycle began with the Exploration Phase in which students explore and raise questions when introduced to new content with minimal guidance from the teacher. The next phase is called Concept Invention where the concept is explained by the teacher. In the last stage, Concept Application, the concept is practiced and repeated (Constructivist Learning Cycle, 2013). In 1986, Roger Bybee expanded on the Karplus Learning Cycle in order to eliminate scientific misconceptions through hands on activities and reflective practices, allowing the student to use their own reasoning to understand concepts (Belict, 2006; Sibel, 2011). The model consists of five different stages: Engagement, Exploration, Explanation, Extension, and Evaluation (5E). In the Engagement stage, the student is motivated by previous knowledge and the teacher identifies misconceptions. During the Exploration stage of the 5E Learning Cycle, students participate in hands on activities, such as a laboratory experiment. The next phase, Explanation, is where the teacher

introduces vocabulary and concepts. The Extension stage, also referred to as Elaboration stage, allows students to gather new information and apply new concepts. Finally, the Evaluation stage allows the teacher to determine if students are correct in their understanding of the concept (Belict, 2006; Llewellyn, 2007; Sibel, 2011). In recent studies, students were more successful during evaluations, had increased levels of retention of material and increased learning levels, as well as a more positive attitude about learning new material, when using the 5E Learning Cycle model (Frazelian, 2010; Pries, 2012; Sibel, 2011).

At what point should teachers introduce new vocabulary to their students? According to Sibel (2011), it is during the Explanation stage of the 5E Learning Cycle that students should be introduced to new vocabulary so they can make greater connections between the word and content. Inquiry-based instruction has defined how students will use their own ideas to explain previously unknown content. Yet some teachers continue to use a more traditional method and introduce vocabulary prior to delivery of content. However, when students are expected to learn new terms incidentally, they tend to struggle as they have no prior knowledge of the term (Carlisle, 2000). Students will need to utilize their vocabulary skills in order to read, write and understand more scientific concepts and cross-curriculum content (Boy, Sullivan, Popp, & Hughes, 2012). Consequently, the Next Generation Science Standards (NGSS) have defined how educators will deliver content and assess student performance, which includes inquiry and language acquisition (National Research Council, 2011).

The NGSS are based on the document, The Framework for K-12 Science Education, developed by the National Research Council (NRC, 2011). The report lays

out three key performance expectations for students; science and engineering practices, disciplinary core ideas, and crosscutting concepts (Willard, Pratt, & Workosky, 2012). These new standards have refined the meaning of inquiry-based science and provide clear definition to science and engineering practices. The new standards will enable students to shift away from their misconceptions of the world and gradually transition into more scientific-based concepts. As a result, more student discourse will occur in the classrooms as students speak and listen as ideas and explanations are shared (Lee, Quinn, & Valdes, 2013).

METHODOLOGY

Project Treatment

The purpose of this study was to determine the effects of inquiry-based instruction on students' ability to effectively manipulate and understand science vocabulary in their discussions and written assessments. This study helped answer the question, "Will the 5E Learning Cycle increase students ability to effectively integrate content vocabulary on assessments?" The treatment began in January 2014 and included all four sections of Generaux's 8th grade physical science classes and concluded in April 2014. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained (Appendix B).

Prior to the initiation of the treatment, student achievement data was collected between September and December 2013. This data was collected from quizzes and unit tests. During the pre-treatment period subject content was delivered to students using direct instruction strategies. Students recorded notes, read sections of the textbook, and

used the class website to access PowerPoint and Prezi presentations prepared by the teacher. Students also accessed the class website to link to specific content related websites determined by the teacher. In addition, vocabulary was frontloaded to students using the Vocabulary Template. Students recorded definitions provided by the teacher, created their own sentences, and drew an image of what the word might look like. Students also conducted at least one laboratory investigation for each unit (Appendix C). During the pre-treatment period, three units of physical science were taught. These units included astronomy, the atom, and the periodic table as shown in Table 2 below.

Table 2
Pre-treatment Units and Lessons

UNIT	LESSONS
Astronomy	Solar System Planets Asteroids and Meteorites
The Atom	Understanding the Atom Parts of the Atom
Periodic Table	Elements The Periodic Table

Once the treatment began, direct instruction and the frontloading of vocabulary was replaced with inquiry-based instruction using the 5E Learning Cycle. The first day of each lesson began with an instructional strategy to evaluate students' prior knowledge or identify misconceptions using misconception probes (Appendix D). The second day, students were allowed time to explore with the content through hands-on activities. On most occasions, students recorded observations, questions, and inferences in their notebooks (Appendix E). On other occasions, when the inquiry was more rigorous, students completed a packet prepared by the teacher (Appendix F). The third

day would begin with a whole class discussion of what was discovered by the students followed by an explanation by the teacher. Students then recorded notes into their notebooks, as well as completed the Vocabulary Template. One to two more days were used to allow students to practice and review the material. On these days, students practiced vocabulary and participated in activities to reinforce what they had learned. Each lesson also included an extension activity. Depending on the lesson, these activities included another laboratory activity, use of textbooks, or interaction with computers. On occasions when students used computers, they once again used the class website and teacher recommended websites. At the end of each lesson, students completed a multiple choice quiz to evaluate their understanding of the material and vocabulary.

Upon completion of all the lessons in the unit, a two part summative test was given to the students. One portion of the test consisted of multiple choice questions and the other part was a short essay question. A total of two units were taught which included motion and forces during the treatment period. Each unit was then broken down into separate lessons as shown in Table 3 below.

Table 3
Treatment Units and Lessons

UNIT	INQUIRY LESSONS
Motion	Position Speed Motion Snapshots
Forces	Types of Forces Force Diagrams Laws of Motion

During the treatment of this project, both quantitative and qualitative data collection tools were created and administered. Data collection instruments included

student surveys and interviews, pre-treatment assessment data, treatment quiz and test data, writing assessment data, student journals and teacher field notes. A focus group comprised of 12 total students, three from each class section, met several times during the treatment. The purpose of the focus group was to provide more specific feedback related to delivery of content, vocabulary and use of inquiry-based lessons.

Data Collection Instruments

Prior to beginning the first unit, all students completed the Student Vocabulary Survey (Appendix G). The Likert-scale survey consisted of a five response category: *Strongly Agree (SA)*, *Agree (A)*, *Neutral (N)*, *Disagree (D)*, and *Strongly Disagree (SD)*. Responses were recorded into an Excel spreadsheet by assigning each response with a point value, SA = 5, A = 4, N = 3, D = 2 and SD = 1. Data was then analyzed as a baseline to determine student opinions of vocabulary worksheet, reading and writing vocabulary on written assignments, and how students approached vocabulary words on assessments. In addition to the Student Vocabulary Survey, a student focus group consisting of 12 students, met and completed the survey Focus Group Survey #1 (Appendix H). The focus group students responded to questions that were both Likert-scale and open-ended. Questions related to the Vocabulary Template, the use of the classroom word wall, and strategies used to teach vocabulary. Data collected from the focus group were entered into an Excel spreadsheet and analyzed to identify themes and trends in student responses.

Throughout the treatment, quantitative data consisted of teacher-created formative assessments that were administered at the end of each lesson of a unit. In addition, a teacher created summative assessment was administered at the end of each unit.

Students used computers to complete all assessments using an online assessment program called Exit Ticket (Appendix I). All assessments were multiple choice questions with four possible answers. Each assessment was formatted in this manner with the exception of the summative unit test. The unit test included one essay question component which students completed after they finished their online assessment. Student scores, by class, were exported from Exit Ticket into an Excel spreadsheet. Correct responses were coded with a 1 and incorrect responses with 0. Assessments were evaluated based on scoring percent's and cut points as shown in Table 4 below.

Table 4
Multiple Choice Assessment Scoring Rubric

A	B	C	D	F
90 – 100	80 – 89	70 – 79	60 – 69	59 and below

During the first unit of the treatment, students completed three assessments. The first assessment, Quiz: Position and Direction, consisted of six multiple choice questions (Appendix J). This assessment evaluated students' ability to interpret and answer application-type problems based on coordinates, directions and vectors. The next assessment, Quiz: Speed, consisted of seven multiple choice questions (Appendix K). In this assessment, students demonstrated their ability to solve motion problems by solving for speed, distance or time. Students were given the equation speed equals distance divided by time, but had to determine how to rearrange the equation to solve for distance or time. At the conclusion of the unit, a two-part test was given to the students. The assessment, Unit Test: Position and Speed included 18 question multiple choice questions and one essay question (Appendix L). The test included questions related to position, direction, speed problems and motion snapshots. The essay question required students to

choose three vocabulary words, describe what they had learned about each word, include examples and experiences from class, as well as the real world. Included with the essay portion of the test was an Essay Rubric: Position and Speed identifying writing criteria (Appendix M).

In the second unit of the treatment, students completed two assessments. The first assessment, Quiz: Force and Motion, included 10 questions (Appendix N). Questions in this quiz required students to identify the type of force being applied to an object. Questions included a scenario or situation where forces were being applied as well as photographs and drawing. In addition, students had to calculate the net force acting on an object and determine the direction of motion. At the conclusion of the unit, students completed the Unit Test: Force and Motion (Appendix O). This assessment included questions related to types of forces and application problems based on Newton's Laws of Motion. This test included 21 questions and one essay question. Similar to the previous unit test essay question, students were asked to choose three vocabulary words, describe what they had learned about each word, and include examples and experiences from class as well as the real world. Included with the essay portion of the test was an Essay Rubric: Force and Motion identifying writing criteria (Appendix P).

In addition to the quantitative data, a field notebook was used to record the teacher's observations, reflections and ideas throughout the duration of the treatment. Each entry began with a comment describing the planned activity. During each class period, observations were written into the journal by the teacher. Observations included how students were engaging with activities and vocabulary, difficulties students were experiencing, comments students were making, how students were using vocabulary

during discussions, and teacher thoughts on how a lesson might be improved. At the end of each day during prep period, daily observations and reflections were then transferred into a Word document (Appendix Q). Additional comments and ideas were also added at that time.

A focus group was also formed to collect both qualitative and quantitative data. The focus group met a total of three times during the treatment. The group met for the first time, prior to the start of the treatment, to discuss their role and protocol during the meetings and to complete Focus Group Vocabulary Worksheet (Appendix G). The group met again midway through the treatment and completed the survey Focus Group Survey - Motion (Appendix R). The survey and group discussion were used to get a pulse on how the new type of instruction and vocabulary strategies were benefiting students' performance on assessments. The group met for a final time after the completion of the treatment. During this meeting, students completed Focus Group Survey: Forces (Appendix S). As with previous surveys, the questions were a mix of both Likert and open-ended. In the final meeting with the group, students were asked to discuss the overall effectiveness of inquiry instruction, how use of vocabulary has changed in their written assignments and group discussions, and the usefulness of the Vocabulary Template and other strategies that were used. Students were also shown pre and post-treatment data from assessments and Student Vocabulary Survey. Data and responses were entered into an excel spreadsheet and analyzed for themes and trends.

Upon the completion of the last unit of the treatment, all 8th grade students once again completed the Student Vocabulary Survey (Appendix G). Students who were recently enrolled or did not complete the initial survey given prior to the treatment were

excluded. Data were compared from both pre and post-treatment to determine and identify if student opinions of the Vocabulary Template, reading and writing vocabulary on written assignments, and how students approached vocabulary words on assessments have changed.

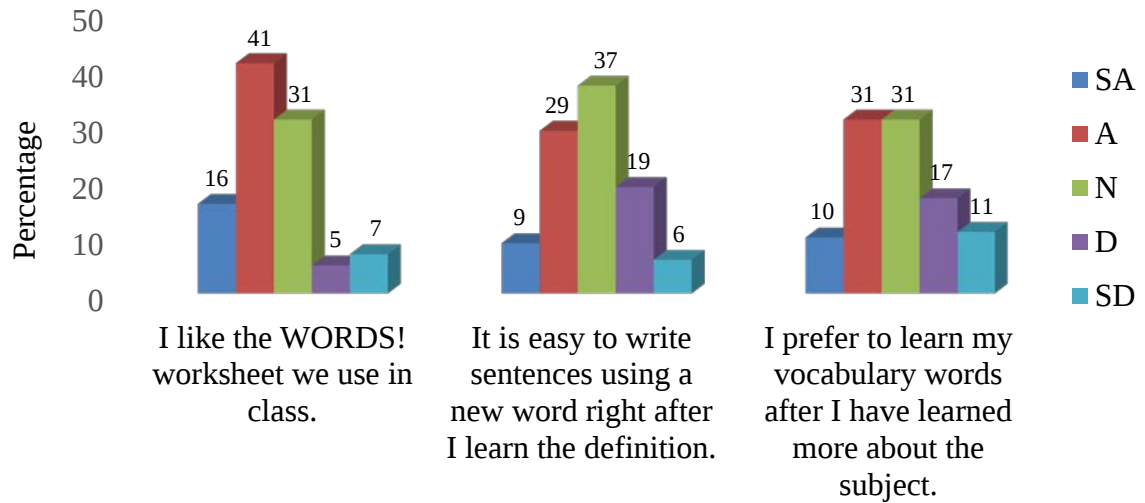
A triangulation matrix in Table 5 below shows all questions for this treatment, as well as the data collection sources associated with each question.

Table 5
Triangulation Matrix

Research Questions	Data Source 1	Data Source 2	Data Source 3
1. Will the use of the 5E Learning Cycle, to introduce vocabulary, have an effect on student assessments?	Exit Ticket assessments	Teacher Observation	Focus Group Surveys
2. How will students use of vocabulary change on writing assessments as a result of inquiry instruction?	Essay Questions	Focus Group Surveys	X
3. What affect will inquiry instruction have on student discourse and use of vocabulary?	Teacher Observations	Field Notebook	Focus Group Surveys
4. How will student confidence and attitude toward vocabulary change in response to inquiry instruction?	Student Survey	Teacher Observations	Focus Group Surveys

DATA ANALYSIS

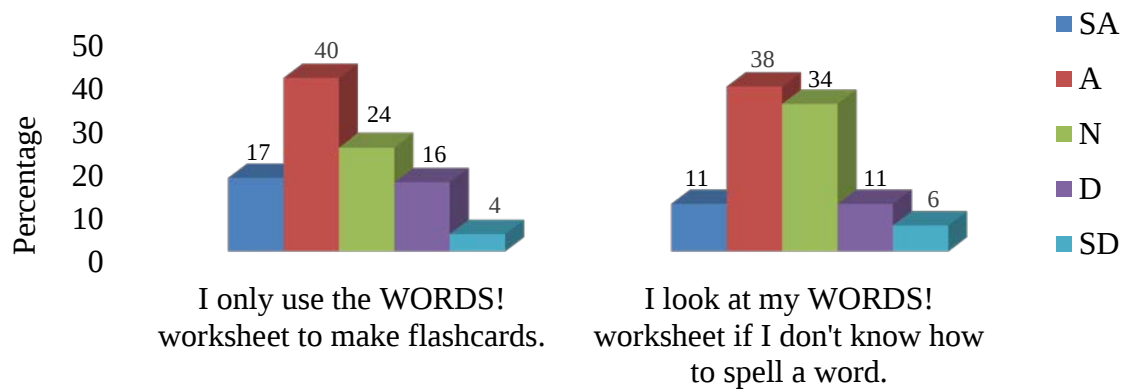
The Student Vocabulary Survey was given to students in Generaux's 8th grade Physical Science class prior to the treatment period to obtain a baseline regarding student opinion and self-confidence about vocabulary and assessments (Appendix G). Three major themes emerged from the survey data. The first theme identified students' opinions about the Vocabulary Template, the second identified how students used it during the week, and the third theme linked laboratory investigations and students ability to recall vocabulary words and their meanings on assessments. The results of the pre-treatment Student Survey show students liked completing the Vocabulary Template but many students did not use it afterwards (N=102). Data from the survey show 16% of students *strongly agreed* and 41% *agreed* they liked completing the Vocabulary Template. The survey also showed 9% *strongly agreed* it was easy to create sentences using new vocabulary words, while 29% *agreed*. In addition, 10% *strongly agreed* and 31% *agreed* they preferred to learn more about the subject matter before they learned new vocabulary words (Figure 2).



Student Vocabulary Survey Questions

Figure 2. Students' Opinions of Using the Vocabulary Template When Learning New Vocabulary, (N=102). Note. SA= Strongly Agree, A=Agree, N= Neutral, D= Disagree, and SD=Strongly Disagree.

Once students complete the Vocabulary Template they are expected to use it during the week to review definitions and make flash cards, as well as use it as a resource for writing assignments. Nearly 20% of students *strongly agreed* they only use the Vocabulary Template to make weekly flash cards, while another 40% of students *agreed*. In addition, 11% of students *strongly agreed* and 38% *agreed* that they do use the template if they do not know how to spell a word (Figure 3).



Student Vocabulary Survey Questions

Figure 3. Students' Opinions on How They Use the Vocabulary Template, (N=102). Note. SA= Strongly Agree, A=Agree, N= Neutral, D= Disagree and SD=Strongly Disagree.

Finally, the survey results showed that students did make connections between laboratory investigations, inquiry activities, and the classroom word wall to help them recall vocabulary words and understand assessment questions (Appendix T). Nearly 20% of students stated they *strongly agree* the word wall helped them recall what they had learned in class, while 42% *agreed*. When students were asked if they recalled a laboratory investigation or activity, if they did not know the answer to a question on a test or quiz, 10% of students *strongly agreed* and 49% *agreed*. Finally, 13% of students *strongly agreed* and 45% *agreed*, that participating in lab investigations and activities helped them identify answers to questions on assessment easier (Figure 4).

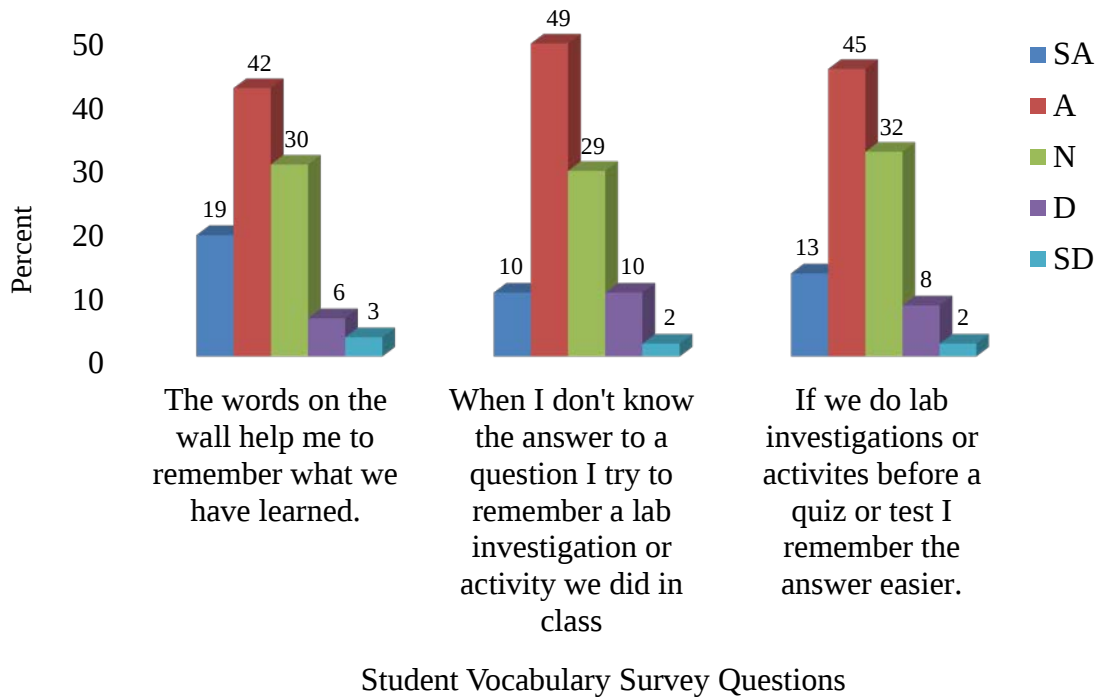


Figure 4. Students' Opinions of Laboratory Investigations and Classroom Word Wall. (N=102). Note. SA= Strongly Agree, A=Agree, N= Neutral, D= Disagree and SD=Strongly disagree.

The results from the post-treatment Student Vocabulary Survey, show students' opinions of the vocabulary worksheet, laboratory investigations and assessments had changed (N=102). After the treatment, 27% of students *strongly agreed* and 45% *agreed* that they liked using the Vocabulary Template. When these are combined, this is a 15% increase in students stating they liked the worksheet. There was a evident increase in students' ability to create sentences on the worksheet. Prior to the treatment, less than 9% of students *strongly agreed* it was easy to create sentences; however, after the treatment this figure increased to 25%. There was also an increase in student opinion on when the want to learn new vocabulary. Students who *strongly agreed* they they preferred to learn vocabulary after they had an opportunity to learn about the subject

increased from 10% to 15%, while those who *agreed* increased from 31% to 40% (Figure 5).

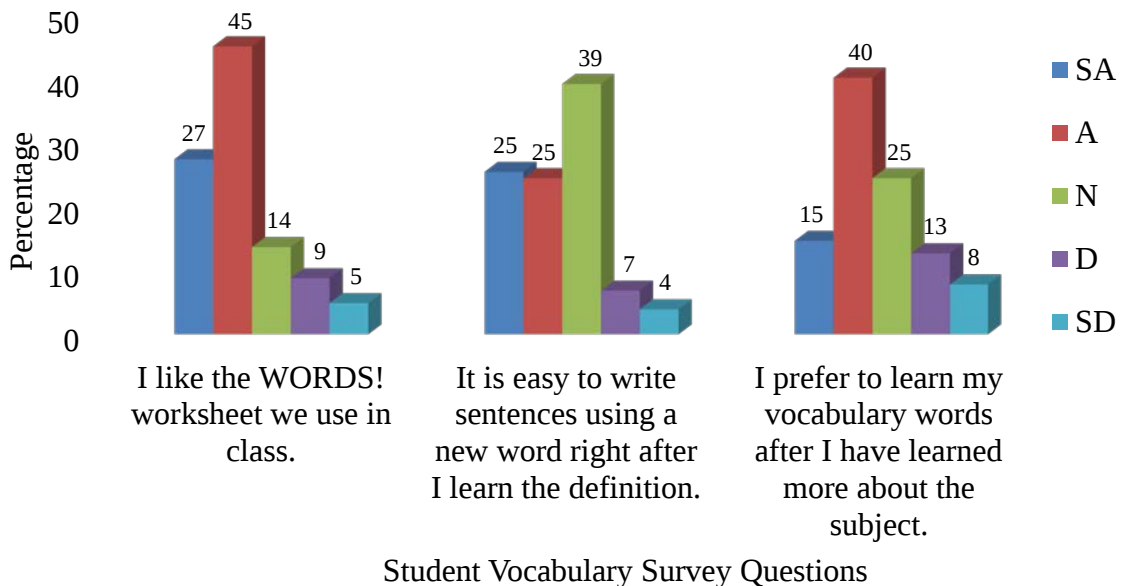


Figure 5. Students' Opinions about the Vocabulary Template Post-treatment, (N=102). Note. SA= Strongly Agree, A=Agree, N= Neutral, D= Disagree and SD=Strongly Disagree.

The survey also revealed that student opinion on how they used the Vocabulary Template had changed. Prior to the treatment, 57% of students *strongly agreed* or *agreed* they only used the template to make flashcards. After the treatment use of the template increased to over 70%. The survey also showed 21% of students *strongly agreed* that they used the worksheet to help them spell words, an increase of 10%. In addition, 10% of students *disagreed* or *strongly disagreed* they referred to the worksheet to spell words, a 7% decrease (Figure 6).

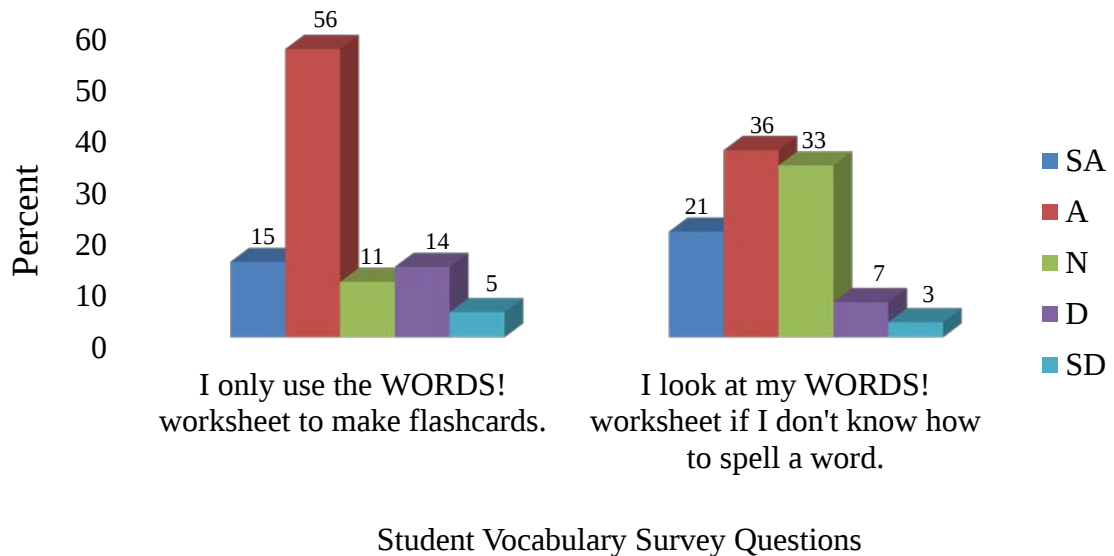
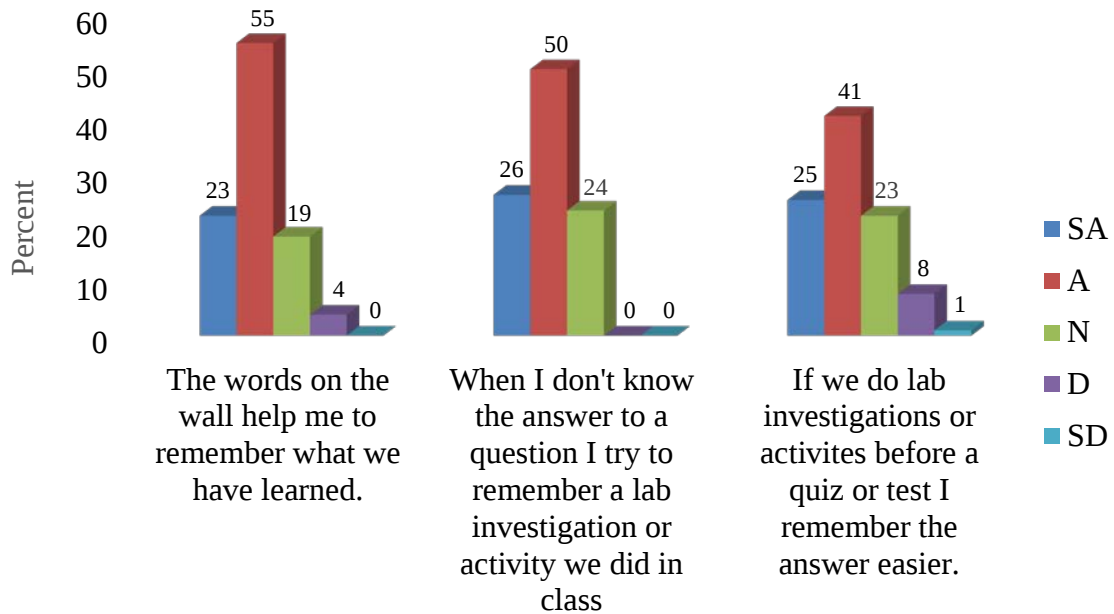


Figure 6. Students' Opinions on How They Use the Vocabulary Template Post-treatment, (N=102). Note. SA= *Strongly Agree*, A= *Agree*, N= *Neutral*, D= *Disagree*, and SD= *Strongly Disagree*.

The final theme in the survey, the relationship between lab investigations and activities and assessments, also showed student opinions had changed. Prior to the treatment, 61% of students *strongly agreed* and *agreed* that the word wall helped them remember what they had learned. After the treatment nearly 80% *strongly agreed* and *agreed* to the benefits of the word wall. When students were asked if they try to remember labs and activities during an assessment, 26% *strongly agreed* and 50% *agreed*, a 17% increase from the pre-treatment survey. In addition, 0% of the students *disagreed* or *strongly disagreed* that they try to remember labs and activities, this is a 12% decrease from the pre-treatment results. Finally, nearly 70% of students *strongly agreed* and *agreed* that lab activities helped them identify answers on assessments, which is an increase from the 58% of students who made this claim prior to the treatment (Figure 7).



Student Vocabulary Survey Questions

Figure 7. Students' Opinions on How Laboratory Investigations, Inquiry Lessons, and the Classroom Affect their Ability to Recall Vocabulary Words on Assessments Post-treatment Period. (N=102). Note. SA= Strongly Agree, A=Agree, N= Neutral, D= Disagree, and SD=Strongly disagree.

In addition to the changes in opinions about vocabulary, data collected also show a change in student performance on assessments. Prior to treatment the average assessment score for students participating in the study was 77%. During the treatment period, the average assessment score increased to 83% (N=102). All four classes showed an increase in average assessment scores (Figure 8). Each class period gained at least 5% in average assessment score. The class with the greatest gain in assessment scores

was 4th period which was 7%.

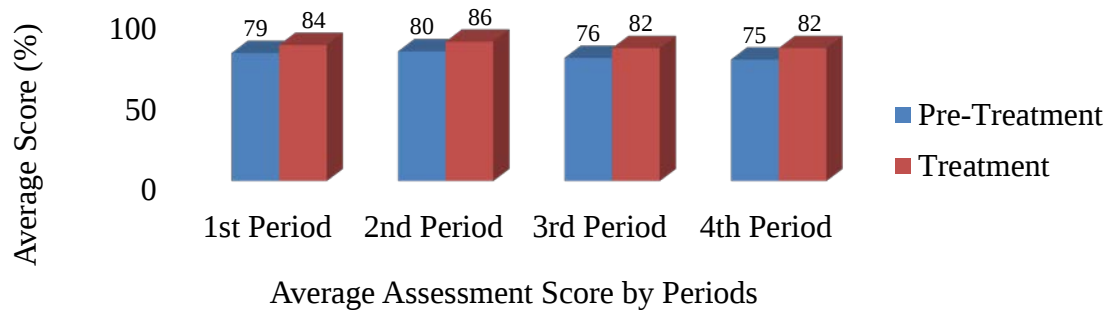


Figure 8. Average Assessment Scores for 8th grade Students, (N=102).

Data was also analyzed by gender and ethnicity. The results of this study show that Latinos and Pacific Islanders increased their average assessment scores by 5% (N=43). Prior to the treatment, Latino males averaged 81% on assessments, during the treatment their average score increased to 86%. The least amount of growth was 3%, which occurred among the Vietnamese males. Pre-treatment scores for Vietnamese students was nearly 95% while treatment scores were 97% (Figure 9).

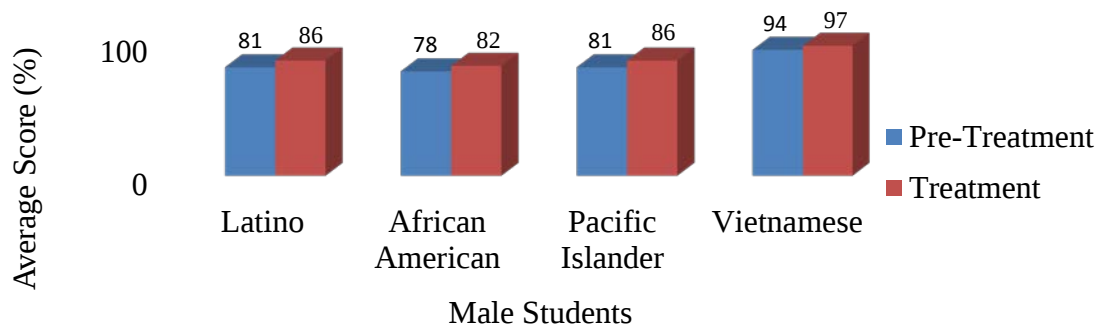


Figure 9. Average Assessment Scores for 8th Grade Males by Ethnicity, (N=43).

Female students participating in the study showed the highest gains in assessment scores (n=59). The greatest gains were observed in African American females who

increased their average assessment scores from 70% to 81%. Vietnamese females showed second highest gains which increased from 76% to 84%. In addition, these females also had the highest average scores on assessments. Latino females increased their scores by 6%, while Pacific Islanders showed no gain on assessment scores (Figure 10).

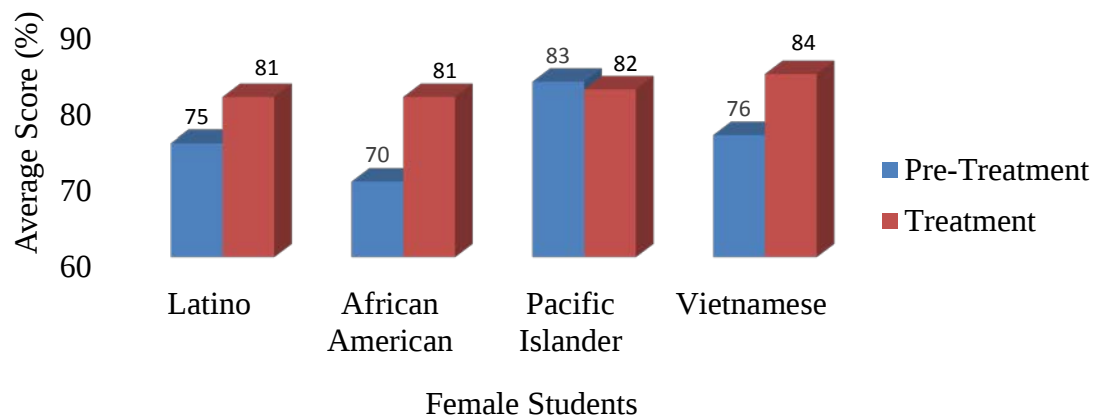
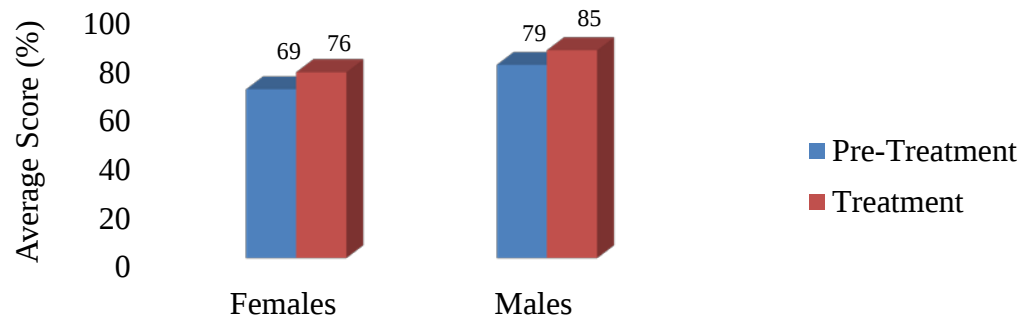


Figure 10. Average Assessment Scores for 8th Grade Females by Ethnicity, (N=59).

Finally, English Language Learners (ELL) also showed an improvement in assessment scores. Both male and female ELL students show just over a 5% increase in scores ($n = 24$). Female ELL students increased their scores from 69% to 76%, which is still below the overall 8th grade average of 83%. On the other hand, male ELL students' average score of 85%, during the treatment, is slightly higher than the grade level average of 83% (Figure 11).



Average Assessment Scores for English Language Learners

Figure 11. Average Assessment Scores for 8th Grade English Language Learners, (N=24).

During the treatment period of this study, two unit tests were administered. Each test included an essay question based on vocabulary from the unit. Results from the Position test show 22% of the students were able to write an essay that demonstrated they *Mastered* vocabulary, while 42% of the students *Almost Mastered* vocabulary. Nearly 40% of students demonstrated they had *Not Yet* mastered their vocabulary (N=102). On the second unit test, Motion and Forces, nearly 50% of students successfully *Mastered* vocabulary (Figure 12). In addition, the number of students who had *Not Yet Mastered* their vocabulary reduced by 13% (Figure 12).

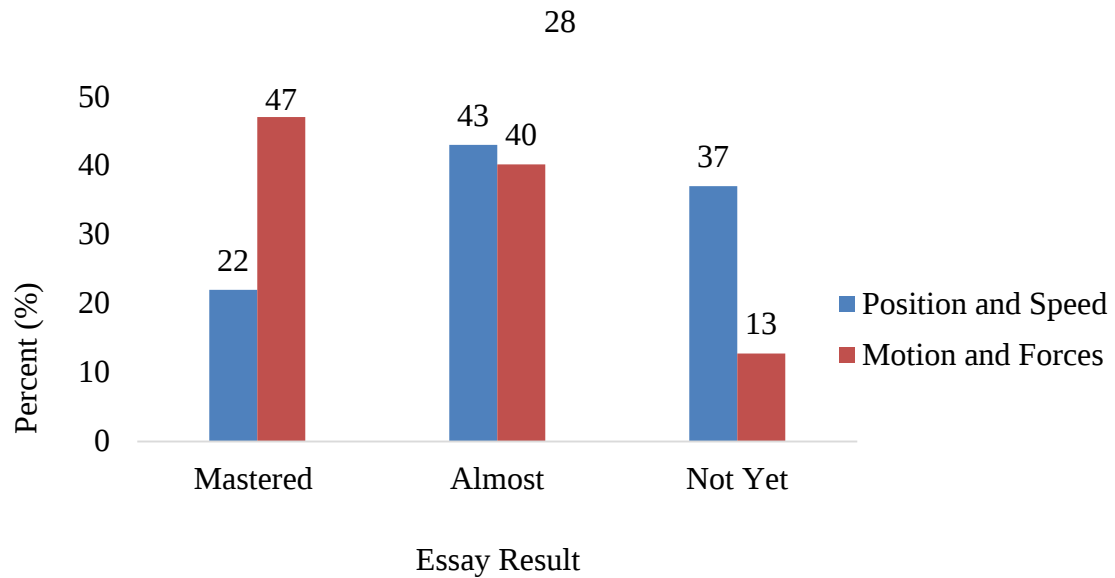


Figure 12. Unit Test Essay Results for 8th Grade Students, (N=102).

INTERPRETATION AND CONCLUSION

The purpose of this study was to determine if the 5E Learning Cycle would have an impact on student assessments, discourse, and ultimately, attitudes and opinions toward vocabulary. Fifty-seven percent of students had stated prior to the treatment they liked using the Vocabulary Template. One student stated he liked using the worksheet because “it is simple and I know where everything goes.” Another student stated, “It helps me review for tests.” After the treatment, over 70% of the students said they like using the Vocabulary Template. When asked why more students liked using the worksheet more during the treatment period, one student stated, “before definitions didn’t make sense, but when we have a chance to do labs before we even know what we are learning, well it just puts things in context.” It is possible that inquiry instruction also changed student engagement with the Vocabulary Template. Students were often observed writing their own definitions, as one student said “I already know what the word means now.” Inquiry instruction also had an impact on how students used the

Vocabulary Template throughout the week. Before the treatment, 50% of students only used the worksheet to make flash cards, but after the treatment this rose to 70%. One reason this may have happened is because students requested that the word wall be placed in front of the room in the direction they are mostly looking. Another reason is that students were given more opportunities to interact with vocabulary on class starters, interactive computer games, and class activities. Thus, it appears that the more they were exposed to the words and meanings, the less they needed to rely on the worksheet.

The most evident change in student attitude toward vocabulary was due to inquiry lessons. Prior to the treatment, only 59% of students mentally referred back to laboratory investigations in order to help them identify an answer on a quiz or test. However, after the treatment, 85% of students stated remembering a lab activity helps them more easily identify answers. One student said, “when I read a test question I can see it in my head now, it’s like I’m doing it again.” Another student stated “even if the question is not exactly like the lab we did, I can apply what I learned and figure it out.” Some of the most dramatic results of this study appear in the data collected from student assessments. Average assessment scores among males and females grew slightly during the treatment. Male students’ scores improved by 5% and female students’ by 7%. More evident growths were identified when data was broken down by gender and ethnicity. African American females’ average score increased by 11% and Vietnamese female scores improved nearly 10%. When female students first started working with lab materials and equipment, they were apprehensive and often let the male students take the lead. After several iterations of inquiry activities, I observed that the female students began to take more of a leadership role within their groups. It was also observed that female students

started asking more questions about what they were learning. When asked why they think their scores increased so much, one African American female said, “we never did labs until this year, I never even knew how to use a ruler.” Another student said, “teachers always let the boys do everything, this is the first time I was allowed to check out equipment.” Female Pacific Islander students showed no growth. One female Pacific Islander student stated, “in our community girls are expected to do everything that boys do when it comes to sports and school.” This may explain why their scores showed no change as they are already confident using tools and instrument and their ability to analyze problems.

English Language Learners (ELL) also showed some growth as a result of the study. Male ELL students’ average score of 6% was similar to that of all the male students. Female ELL students improved their average score by 7%. Attendance records for both male and female ELL students show high absenteeism rates. Many of these students missed one to two days a week. However, of note, one student who made the most gains on assessment data is a female ELL student. Prior to the treatment, her assessments scores ranged from 35% to 40%. During the treatment her scores improved to just over 72%. On a recent unit test, which was not included in this study, her score was 85%. When asked why she thought her scores improved so much she said, “I know what the words mean when I read questions now, I think it’s because I did it first.”

The 5E Learning Cycle has made a difference in students’ academic achievement as well as their ability to use vocabulary correctly on written assignments and in group discourse. Inquiry instruction has promoted confidence in African American and

Vietnamese females, as well as ELLs. Even with high absenteeism rates, inquiry instruction has promoted student learning and understanding of content and vocabulary.

VALUE

The results of this study clearly show when students, male or female, are given an opportunity to experience content through inquiry activities, they make better connections and retain more information. Although the average assessments scores were not as high as was anticipated, the results of the study show evident growth by female students. During the treatment, students began using vocabulary more often, whether it was on writing assignments or in group discussions. At times, it was observed that students even correcting each other's use of vocabulary. The question will be whether or not to even use the Vocabulary Template next year. Students are only using it to make flashcards and they do not even use the flash cards from which to study. Students need to have a much wider exposure to vocabulary, using a variety of strategies, rather than just a worksheet.

The results of this study also identifies minor growth in male students' engagement and academic achievement. Male students were completely engaged during labs and lessons, yet their assessment scores showed little or no growth. Male students were often overhead during labs or hands-on activities saying, "Oh I already know how to do this," or "I saw this on a TV show." The growth by the female students was unexpected. One question I am already asking is *how will I engage male students to increase their curiosity and willingness to learn something with which they have some familiarity?* Another question I have about inquiry is *how can I better incorporate students' prior knowledge into inquiry lessons?*

One of the greatest benefits to both the students and myself was the constant feedback during the study. During the treatment, more time was spent reading students' comments on labs and other written assignments. Identifying misconceptions occurred more quickly, as well as a better understanding of what students were attempting to explain. Even though students were just still struggling with how to explain a concept they started to formulate ideas and thoughts that began to demonstrate they were grasping the material.

Keeping a journal was one of the most beneficial tools for me as an educator. I found myself referring to it often. On many occasions I carried it with me around the classroom. Several times students asked me if I was going to write down their comments in my journal. The use of journals and daily reflections has been used in the past but not with the regularity as during this study. Being able to keep track of students who needed additional support and what should be changed about a lesson instantly is invaluable.

As I move into planning for next year, there are many things I must consider that came to mind during this study. Which lessons and activities worked and did not work during inquiry instruction will need to be addressed and modified. In addition, a need for more rubrics need to be in place for laboratory activities, such as expectations in groups and completing work. Finally, students need access to a discourse protocol and starter sentences that students, whether they use flash cards or can glue them into their notebooks, to help them equitably discuss the results of their labs and activities.

I realize I still need to work on the delivery of inquiry instruction. Patience and self-controlled must be maintained in order to not give students answers when they were engaging and exploring content. In addition, I need to rely more on available resources

and less on creating my own inquiry lesson. I feel this project has made me more open to trying new things in the classroom, accepting failures in lessons, but, most of all, the use of inquiry instruction has given me an opportunity to talk to students one on one and in small groups. Conducting action research in the classroom has resulted in valuable connections with students due to the constant interactions and feedback.

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APPENDICES

APPENDIX A

VOCABULARY TEMPLATE

WORDS! - The Atom

WORDS!	EXAMPLE	LOOKS LIKE...
Proton	<i>Example: The proton was first discovered by</i>	
	My sentence:	
Neutron	<i>Example: The <u>neutron</u> was not discovered until 1932.</i>	
	My sentence:	
Nucleus	<i>Example: Dalton did not believe atoms had a <u>nucleus</u>.</i>	
	My sentence:	
Electron	<i>Example: The idea of an <u>electron</u> was first suggested by Thomson in 1903.</i>	
	My sentence:	
orbital	<i>Example: Scientists think electrons move around the nucleus in an <u>orbital</u> path.</i>	
	My sentence:	

APPENDIX B

MONTANA STATE UNIVERSITY'S INSTITUTIONAL REVIEW BOARD



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

567 Technology Blvd, Room 127
c/o Immunology & Infectious Diseases
Montana State University
Bozeman, MT 59717-8
Telephone: 406-994-6783
Fax: 406-994-4303
Email: cheryl@montana.edu

Chair: Mark Quinn
406-994-5721
mquinn@montana.edu
Advisory: Cheryl Johnson
406-994-6783
cherylj@montana.edu

MEMORANDUM

TO: Shari Generaux and John Graves

FROM: Mark Quinn, Chair *Mark Quinn, chair*

DATE: November 12, 2013

RE: "The Effects of the 5E Learning Cycle on Student Integration of Vocabulary" [SG111213-EX]

The above research, described in your submission of November 12, 2013, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- ☒ (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- ☒ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- ☐ (c) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- ☐ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- ☐ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- ☐ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

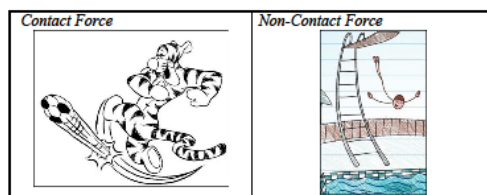
APPENDIX C
LABORATORY INVESTIGATION

EXPLORING FORCES

Name: _____ College: _____

Task: Today you will explore different types of forces. You will draw vectors showing direction of force, you will explain how the force causes an object to change direction, shape or size.

Background: As you have already learned a force is any type of push, pull or lift. The way an object moves or changes direction depends on the amount of force you exert on an object. *Exert* means to use power or energy to cause something to move. There are two types of forces that can be exerted on objects; contact and non-contact. For example kicking a soccer ball is an example of a contact force. The contact is between the ball and the foot. On the other hand, falling into a swimming pool is an example of a non-contact force. The force of gravity is pulling you downward.



Q1. What are some other examples of contact between objects that result in motion or change in motion?

Q2. What are some examples of gravity pulling on objects? Be creative!

Part 2: Drawing Vectors

When you work with forces you will want to include a vector arrow to show the direction of the force being applied to the object.

The direction of the force is the direction of the push. 	<i>Q3. What direction is the force in this image?</i> 
---	--

Part 3: Exploring Forces

There are several different types of forces you experience everyday without even knowing it. Now you and your lab partners will explore some of these forces.

- Get your lab materials from your teacher.
- Use the materials provided to complete the worksheet.

Wooden Block

- Place the block on your table.
- Trying to stay at a constant speed push the block across the table.

Draw a picture of the wooden block and add direction vector(s) of any force exerted on the box to the right.

- Now place 3-4 science notebooks onto the block.
- Again at constant speed push the block and notebooks across the table.

Q4. How did the block move differently this time? How did it feel?

Q5. What caused the block to move differently this time?

Q6. Is this an example of a contact or non-contact force? How do you know?

Rubber Band

- Gently stretch the rubber band between your fingers.
- Gently bring your fingers closer together.
- Do this several times.

Draw a picture of the stretched out rubber band and add direction vector(s) of any force exerted on the rubber band.

Q7. Explain what you felt as you stretched the rubber band.

Q8. Imagine using a rubber band that is wider. Do you think it would pull differently? Explain why.

Q9. Is this an example of a contact or non-contact force?

Sponge

- Place the sponge onto the table

Draw a side view image of the sponge in the box to the right.

Q10. List any forces being exerted on the sponge?

- Now take the wooden block and place it onto the sponge.
- Gently push down on the block until you can't push any more.

Q11. Explain what happened to the sponge.

Draw an image of what the sponge looked like when you pushed on the block. Add any direction vectors.

Q12. Is this a contact or non-contact force?

Cardboard Paper

- Using the piece of paper gently fan your face.

Q13. What do you feel on your face?

Draw an image of what this looks like in the box to the right. Be sure to add direction vectors.

- Now fan the paper faster in front of your face.

Q14. How did this feel different than before?

Q15. Is this an example of a contact or non-contact force?

APPENDIX D
MISCONCEPTION PROBE

Crossing the Finish Line



Frances and Greg decide to have a footrace. Frances gets off to a good start and gets ahead of Greg. Greg catches up to Frances right at the finish line so that they cross the finish line at the same time. Immediately after crossing the finish line, both are still running at their same pace and Greg passes Frances. Their friends argue about who ran faster right at the finish line. This is what they say:

Donica: "I think Frances was faster at the finish line."

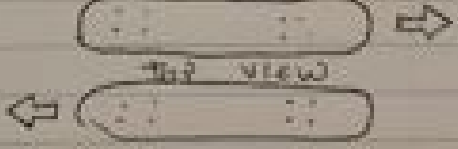
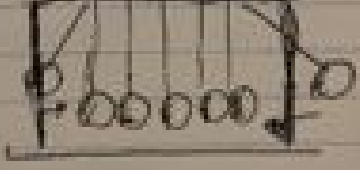
Hannah: "I think Greg was going the fastest at the finish line."

Evan: "I think they were running at the same speed the instant they crossed the finish line."

Circle the name of the student you most agree with. Explain why you think that is the best answer.

APPENDIX E

STUDENT NOTEBOOK ENTRY

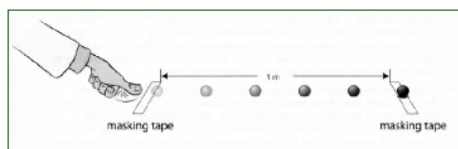
#31 Observations :	what it looks like
1. Bowling Ball - Balanced	
2. Air puck - not balanced	
3. Bowling Ball: - speed accelerated - was constant - then slowed down	
4. Skate Boards: both - Balanced First Sho - moved farther He - moved a bit both - moved in opposite Newton's Cradle	
a Mirror effect	

APPENDIX F
LABORATORY EXPLORATION PACKET

TIME TO ROLL!

Name: _____

Task 1: With your lab partner, mark off 1 meter on your table. Put a piece of tape at one end and another piece at the other end. Find a starting point a few centimeters before the first piece of tape. Decide who will roll the ball towards the first piece of tape, and who will count how long it takes to roll to the second piece of tape. Start counting the seconds when the ball reaches the first piece of tape, as in "one thousand one, one thousand two, one thousand three, ..." Stop counting when the ball reaches the second piece of tape.



Record your time here: _____ seconds

Now do a simple division calculation. Divide the distance the ball traveled (1 meter) by the time it took to travel that distance (the seconds you counted).

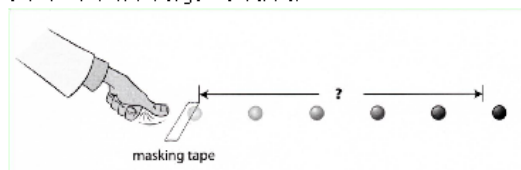
$$\frac{\text{distance ball traveled}}{\text{time to travel that distance}} = \underline{\hspace{2cm}}$$

Record your calculation on the board and answer the questions below.

1. Compare the calculations recorded on the board? Describe what you notice.

2. Explain why you think this happened.

Task 2: This is a lot like task 1, with a slight change. This time place one piece of tape about 10 centimeters from the edge of your table. Again, have one partner roll the ball while the other counts time. Just like in the first task, start the ball before the measuring tape. Continue counting until the ball reaches the edge of the table.



Record your time here: _____ (seconds)

Now measure the total distance the ball traveled in meters. This will be the distance between the piece of tape and the edge of the table.

Record your distance here: _____ (meters)

Time for another calculation. Divide the distance the ball traveled by the time it took to roll that distance.

$$\frac{\text{distance ball traveled}}{\text{time to travel that distance}} = \underline{\hspace{2cm}}$$

2. Was this calculation similar to the calculation from task 1? YES or NO
3. Explain why you think it was similar or not similar.
4. Why do you think each group had slightly different calculations?
5. What would have made your calculations more accurate? What would you need to do this?

APPENDIX G
STUDENT VOCABULARY SURVEY

STUDENT VOCABULARY SURVEY

Participation in this research is voluntary and participation or non-participation will not affect a student's grades of class standing in any way.

Directions: Read each statement below carefully and then circle your response.

Part 1: This section is about the hands on activities and vocabulary.

1. I like the WORDS! worksheet we use in class after we do hands on activities.
Strongly agree Agree Neutral Disagree Strongly disagree
2. It is now easier to write sentences using a new word right after I learn the definition.
Strongly agree Agree Neutral Disagree Strongly disagree
3. I put more effort into creating sentences for my worksheet.
Strongly agree Agree Neutral Disagree Strongly disagree
4. I still don't like making up sentences on the worksheet.
Strongly agree Agree Neutral Disagree Strongly disagree
5. It is easier for me to draw a picture that represents a word I just learned.
Strongly agree Agree Neutral Disagree Strongly disagree
6. After I write my sentence and draw my picture I know meaning of the new word completely.
Strongly agree Agree Neutral Disagree Strongly disagree
7. I prefer to learn my vocabulary words after I have learned more about the subject.
Strongly agree Agree Neutral Disagree Strongly disagree
8. During the week I review the vocabulary words on the worksheet at least 1 time.
Strongly agree Agree Neutral Disagree Strongly disagree
9. I only use the WORDS! worksheet to make flash cards.
Strongly agree Agree Neutral Disagree Strongly disagree

Part 2: This part deals with reading and writing about science.

1. When I read in science and don't know a word I skip over it and keep reading.
Strongly agree Agree Neutral Disagree Strongly disagree
2. When I read in science I circle or underline words I don't know.
Strongly agree Agree Neutral Disagree Strongly disagree
3. There are many words I don't know when I read from the websites on the Modules.
Strongly agree Agree Neutral Disagree Strongly disagree

4. When I read information from the website there are always words I don't know.
Strongly agree Agree Neutral Disagree Strongly disagree
5. When I write a paragraph in science class I forget to use new vocabulary words.
Strongly agree Agree Neutral Disagree Strongly disagree
6. I always check to make sure I spell my words correctly.
Strongly agree Agree Neutral Disagree Strongly disagree
7. I look at the words posted on the walls to help me write in science class.
Strongly agree Agree Neutral Disagree Strongly disagree
8. The words on the wall help me to remember what we have learned.
Strongly agree Agree Neutral Disagree Strongly disagree
9. I look at my WORDS! worksheet if I don't know how to spell a word.
Strongly agree Agree Neutral Disagree Strongly disagree

Part 3: This last part is about vocabulary words you see on a quiz or test.

1. Before a quiz or test I review my WORDS! worksheet.
Strongly agree Agree Neutral Disagree Strongly disagree
2. I don't always know what words mean on a quiz or test.
Strongly agree Agree Neutral Disagree Strongly disagree
3. When I don't know the answer to a question I try to remember a lab investigation or activity we did in class to help me remember.
Strongly agree Agree Neutral Disagree Strongly disagree
4. In the past I have chosen an answer to a question even if I don't know what some of the words mean.
Strongly agree Agree Neutral Disagree Strongly disagree
5. If we do lab investigations or activities before a quiz or test I remember the answer easier.
Strongly agree Agree Neutral Disagree Strongly disagree
6. If I don't know the meaning of a word on a question I skip over it and keep reading.
Strongly agree Agree Neutral Disagree Strongly disagree
7. If I don't know the meaning of a word on a question I stop and try to remember the meaning.
Strongly agree Agree Neutral Disagree Strongly disagree

Thank you again for taking the time to complete this survey!

APPENDIX H

FOCUS GROUP SURVEY VOCABULARY WORKSHEET

Focus Group - Vocabulary Worksheet

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

Directions: Carefully read and answer each statement below

1. What I like about using the worksheet is _____

2. What I dislike about using the worksheet is _____

3. Sometimes it is difficult to create a sentence using the new word because _____

4. In your opinion does drawing a picture help you learn a new word? Yes No

5. How often do you review the WORDS! worksheet? 1-2 days 3-4 days Everyday

Explain why you review your worksheet this amount of time. _____

APPENDIX I
EXIT TICKET

UNIT TEST: Astronomy

New Question

Which type of force best describes why a nebula collapses and flattens.

✓ gravity

✓ friction

✓ density

✓ gradual

Next

New Question

The four rocky planets closest to the sun are also called

✓ small

✓ inner

✓ outer

✓ gaseous

Next

New Question

Large gas planets located far from the Sun are also called

✓ inner

✓ massive

✓ outer

✓ atmospheric

Next

APPENDIX J

QUIZ: POSITION AND DIRECTION

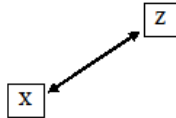
QUIZ: Position and Direction

Name: _____

PART 1: Using Vocabulary (2 points each)

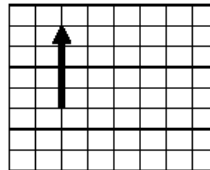
1. Which word below best describes the amount of *space* between two points?

- a) direction
b) distance
c) vector
d) position



4. Which of the following best describes the *size and direction* of the vector in the image below?

- a) 4 meters North c) 4 meters South
b) 40 meters North d) 40 meters South



1 square = 10 meters

2. Objects that move in only *one direction* are called _____.

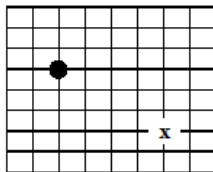
- a) two dimensional
b) two directional
c) one dimensional
d) one directional

5. The *starting point* used to describe the position of an object is called a _____.

- a) location
b) origin
c) reference point
d) both B & C

3. Describe the *position* of the X in relationship to the reference point in the image below.

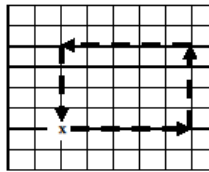
- a) 3 South, 4 East c) 15 North, 20 West
b) 15 South, 20 East d) 20 North, 30 West



1 square = 5 meters

6. Determine the total *distance* walked in the image below.

- a) 0 meters c) 90 meters
b) 18 meters d) 180 meters



1 square = 10 meters

APPENDIX K

QUIZ: SPEED

QUIZ: Speed

Name: _____

PART I: Applying Vocabulary (2 points each)

1. What two things must you know to calculate the speed of a moving object? a) location & distance b) distance & speed c) distance & time d) time & magnitude	4. A ball rolls a distance of 45 meters in 5 seconds. Calculate the speed of the ball. a) 9 m/s b) 40 m/s c) 50 m/s d) 225 m/s
2. A car travels a distance of 195 miles and has a speed of 65 miles per hour. Calculate the time it will take the car to reach its destination. a) 1 hour b) 3 hours c) 5 hours d) 10 hours	5. A player kicks a soccer ball 20 yards in 5 seconds to his team mate. This player kicks the ball another 16 yards in 4 seconds. Calculate the average speed of the ball. a) 4 m/s b) 8 m/s c) 9 m/s d) 45 m/s
3. A jet plane can fly at a speed of 120 kilometers per hour. If the plane flies for 3 hours what distance will it have traveled? a) 40 kilometers b) 100 kilometers c) 250 kilometers d) 360 kilometers	6. Which of the following objects has the greatest speed? a) a dog running at 5 m/s b) a mouse running at 1 m/s c) an elephant running at 10 m/s d) a car driving at 8 m/s
7. Which of the following best describes how to calculate average speed? a) total distance $\times$ total time b) total distance $\div$ total time c) total distance $+$ total time d) total distance $-$ total time	8. Which unit of measure below would you use to describe distance? a) meters per second b) seconds c) meters d) hours

APPENDIX L

UNIT TEST: POSITION AND SPEED

UNIT TEST: Position and Speed

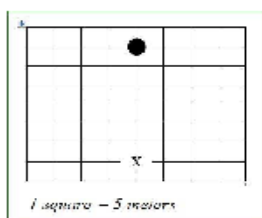
Name: _____

PART 1: Multiple Choice

1. The amount of space between two points is called:
- direction
 - distance
 - vector
 - position

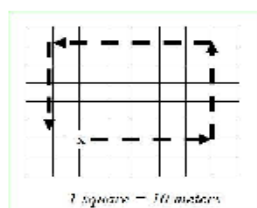
4. You are asked to find the reference point on a map. There reference point is the
- Ending position
 - Last position
 - Middle position
 - Starting position

2. Where is the X located on the map below in relationship to the reference point?



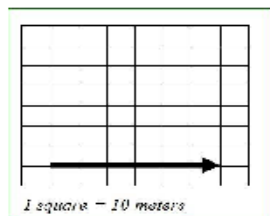
- 30 m North
- 30 m South
- 15 m North
- 15 m South

5. Calculate the total distance walked in the image below.



- 0 m
- 100 m
- 200 m
- 400 m

3. Determine the distance and direction of the arrow in the image below.



- 60 m East
- 60 m West
- 30 m East
- 30 m West

6. What two things must you know to calculate the speed of a moving object?
- distance and magnitude
 - distance and time
 - distance and position
 - distance and origin

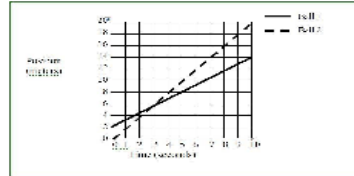
7. A car has an average speed of 60 mph and travels a distance of 360 miles. Calculate the time the car traveled. a) 6 hours b) 60 hours c) 360 hours d) 1080 hours	11. An eagle flies at a constant speed of 60 miles per hour for 3 hours. How many miles did the eagle fly? a) 20 miles b) 100 miles c) 180 miles d) 360 miles
8. To calculate the average speed of an object you must divide the total distance to object traveled by a) total speed b) total time c) total size d) total recall	12. You place a marble at the top of a wooden ramp. You observe it takes the ball 5 seconds to roll down the 100 centimeter ramp. What is the speed of the marble? a) 20 cm/s b) 50 cm/s c) 150 cm/s d) 200 cm/s
9. You ride your bike 20 miles in 1 hour. You stop to drink some water. Then you ride your bike for another 25 miles in 2 hours. What is the average speed of your bike ride? a) 3 mph b) 6 mph c) 12 mph d) 15 mph	13. Which unit of measure below best describes speed? a) cm b) sec c) cm/s d) s/cm
10. How would you describe the speed of the ball in the snapshot below?  a) increasing b) decreasing c) constant d) at rest	14. How would you describe the motion of the ball in the snapshot below?  a) increasing b) decreasing c) constant d) at rest

15. Determine the speed of the ball in the image below.



- a) 1 m/s
b) 2 m/s
c) 6 m/s
d) 12 m/s

17. Which ball in the image below has the greatest speed?



- a) Ball 1
b) Ball 2
c) Both have the same speed
d) Neither ball

16. How many seconds did it take for the ball to reach the wall in the image below?



- a) 5 seconds
b) 6 seconds
c) 10 seconds
d) 20 seconds

18. You can use the _____ of a line on a graph to calculate the speed of an object.

- a) size
b) starting point
c) slope
d) origin

APPENDIX M

ESSAY RUBRIC: POSITION AND SPEED

ESSAY RUBRIC: Position and Speed

Name: _____

Directions: On a piece of notebook paper write an essay describing everything you know about 3 words from the word wall.

1. Which 3 words will you write about?

2. Your paper should:

- a. Have a separate paragraph for each word
- b. Be neat and organized
- c. Follow grammar rules
- d. Indent each paragraph

3. Your paper will be graded on the rubric below.

Mastered	Almost Mastered	Not Yet Mastered
Student completed all 3 paragraphs	Student completed 2 paragraphs	Student completed only 1 paragraph
Student demonstrated understanding of each word.	Student demonstrated some understanding of each word.	Student demonstrated little understanding of each word
Student included examples of how each word is used in the real world	Student included some examples of how each word is used in the real world	Student did not include examples of how each word is used in the real world
Student had little or no grammar errors	Student had some grammar errors	Student had several grammar error

When you are finished with your essay staple it to the back of this rubric and place into the metal tray

APPENDIX N

QUIZ: FORCE AND MOTION

Quiz: Forces and Motion

New Question

_____ is an attractive force between two objects with mass.

☐ Gravity

☐ Friction

☐ Compression

☐ Tension

Next

New Question

Objects with a net force equal to 0 N do not move. The forces are considered to be

☐ unbalanced

☐ balanced

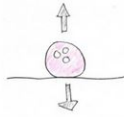
☐ heavy

☐ sliding

Next

New Question

In the image below the arrow pointing up represents what type of force?



☐ friction

☐ air resistance

☐ normal

☐ thrust

Next

New Question

A skateboarder is rolling down a steep hill. What force is acting to slow him down?



☐ compression

☐ Gravity

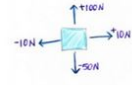
☐ Tension

☐ Friction

Next

New Question

Calculate the net force for the object represented in the free body diagram below.



☐ 10 N

☐ 20 N

☐ 50 N

☐ 150 N

Next

New Question

A person is pushing a box to the right with 50 N of force. Another person is pushing the box to the left with 100 N of force. Which direction will the box move?



☐ Left

☐ Right

☐ It won't move

☐ Down

Next

New Question

What type of force is pushing up on the skydiver's parachute in the image below?



☐ Gravity

☐ Friction

☐ Air resistance

☐ Thrust

Next

New Question

An example of a non-contact force is

☐ Tension

☐ Compression

☐ Gravity

☐ Air resistance

Next

New Question

The unit of measure for force is called a

☐ Newton

☐ Electron

☐ Batach

☐ Pion

Next

New Question

The car in the image below is moving to the right. What direction is friction?



☐ Left

☐ Right

☐ Upward

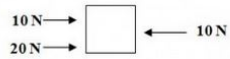
☐ Downward

Next

APPENDIX O

UNIT TEST: FORCE AND MOTION

Calculate the net force for the free body diagram below.


☐ 10 N

☐ 20 N

☐ 30 N

☐ 40 N

The word or symbol that represents the size and direction of a force.


☐ arrow

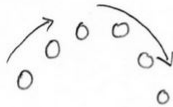
☐ direction

☐ vector

☐ magnitude

Next

A ball is tossed into the air. It begins to slow down and then changes directions. The image below best describes which Law of Motion?


☐ 1st Law, the object is at rest.

☐ 2nd Law, the object is accelerating.

☐ 3rd Law, the object has momentum.

☐ 4th Law, forces are constantly changing.

Next

What is the upward force acting on the bowling ball in the image below.


☐ Gravity

☐ Tension

☐ Air Resistance

☐ Normal

What is the upward force acting on the skydiver in the image below?

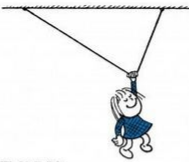

☐ Air Resistance

☐ Gravity

☐ Normal

☐ Thrust

You pull on a string. What force are you exerting on the string?


☐ Tension

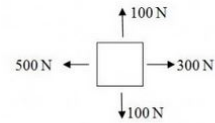
☐ Compression

☐ Gravity

☐ Friction

Next

Calculate the net force and direction of motion for the free body diagram below.


☐ 200 N, right

☐ 200 N, left

☐ 300 N, right

☐ 500 N, left

Which direction will the box move in the image below?



1000 N → ← 900 N

☐ Right

☐ Left

☐ It will not move

☐ upward

Next

What is the name of the attractive force pulling the person downward into the water?


☐ Air Resistance

☐ Gravity

☐ Normal

☐ Thrust

An object at rest will remain at rest until a force is applied is Newton's ____ Law of Motion.


☒ 1st

☒ 2nd

☒ 3rd

☒ No law applies

When the net force on an object is equal to zero forces are _____.

☒ balanced

☒ unbalanced

☒ heavy

☒ light

Next

A rocket ship is traveling in space at a constant speed. Which Law of Motion states that it will remain at constant speed until a force is applied?


☒ 1st Law

☒ 2nd Law

☒ 3rd Law

☒ No law applies

This law states that force come in pairs. If you are pushing on a wall, then the wall is pushing back on you (action/reaction).


☒ 1st

☒ 2nd

☒ 3rd

☒ No law applies

When the net force acting on an object are greater than zero the forces are _____.

☒ balanced

☒ unbalanced

☒ stable

☒ equal

Next

This word, or symbol, is the unit of measure used to describe a force.

☒ Newton (N)

☒ Kilogram (kg)

☒ Volt (V)

☒ Kelvin (K)

Next

In the image below a car that was driving at 100 mph suddenly comes to a stop. Which answer below best describes what happens to the person in the car.


☒ The person also stops.

☒ The person continues to move at 100 mph.

☒ Gravity pushes the person out of the car.

☒ Normal force pushes the person upward.

Acceleration describes and object that is

☒ speeding up

☒ slowing down

☒ changing directions

☒ all of these

Next

Which Law of Motion best describes this object?


☒ 1st Law, the object is at rest.

☒ 2nd Law, the object is accelerating.

☒ 3rd Law, the books are pushing down on the table and the table is pushing back up on the books with the same force.

☒ Both 1st Law and 3rd Law

Next

APPENDIX P

ESSAY RUBRIC: FORCE AND MOTION

ESSAY RUBRIC: Force and Motion

Name: _____

Directions: On a piece of notebook paper write an essay describing everything you know about 3 words from the word wall.

1. Which 3 words will you write about?

2. Your paper should:

- a. Have a separate paragraph for each word
- b. Be neat and organized
- c. Follow grammar rules
- d. Indent each paragraph

3. Your paper will be graded on the rubric below.

Mastered	Almost Mastered	Not Yet Mastered
Student completed all 3 paragraphs	Student completed 2 paragraphs	Student completed only 1 paragraph
Student demonstrated understanding of each word.	Student demonstrated some understanding of each word.	Student demonstrated little understanding of each word
Student included examples of how each word is used in the real world	Student included some examples of how each word is used in the real world	Student did not include examples of how each word is used in the real world
Student had little or no grammar errors	Student had some grammar errors	Student had several grammar error

When you are finished with your essay staple it to the back of this rubric and place into the metal tray

APPENDIX Q
TEACHER OBSERVATIONS AND REFLECTIONS

Post Lesson Reflections

January 6, 2014 – Drop the Ball was a great inquiry/team building activity to get started back to school. Students really enjoyed the challenge of working together to build the container. Even students who were initially reserved and not participating were actively engaged by the end of the activity. For future inquiry reflections there should be more in-depth questions, today was just to get them comfortable with writing again. Students need more time to reflect and write and not be rushed. Also, have time the following day to debrief and discuss. I will do this on Wednesday as I am out tomorrow. Reminders for next Engage activity:

- Don't explain so much
 - Keep them on time line
 - Have duties: Recorder, those who want to be hands on, presenters...etc.
- It was evident that each class was engaged based on their dynamics. It will be interesting to see if their engagement and buy-in will be visible in their assessments:
- [REDACTED] – sluggish, typically only 2 people designed, not excited about attempting trials in front of the class
 - [REDACTED] – Very supportive of each other, encouraged other teams who were struggling with their drops, offered positive suggestions, many groups discussed or drew plans prior to actual construction
 - [REDACTED] – lots of off task students, many groups were watching what other groups were doing in order to get ideas
 - [REDACTED] – the most engaged and excited class for the challenge, many groups worked beyond the boundaries of the directions (splitting the tape in half, using tape so adhesive would cause ball to stick..., very supportive of each other, sitting on desks & very comfortable with the class surroundings

January 8, 2014 – Today the students participated in a short activity to identify what they already know about directions and words that represent a direction. It was surprising how many students did not know how distinguish between left/right, up/down. Some students were confused about the difference between units of measure and directions. Some students listed words like map, GPS, and arrows as words that represent direction.

- It is obvious that I need to confirm their words to relate to directions but that up,down,left...but that maps and GPS are used as tools to get us from one place to another. That these tools need 2 pieces of information to get us there.
- Sharing as a group and then as a class definitely triggered more students coming up with other words.

:

APPENDIX R

FOCUS GROUP SURVEY - MOTION

FOCUS GROUP SURVEY - Motion

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

Directions: Carefully read and answer each statement below

1. Hands on activities helped me better understand vocabulary. Agree Neutral Disagree

Explain: _____

2. I like using the WORDS! worksheet after we learned about motion. Agree Neutral Disagree

Explain: _____

3. I was able to understand vocabulary better on our unit test. Agree Neutral Disagree

Explain why your answer: _____

4. I had plenty of time to review and practice the new vocabulary. Agree Neutral Disagree

Explain why your answer: _____

5. I feel comfortable correcting students who use vocabulary incorrectly. Agree Neutral Disagree

Explain why you think this happens: _____

6. I am including more vocabulary words in my lab reports and summaries. Agree Neutral Disagree

Explain why you think this happens: _____

7. Which vocabulary review activity did you enjoy the most?

8. Which vocabulary review activity did you enjoy the least?

APPENDIX S

FOCUS GROUP SURVEY: FORCES

FOCUS GROUP SURVEY: Forces

Participation in this research is voluntary and participation or non-participation will not affect a student's grades of class standing in any way.

Directions: Carefully read and answer each statement below

1. Even without the WORDS! worksheet the hands on activities helped me better understand vocabulary.

Agree Neutral Disagree

Explain: _____

2. I think we should still use the worksheet to help us learn new vocabulary. Agree Neutral Disagree

Explain: _____

3. I am using more science vocabulary when I talk to other students. Agree Neutral Disagree

Explain why you think this is happening. _____

4. I recognize when other students use the vocabulary incorrectly. Agree Neutral Disagree

Explain why you think this happens: _____

5. I feel comfortable correcting students who use vocabulary incorrectly. Agree Neutral Disagree

Explain why you think this happens: _____

6. I am including more vocabulary words in my lab reports and summaries. Agree Neutral Disagree

Explain why you think this happens: _____

7. Which vocabulary review activity did you enjoy the most?

8. Which vocabulary review activity did you enjoy the least?

APPENDIX T
WORD WALL

