

THE EFFECTS OF LATIN AND GREEK-BASED
ROOT WORD AND AFFIX INSTRUCTION ON SIXTH-GRADE
STUDENTS' UNDERSTANDING OF LIFE SCIENCE VOCABULARY

by

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ABSTRACT

In this project, instruction in Latin and Greek-based prefixes, suffixes, and root words was implemented to determine its effects on sixth-grade students' understanding and long-term memory of life science vocabulary, their ability to predict the meaning of new vocabulary, and their attitudes and motivation regarding learning vocabulary, as well as my teaching and attitudes to teaching. Latin and Greek morphemes were taught, recorded, and used in prediction and learning exercises. Pre and postunit and delayed assessments and concept interviews, pre and posttreatment surveys, my observations and journaling, peer observations, and a self-evaluation were analyzed. Results regarding student understanding and long-term memory were inconclusive. The data showed that students' ability to predict new vocabulary meanings improved. Students' attitudes and motivation were not affected and my attitudes were at first positive, but later declined.

INTRODUCTION AND BACKGROUND

For my capstone project, I investigated the effects of Latin and Greek (L/G) root and affix instruction on sixth-grade students' understanding of life science vocabulary. I chose this topic because I had observed recurring struggles with vocabulary acquisition and retention among my sixth-grade life science students, often with multimorphemic L/G-based terms. After much reflection, I realized that these struggles had negatively affected their understanding of life science concepts. I hoped to determine whether L/G instruction could help them to achieve greater success. Also, I chose this topic because the L/G root and affix instruction that I received in high school helped me to learn and retain science vocabulary and to decipher new vocabulary.

I teach sixth-grade life science in a suburban Pennsylvania middle school. The students in my study came from a variety of ethnic backgrounds and academic levels. My curriculum focused on genetics and evolution during the project implementation. The results of my project could be helpful to other middle school science teachers for improving science literacy. Additionally, my results could be helpful to my school district administrators and instructional coaches, who are actively promoting content literacy.

My project focus question was, what are the effects of implementing L/G prefix, suffix, and root word instruction using targeted strategies on sixth-grade students' understanding of life science vocabulary? My project subquestions were as follows: what are the effects of L/G affix and root word instruction on students' long-term memory of life science vocabulary; what are the effects of L/G affix and root word instruction on students' ability to predict the meaning of new vocabulary; what are the effects of L/G

affix and root word instruction on students' attitudes and motivation; and what are the effects of L/G affix and root word instruction on my teaching and attitudes to teaching?

A multimorphemic word consists of more than one linguistic unit. A root is the primary morpheme that provides the most significant meaning of words, and it cannot be broken down further. An affix is a morpheme that is joined to a root to form a new word. A prefix is added to the beginning of the word and a suffix is added to the end. My targeted strategies were instruction in morphemic analysis (MA), L/G root and affix instruction, vocabulary flip charts, morpheme word trees, and morpheme word charts displayed in my classroom. Also, L/G and MA instruction were implemented in content-specific lessons, with relevant vocabulary examples accompanying each morpheme.

My capstone advisor was Dr. Jewel Reuter and my project reader was Dr. David Willey from the ecology department at Montana State University. Two of my colleagues comprised my capstone support team. Brian Chubb, who teaches sixth-grade life science at my school, helped me to develop teaching strategies for my project. Debra Hines, a secondary-level literacy instructional coach in my district, helped me to select vocabulary and literacy teaching strategies and provided me with resources.

CONCEPTUAL FRAMEWORK

A review of the literature provided insight into low-reading comprehension among students and its link to their unfamiliarity with L/G-based science vocabulary. The literature advocated the use of L/G and MA instruction to improve students' understanding of vocabulary, and suggested effective strategies for their implementation.

Research indicated that L/G and MA instruction improved students' long-term memory of vocabulary and ability to decipher new vocabulary as well. Finally, studies brought to light the attitudes and motivation of students and teachers regarding L/G instruction.

For many students, literacy achievement decreases beginning in fourth-grade and continues thereafter (Sanacore & Palumbo, 2009). Sanacore and Palumbo (2009) stated that the theory of Chall describes this decline and indicates that the decline stems from students' transition from learning how to read, in which they are taught basic literacy skills through narrative texts, to acquiring content-based knowledge through descriptive texts. The structure and content of descriptive texts, such as textbooks, are very different from those of narrative texts, such as storybooks. Fang (2006) stated that students' unfamiliarity with the language of descriptive texts may decrease reading comprehension. Science texts are particularly challenging because of their technical nature; science vocabulary is typically multimorphemic and often derived from L/G (Fang, 2005, 2006).

To help students understand descriptive texts more effectively, Fang (2006) stated that instruction should focus on "the barriers that prevent students from successfully applying the skills and strategies they already possess when reading academic subject texts" (p. 517). The literature advocated direct vocabulary instruction in two ways: morphemic analysis, or breaking down complex words into roots and affixes, and contextual analysis, or using clues within a sentence or paragraph to decipher new words (Baumann, Edwards, Boland, & Olejnik, 2003; Baumann, Edwards, Font, & Tereshinski, 2002). For my project, I implemented instruction in morphemic analysis of L/G morphemes.

My primary focus question regarded the effects of L/G instruction on students' understanding of life science vocabulary. It is widely asserted that L/G instruction is beneficial to vocabulary development (Adams & Henry, 1997; Rasinski, Padak, Newton, & Newton, 2008; White, Power, & White, 1989). Sarma (2004, 2006) implemented L/G instruction in college-level chemistry and Earth science courses due to the large number of L/G-based science words. Sarma (2004, 2006) stated that knowledge of the relationships among vocabulary and their L/G origins can help students to better understand science concepts. Sarma (2006) stated, "The knowledge of etymology of technical terms can possibly remove the often intimidating appearance of technical terms and help students to better understand the concepts represented" (p. 24).

Rasinski, Padak, Newton, and Newton (2011) advocated similar L/G instruction for elementary-aged students. They stated that knowledge of just one L/G morpheme can help elementary students to understand up to 20 words. They described an unpublished study from 2010 in which Iisha Porter-Collier implemented a 10-week L/G instruction program in her third-grade class. She reported that the percentage of students that met her school district's vocabulary standard rose from 19% to 47%.

Additionally, in another unpublished study from 2010, Joanna Newton surveyed 10 elementary teachers that had implemented L/G instruction in their classrooms (Rasinski et al., 2011). Over half of the teachers surveyed stated that the L/G instruction resulted in improvement in their students' understanding of content-related texts. Because it helped students to understand vocabulary, Rasinski et al. asserted that L/G instruction should begin in elementary grades and continue through high school. Therefore, I

believed that by implementing L/G instruction in my sixth-grade classes, I could help to improve my students' understanding of life science vocabulary.

My first subquestion regarded the effects of L/G instruction on students' long-term memory of vocabulary. Otterman (1955) carried out a study in which students in 20 seventh-grade English classes were taught one L/G root word or prefix each day for six weeks. A delayed assessment administered six weeks after the L/G instruction was completed indicated that students remembered the meanings of many L/G morphemes. Additionally, Graves (1986) described a report by Pressley, Levin, and McDaniel in which elementary and college students that were taught roots showed greater long-term memory of vocabulary definitions on a delayed test than students from control groups. This research indicated that L/G instruction has a positive effect on long-term memory of vocabulary and suggested that my students may benefit from it.

My second subquestion focused on the effects of L/G instruction on students' ability to decipher new vocabulary. Kail (2008) stated that direct memorization of Latin roots improved her 10th-grade English students' ability to define new vocabulary. Kail's students memorized a list of Latin roots each week. She often led class discussions of relevant word derivations as well. After several weeks, Kail's students began to define new words from their textbooks by breaking them down into their separate morphemes.

Additionally, in a study by White, Sowell, and Yanagihara (1989), 23% of third-grade students that received prefix instruction were able to define new vocabulary, as opposed to only 6% in the control group. Graves (1986) described a study by Graves and Hammond in which seventh-grade students were taught prefixes and then required to decipher new vocabulary. Graves also described an unpublished study by Nicol, Graves,

and Slater that included fourth, fifth, and sixth-grade students. A study by Baumann et al. (2002) involved only fifth-grade students. In all three of these studies, the students that received prefix instruction scored higher on vocabulary prediction assessments than students from control groups. By providing my students with L/G instruction, I hoped to help them predict the meaning of new vocabulary as well.

My third subquestion referred to students' motivation and attitudes regarding L/G instruction. In a study of the effects of MA and contextual analysis instruction on multiple fifth-grade social studies classes, most students enjoyed learning vocabulary by identifying morphemes (Baumann et al., 2003). In Kail's (2008) 10th-grade English class, students were required to memorize a list of Latin root words each week. At first, the students did not enjoy the exercise and questioned its relevance. However, after Kail began incorporating class discussions about derivations of the root words, the students' attitudes changed. They began to point out words in their textbooks that were derived from the roots. Students also enjoyed manipulating roots and affixes to create new words, which they eagerly searched for in a dictionary to see if they were actual words. By utilizing instructional strategies that familiarized my students with L/G morphemes, I hoped to promote positive attitudes and motivation regarding vocabulary acquisition.

My final subquestion regarded my attitudes and motivation while implementing my project. In a 2008 study, Fang et al. measured the effects of reading on sixth-grade students' science literacy. At first, the teachers were skeptical about implementing reading strategies. When instructional time was limited, they became concerned about falling behind and felt pressured to cover content material before literacy instruction.

While reading this study I realized that I, too, felt a conflict between allocating instructional time for vocabulary development and content material.

Fang et al. (2008) showed that by the end of the study, however, the teachers had come to appreciate the importance of reading strategies. Guskey (1986) explained that teachers' attitudes and beliefs regarding new classroom practices change when there is a change in students' learning outcomes. Kail (2008) described a similar effect on attitude. At first she disliked her school's requirement that her students memorize Latin root words. She thought that rote memorization would not promote higher level learning in her students. However, Kail's students used roots to define new words and reported that root memorization benefitted their understanding in other classes such as biology, algebra, and Spanish. As a result, Kail hailed the effectiveness of root memorization and continued to utilize it in her classroom. The attitudes and motivation of teachers found among the literature provided insight into the attitudes that I might have during and after my project implementation.

The literature also helped me to develop my targeted instructional strategies. The Partnership for Reading (2001) advocated explicit instruction of L/G roots and affixes accompanied by MA instruction. When developing L/G and MA instruction for my project, I drew upon the works of Baumann et al. (2002) and Burke (1998). Burke implemented L/G and MA instruction in a college course. He first explained that morphemes are individual linguistic units within a compound word and used common English words until his students fully understood this concept. He also reviewed parts of speech and explained how to categorize morphemes within them. Then Burke demonstrated how L/G-based words can be deconstructed in the same manner. Baumann

et al. evaluated the effects of MA on fifth-grade students' learning of vocabulary. Their treatment began with an introduction to MA through direct instruction of common prefixes, followed by teacher modeling of MA and guided student practice.

In both studies, the instructional strategies worked towards a gradual release of responsibility to the students, which culminated in independent practice of MA (Baumann et al., 2002; Burke, 1998). I thought that this model was sequential and orderly, so I decided to follow it when implementing my project. Additionally, Kieffer and Lesaux (2007) stated that L/G instruction should be taught within the context of a meaningful lesson, and not as discrete lists of morphemes. This helped students to understand the relationships among the L/G morphemes and the concepts. For my project, all L/G instruction was implemented within content-specific lessons.

Additionally, Fang (2006) advocated the use of vocabulary word charts. My targeted strategies included vocabulary flip charts and a word chart displayed in my classroom. Bromley (2007) suggested implementing word trees, which required students to look up words containing specified morphemes using a dictionary or other resource. I adapted Bromley's word trees for my project. Finally, my use of delayed tests owed to Baumann et al. (2002), Otterman (1955), and Graves (1986).

In conclusion, the literature attributed middle school students' difficulty with science texts partly to their unfamiliarity with technical vocabulary. Content-specific instruction in MA and L/G-based roots and affixes was advocated for improving understanding and long-term memory of science vocabulary, and to decipher new vocabulary. Students responded positively to L/G and MA instruction. Teachers, though

skeptical at first, came to see the benefits of literacy instruction. The literature also helped me to develop research-based targeted strategies.

METHODOLOGY

Project Treatment

I used one nontreatment unit and two treatment units to allow for comparison. The nontreatment unit focused on the genetic code. The treatment units focused on biotechnology and evidence for evolution. All units were taught using guided note-taking with PowerPoint presentations, graphic organizers, video clips, concept mapping, and vocabulary flip charts.

Each unit also featured other instructional strategies. I taught about the structure of DNA, protein synthesis, and genetic mutations through puzzle and model-building labs, interactive online labs (WebLabs), and small group research presentations. I taught about biotechnology and practical applications of genetics through DNA extraction, electrophoresis, a DNA fingerprinting lab, a cloning WebLab, and a class discussion about genetically modified organisms. The second treatment unit featured fossil examination, a radiometric dating lab, a time travel lab, and drawing, coloring, and writing activities to teach about homology and vestigial structures.

I began my nontreatment unit by teaching about the discovery of the structure of DNA. I used a PowerPoint presentation with pictures of scientists and a film clip from Discovery Education to help the students see the relationship between DNA and

chromosomes. The students were then given paper puzzle pieces that represented the structural components of DNA. They worked in pairs to manipulate the pieces to make a DNA molecule. The pieces are in Appendix A and were adapted from Salter (2006).

Next, the students used their textbooks to complete a graphic organizer on the structure of DNA. The graphic organizer is in Appendix B. Then, they wrote the vocabulary terms *double helix*, *nucleotide*, *sugar-phosphate backbone*, and *nitrogen base* and their definitions in their vocabulary flip charts. The flip charts were made by taping several notecards into a manila folder. An example of a flip chart is in Appendix C.

Finally, students worked in pairs to build three-dimensional DNA models with K'nex kits. The students used their graphic organizers and vocabulary flip charts to help them. I ended the lesson with a summarizing prompt that required students to synthesize their understanding of genetics and the structure of DNA to answer the question, how is the genetic code stored in DNA? Throughout this lesson no L/G strategies were used.

Immediately following the nontreatment unit, my intervention began by reviewing parts of speech with the students and by explaining the concept of morphemes. Students practiced breaking down English compound words such as *homework* and *football* before I introduced L/G morphemes. I also provided students with a scanned excerpt from their textbook and asked them to circle all the compound words. As a class, we then separated the compound words into roots, prefixes, and suffixes. This exercise showed students that they could use MA to help them break down difficult textbook vocabulary.

Each lesson that the intervention was implemented, I wrote a relevant L/G root or affix on the board, followed by its meaning and a word that contained that morpheme that the students already knew. The students recorded this information in their vocabulary flip

charts. Then, I wrote a new vocabulary word on the board that featured the L/G root or affix. I asked students to first record the word in their flip charts, and then use their understanding of the L/G morpheme to predict the meaning of the new word. Students wrote their predictions on the back of the notecards. After allowing students to share their predictions with partners, I asked volunteers to share them aloud. The correct definition was written on the board and the students copied it into their flip charts. The list of vocabulary words and L/G morphemes that were taught in each unit is in Appendix D.

A word chart containing each vocabulary term, root word, and affix taught was displayed in the classroom throughout the intervention period. Also, students were instructed to use their vocabulary flip charts and to refer to the classroom word chart for all assignments and reading activities. I did this to ensure that my intervention was integrated throughout all learning, and not used merely as discrete exercises.

Additionally, during the first unit, I reviewed how to create a concept map by showing an example on the board. During or at the conclusion of each unit, the students created their own concept maps to demonstrate their understanding of the relationships among the concepts, vocabulary words, L/G morphemes, and their meanings. An example of a concept map is in Appendix E. Students were also given a word tree assignment once each unit. The word tree included a selection of root words, prefixes, and suffixes from the unit. Using a dictionary or other texts, students found new words that contained those morphemes and wrote them on the word tree. A word tree example is in Appendix F. The concept maps and word trees were used to show students that their knowledge of L/G morphemes could help them to understand life science concepts and learn new words.

My first treatment unit featured several biotechnology labs that were carried out consecutively. I began this lesson by writing the L/G morphemes *extractus* (draw out) and *tion* (the action of) on the board, along with their meanings. I also wrote examples of words that the students already knew that contained these morphemes (*extracurricular* and *concentration*). The students wrote this information in their flipcharts. Then I wrote *DNA extraction* on the board and the students wrote it in their flip charts. They then used their knowledge of the L/G morphemes to predict the definition. After writing their predictions, the students shared them with partners. Then, student volunteers shared their predictions aloud. I wrote the complete definition on the board and the students recorded it in their flip charts. An example of the flip chart is in Appendix G.

The students then worked in pairs to complete a DNA extraction from strawberries lab. The lab is in Appendix H and was adapted from Juniata College Science in Motion (2004). In the lab conclusion questions students were asked, how did your knowledge of the L/G words *extractus* and *tion* affect your understanding of the process of DNA extraction? Another question was, what was “drawn out” during the DNA extraction? These questions required students to reflect on their knowledge of the L/G morphemes to make meaning of the lab that they just completed.

Next, I wrote the L/G morphemes *elektro* (attracts other substances) and *phoresis* (being carried) on the board with their meanings. Students volunteered examples of words containing *elektro* (electricity and electrical) and I wrote them on the board. No example for *phoresis* was written on the board because no word contains this morpheme except *electrophoresis*, the life science vocabulary word for the day. Students wrote this information in their flipcharts. Next, I demonstrated how static electricity can attract

other substances by rubbing an inflated balloon on a student volunteer's head; his hair was attracted to the balloon. Then I wrote *DNA electrophoresis* on the board and the students wrote it in their flipcharts. They used their knowledge of the L/G morphemes to predict the definition. After writing their predictions, the students shared them with partners. Then, student volunteers shared their predictions aloud. I wrote the complete definition on the board and the students recorded it in their flip charts.

I then explained the process of DNA electrophoresis to the students, beginning with using restriction enzymes to cut the DNA into small fragments. The students then worked in pairs to complete a DNA electrophoresis simulation using food coloring instead of DNA. The lab procedure was adapted from *Advancing Science*. The students learned how the process of DNA electrophoresis is used to make a DNA fingerprint.

The following day before class I placed a chalk outline of my body on the floor and surrounded it with yellow crime scene tape. I also dressed up as an FBI agent. When the students entered the classroom I informed them that Mr. Shotts had been attacked early that morning and that I, his cousin Agent Shotts, would be leading an investigation to solve this crime. Students worked in pairs to compare the DNA fingerprints (bar codes) of six suspects to the DNA fingerprint from a sample found at the crime scene to determine which suspect was guilty. This lab is in Appendix I and was adapted from Cronkite (2005). After the students identified the guilty suspect I showed them the “mug shots” of all six suspects. They were teachers and administrators in the school.

The lab's conclusion questions asked students, how did your knowledge of the Latin/Greek words *elektro* and *phoresis* affect your understanding of the process of DNA electrophoresis and DNA fingerprinting? They were also asked to explain what was

“attracted” and what was “being carried” during DNA electrophoresis. These questions ensured that students used their knowledge of the L/G morphemes to better understand the concepts taught through the labs.

My treatment unit on evidence for evolution culminated with a simulated time travel lab that helped students to understand how life has changed over time. This lab was adapted from Beals, Parizeau, MacPherson, Hosoume, and Bergman (2003). Before the lesson began, I set up several aquaria and terraria around the room with models, fossils, and living specimens representing five different time periods of Earth’s history. I began this lesson dressed in safari garb and pretending to be a time travel tour guide named Jungle Jim. I told the students that they would soon be going on a time travel adventure, but that they first had to learn some terms in order to read their “road map through time” (geologic time scale). I wrote the L/G morphemes *mesos* (middle), *zoe* (life), and *era* (from which time is reckoned) on the board, along with their meanings. I also wrote examples of words that the students were already familiar with that contained these morphemes (*Mesoamerica*, *zoo*, and *modern era*). The students wrote this information in their flipcharts. Next, I wrote *Paleozoic Era* and *Mesozoic Era* on the board. The students wrote the words in their flip charts and used their knowledge of the L/G morphemes to predict their definitions. I reminded students that they had learned the L/G morpheme *palaio* (old or ancient) earlier in the unit. After writing their predictions, the students shared them with partners. Then, student volunteers shared their predictions aloud. I wrote the definitions on the board and the students recorded them in their flip charts. An example of the flip chart is in Appendix J.

Next, the students visited each time period display and recorded their observations about the organisms and characteristics of each in five separate graphic organizers adapted from a Frayer model. The Frayer model is used to help students understand a word or concept, and is divided into quadrants for a definition, characteristics, examples, and non-examples. My adapted graphic organizer was used to help students understand each time period, and included quadrants for a description of the environment, a drawing of the ecosystem, characteristics of organisms, and examples of organisms. The graphic organizer is in Appendix K.

After completing the time travel lab, the students began a concept map/short essay assignment. The concept map required students to show their understanding of the relationships among the L/G morphemes *palαιο*, *mesos*, *zoe*, and *era*, the vocabulary words *Paleozoic Era* and *Mesozoic Era*, and the plants and animals that they observed at each time period. The students then composed a short essay that answered the question, how do the changes in living things throughout Earth's history indicate that evolution has occurred? In this way, students used their knowledge of L/G morphemes to better understand the changes that they observed in life on Earth. They then synthesized their understanding to answer a fundamental question. This assignment is in Appendix L.

Data Collection Instruments

Classroom Environment and School Demographics

Mechanicsburg Middle School is comprised of nearly 900 students, and is located in a suburb of Pennsylvania's state capital, Harrisburg. The community is comprised

largely of successful individuals in business and health care. Education is regarded as a high priority in this community. I implemented my capstone project with three of my grade 6 life science classes. This is the only subject and grade level that I taught at the time. I chose periods 1, 2, and 3 because they were similar in size and all occurred in the morning. These classes were similar in ability level and engagement as well. Most of the students were eager to learn, excited about science class, and demonstrated good work completion. In general, they had difficulty learning and retaining science vocabulary. I believed that the intervention would prove to be helpful to their learning.

There were a total of 52 students in the intervention, with 22 males and 30 females. The students came from a variety of ethnic backgrounds: 80.8% were Caucasian, 11.5% were African American, 3.8% were Indian, and 1.9% each were Latino and Russian. The students also represented a spectrum of academic and ability levels, including three students with a specific learning disability, one student with emotional disturbance, and one student with autism. 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.

Data Triangulation

I collected various data for each of my focus questions to allow for triangulation. The data triangulation matrix is in Table 1. I believed that triangulation with the data collection instruments described in Table 1 would provide an appropriate array of quantitative and qualitative data to allow me to adequately answer the focus questions.

Table 1
Data Triangulation Matrix

Focus Questions	Data Source 1	Data Source 2	Data Source 3
<i>Primary Question:</i> 1. What are the effects of implementing L/G prefix, suffix, and root word instruction using targeted strategies on sixth-grade students' understanding of life science vocabulary?	Pre and Postunit Assessments	Pre and Posttreatment Survey	Pre and Postunit Concept Interviews
<i>Secondary Questions:</i> 2. What are the effects of L/G affix and root word instruction on students' long-term memory of life science vocabulary?	Postunit and Delayed Assessments	Pre and Posttreatment Survey	Postunit and Delayed Concept Interviews
3. What are the effects of L/G affix and root word instruction on students' ability to predict the meaning of new vocabulary?	Pre and Postunit Assessments	Pre and Posttreatment Survey	Pre and Postunit Interviews
4. What are the effects of L/G affix and root word instruction on students' attitudes and motivation?	Instructor Observations and Field Notes	Pre and Posttreatment Survey	Peer Observations
5. What are the effects of L/G affix and root word instruction on my teaching and attitudes to teaching?	Instructor Journaling	Self-Evaluation	Peer Observations

For my primary focus question concerning the effects of L/G instruction on students' understanding of life science vocabulary, I administered pre and postunit assessments to all students during class. The pre and postunit assessments are in Appendix M. The assessments featured questions from the low, middle, and high-cognitive levels of Bloom's taxonomy. The first question required students to recall and define vocabulary words from the unit. The next two questions required application or analysis of understanding, such as, how can vestigial structures and homology suggest common ancestry? The next question required students to synthesize or evaluate their understanding, such as, how are mutations important to the process of natural selection?

Pre and posttreatment surveys were given to all students during class. The surveys prompted students to reflect upon and describe the effects of L/G instruction on their understanding of life science vocabulary. The pretreatment survey is in Appendix N. The posttreatment survey also included questions about the treatment strategies. I also interviewed six student volunteers individually during lunch: two students each from high, middle, and low-academic levels. The interview questions probed students' perceptions of the effects of L/G instruction on their learning. The interviews also included concept mapping, which assessed students' ability to make connections among life science vocabulary, L/G roots and affixes, and concepts. The preunit interview questions and concept mapping prompts are in Appendix O.

To answer my first subquestion concerning the effects of L/G instruction on students' long-term memory of life science vocabulary, I utilized the pre and posttreatment surveys that were described above. The surveys included questions about students' long-term memory of vocabulary. I also administered delayed concept interviews and assessments two weeks after each unit ended. By comparing results from the postunit and delayed assessments and concept interviews, I was able to assess the effects of L/G instruction on students' long-term memory of vocabulary. Also, the postunit and delayed interviews included specific questions about students' long-term memory of vocabulary.

For my second subquestion concerning the effects of L/G instruction on students' ability to predict the meaning of new vocabulary, pre and postunit assessments were implemented as already described. Students were required to predict the meaning of new life science words containing L/G roots and affixes that were taught in the unit.

Additionally, the pre and postunit concept interviews required students to answer questions about their perception of the effects of L/G instruction on their ability to predict the meaning of new vocabulary. The interviews also included concept mapping, which assessed students' ability to make connections among L/G roots and affixes and new vocabulary. Finally, the pre and posttreatment surveys described earlier included questions about students' ability to predict the meaning of new life science vocabulary.

To answer my third subquestion, the pre and posttreatment surveys included questions about students' attitudes and motivation in regards to L/G instruction. Additionally, I kept field notes during observations of vocabulary instruction and review. Observations were conducted every three days. Each observation lasted about 10 minutes. The prompts for my observations are in Appendix P. Peer observations were conducted once each unit by a reading or English teacher. Each observation lasted 10 minutes. The observers focused attention on students' attitudes and motivation during L/G instruction. The peer observation prompts are in Appendix Q.

For my fourth subquestion concerning the effects of L/G instruction on my teaching and attitudes to teaching, peer observations were conducted as already described. My peers commented on my teaching and attitude to teaching. I also kept a daily journal to record my attitude. The journal prompts are in Appendix R. Finally, I administered a self-evaluation at the end of the intervention. The self-evaluation required me to reflect on my teaching and attitude to teaching throughout the unit. The self-evaluation is in Appendix S.

To answer my project focus questions, I analyzed the data both qualitatively and quantitatively. The assessments provided quantitative data on students' understanding of

life science vocabulary and their ability to predict the meaning of new vocabulary by requiring them to define words. When scoring the assessments, a fully correct definition was awarded two points and a partially correct definition that displayed at least some understanding of the concept was awarded one point. The open-ended questions provided qualitative data on students' understanding of vocabulary and concepts. Finally, postunit and delayed assessment scores were compared to provide quantitative data on the effects of L/G instruction on students' long-term memory of vocabulary.

The pre and posttreatment surveys provided qualitative data about students' understanding and long-term memory of vocabulary, their ability to predict the meaning of new vocabulary, and their attitudes and motivation through open-ended responses. Also, several questions required students to rate their responses on a Likert scale of one through five. These responses provided quantitative data on all of the focus questions and allowed for trends to be identified.

In order to answer my focus question and subquestions, assessment scores and survey responses were compared for students in low, middle, and high-achievement groups. Each student's achievement group was determined by his or her grade in my course. Once defined, the achievement groups varied greatly in the number of students that comprised them. The low-achievement group had the fewest number of students ($n=10$). In order to maintain consistency and to prevent the disproportionately large high-achieving group ($n=26$) from skewing the data analysis, a random sample of 10 students from the middle and high-achievement groups were used for comparison. To avoid gender bias, the proportion of boys and girls in the high and middle-achieving groups were made to be consistent with that of the low-achieving group.

The concept interviews provided qualitative data on students' understanding and long-term memory of vocabulary and concepts and their ability to predict the meaning of new vocabulary through oral responses to open-ended questions. Concept maps were scored quantitatively for clarity of connections and hierarchy and branching of concepts. The scores for each component were averaged among the six interviewees. The concept map scoring rubric was adapted from Novak and Gowin (1984) and is in Appendix T.

Peer and instructor observations and the self-evaluation provided qualitative data on the attitudes and motivation of the students and me through open-ended written questions. Journaling provided qualitative data on my daily attitudes to teaching as well. Additionally, the peer and instructor prompts and self-evaluation included questions that involved rating on a Likert scale. These responses provided quantitative data on my third and fourth subquestions and allowed for trends to be identified.

My capstone project began on January 3, 2012, and lasted 10 weeks, ending on March 16. My project timeline is in Appendix U. The pretreatment survey was given on the last day of the nontreatment unit and the posttreatment survey was given on the last day of treatment unit 2. Preunit assessments and interviews began on the first day of each unit and postunit assessments and interviews began on the final day of each unit. Delayed assessments and interviews were given two weeks after the conclusion of each unit.

DATA AND ANALYSIS

In order to answer my project focus question and four subquestions, data were compared from one nontreatment unit and two treatment units. Various data collection

instruments allowed for triangulation of the data. For my primary focus question regarding the effects of L/G instruction on students' understanding of life science vocabulary, I administered pre and postunit assessments and pre and posttreatment surveys to all students. I also administered pre and postunit concept interviews to six students; two from each achievement group.

The first assessment question corresponded to the lowest level of Bloom's taxonomy, knowledge, by requiring students to define vocabulary from the unit. The next two questions corresponded to Bloom's middle level by assessing students' application or analysis of understanding. The fourth question required students to synthesize or evaluate their understanding, and achieved the highest level of Bloom's taxonomy.

Data from the nontreatment and treatment pre and postunit assessments allowed me to compare the average percent change for students in low, middle, and high-achievement groups. As indicated in Table 2 below, all achievement groups had a higher average percent change in the nontreatment unit than in the treatment units, indicating that the L/G instruction did not improve student understanding.

Table 2
Average Scores and Percent Change from Pre to Postunit Assessment for All Units by Low-Achieving (n=10), Mid-Achieving (n =10), and High-Achieving Groups (n =10) and All Students (N=30)

Group Description	Nontreatment			Treatment 1			Treatment 2		
	Preunit Average	Postunit Average	% Change	Preunit Average	Postunit Average	% Change	Preunit Average	Postunit Average	% Change
Low	3.2	20.6	543.8	12.5	26.9	115.2	8.3	22.5	171.1
Mid	3.1	21.3	587.1	14.0	36.3	159.3	12.6	38.1	202.4
High	11.5	54.4	373.0	27.6	82.5	198.9	19.4	71.9	270.6
All	5.9	32.1	444.1	18.0	48.5	169.4	13.4	44.2	229.9

However, the very high average percent change for the nontreatment unit is largely due to very low preunit assessment scores; many students scored only 1%.

Students of all achievement groups scored much higher on the treatment unit 1 and 2 preunit assessments, resulting in a lower average percent change for these units. One explanation for these data is that students may have had more prior knowledge for the treatment units than for the nontreatment unit and this made it more difficult for the students to have as large of gains as in the nontreatment unit.

Table 2 does provide some indication that L/G instruction may have been most beneficial to high-achieving students. In the nontreatment unit, the high-achievement group had the lowest average percent change. In both treatment units, however, the high-achievement group had the highest average percent change. Therefore, the data indicate that L/G instruction had the most positive impact on high-achieving students.

Data from the pre and postunit assessments also allowed me to compare the average percent change for questions in the low, middle, and high levels of Bloom's taxonomy. As indicated in Table 3 below, the questions from the high and low-cognitive levels had a higher average percent change in the nontreatment unit than in the treatment units, indicating that the L/G instruction did not improve student understanding of these questions. Additionally, the low-level questions had the lowest percent change in all units, indicating that the L/G instruction was least beneficial for knowledge questions.

Table 3
Comparison of Pre and Postunit Assessment Average Scores and Percent Change According to Bloom's Taxonomic Level (N=52)

Level of Cognition	Nontreatment			Treatment 1			Treatment 2		
	Preunit Average	Postunit Average	% Change	Preunit Average	Postunit Average	% Change	Preunit Average	Postunit Average	% Change
Low	9.2	41.9	355.4	26.7	63.9	139.3	19.0	55.2	190.5
Mid	3.4	46.2	1258.8	23.6	57.2	142.4	1.0	40.9	3990.0
High	4.1	31.7	673.2	11.5	56.7	393.0	19.2	69.2	260.4
All	7.2	41.7	479.2	24.0	61.3	155.4	14.4	53.4	270.8

The data for the middle-level questions are more difficult to interpret. The average percent change for the nontreatment unit was greater than for treatment unit 1. However, the average percent change for treatment unit 2 was very high (3990%). This is largely because many students scored 0% on these two questions on the preunit assessment. One question asked students to compare and contrast between structural and developmental homology. Many students had no response and some demonstrated understanding of the meaning of *developmental*, but no understanding of *homology*. The second question asked students to explain how vestigial structures and homology support the theory of common ancestry. No students successfully answered this question on the preunit assessment. Due to this outlier, there is more uncertainty about the impact of L/G instruction for the middle-level questions.

Pre and posttreatment survey data were also compared to determine the effects of L/G instruction on students' understanding of vocabulary. The survey was administered before treatment unit 1 and immediately after treatment unit 2. Average responses for the question regarding students' level of understanding of life science words are compared for low-achieving, middle-achieving, and high-achieving students in Figure 1. The data show that the average response for all groups was slightly higher on the posttreatment survey than on the pretreatment survey, indicating that most students perceived their level of vocabulary understanding to have increased by the end of the intervention.

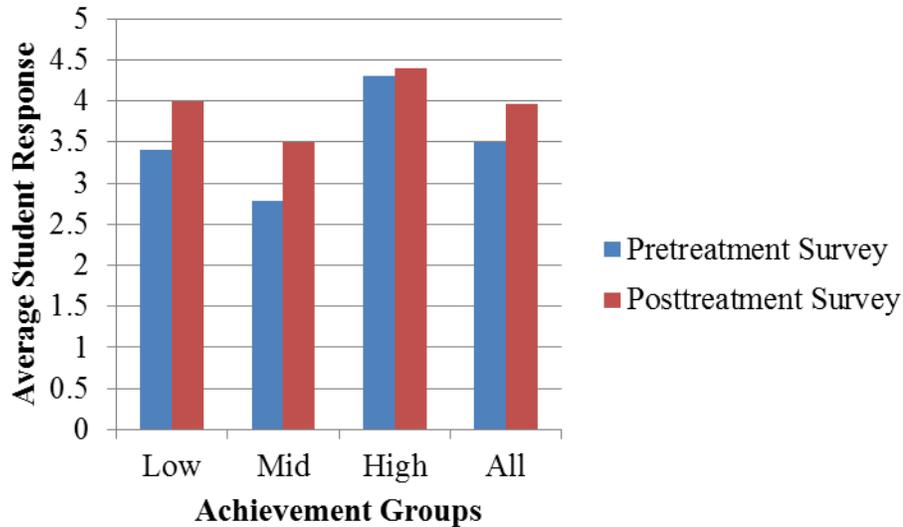


Figure 1. Average response to pre and posttreatment survey question concerning level of understanding of life science words by low-achieving students ($n=10$), middle-achieving students ($n=10$), high-achieving students ($n=10$), and all students ($N=30$). *Note.* 5 = Very Much, 4 = Much, 3 = Some, 2 = Very Little, 1 = None.

Additionally, on both surveys high-achieving students reported the highest level of vocabulary understanding, but showed the lowest increase in average response from the pretreatment survey to the posttreatment survey. Conversely, middle-achieving students reported the lowest level of vocabulary understanding, but showed the highest increase in average response. These data indicate that middle-achieving students experienced the greatest change in their perception of understanding of vocabulary and high-achieving students the least.

Further evidence for this claim was obtained in a posttreatment survey question that asked students to rate the level that L/G instruction affected their understanding of life science vocabulary. A comparison of the average response for students in low, middle, and high-achieving groups can be found in Figure 2.

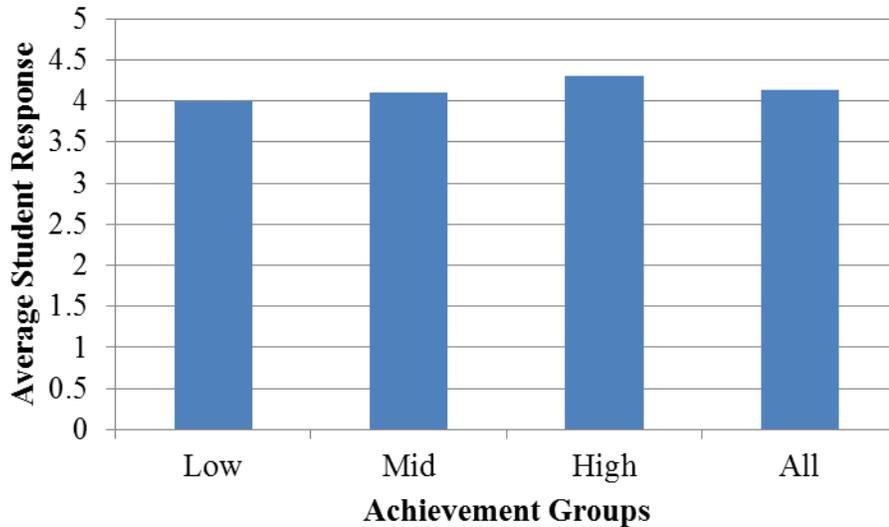


Figure 2. Average response to posttreatment survey question concerning how much L/G instruction affected understanding of vocabulary by low-achieving students ($n=10$), middle-achieving students ($n=10$), high-achieving students ($n=10$), and all students ($N=30$). *Note.* 5 = Very Much, 4 = Much, 3 = Some, 2 = Very Little, 1 = None.

As shown in Figure 2, the average response for low, middle, and high-achieving students was about the same, with the high-achieving group responding the highest and the low-achieving group the lowest. These data indicate that the L/G instruction strongly affected all achievement groups similarly. Student written responses also indicated that the L/G instruction affected their understanding positively. Many of them wrote that the L/G instruction made learning science vocabulary easier and more enjoyable.

Finally, pre and postunit concept interview data were analyzed to determine the effects of L/G instruction on student understanding of science vocabulary. Two students from each achievement level were interviewed and completed a concept map before and after each unit. Concept maps were scored using the rubric in Appendix T. The concept maps were scored according to a clear proposition, levels of hierarchy, cross-linking, and examples for concepts. The average pre and postunit concept map scores and percent change are compared by student achievement group in Table 4. All achievement groups

showed a higher percent change on the treatment unit concept maps than on the nontreatment unit concept map. These data indicate that the L/G instruction did help all students to better understand life science vocabulary.

Table 4

Average Scores and Percent Change from Pre to Postunit Interview Concept Map for All Units by Low-Achieving (n=2), Mid-Achieving (n=2), and High-Achieving Groups (n=2) and All Students (N=6)

Group Description	Nontreatment			Treatment 1			Treatment 2		
	Preunit Average	Postunit Average	% Change	Preunit Average	Postunit Average	% Change	Preunit Average	Postunit Average	% Change
Low	42.7	26.5	-37.9	25.7	34.3	33.5	28.9	75.0	159.5
Mid	45.6	33.8	-25.9	47.1	71.4	51.6	98.1	98.1	0.0
High	55.9	55.9	0.0	27.1	58.6	116.2	94.2	100.0	6.2
All	48.0	38.7	-19.4	33.3	54.8	64.6	73.7	91.0	23.5

During the nontreatment unit, the high-achieving students maintained the same average score for the pre and postunit assessments. However, the data show a negative average percent change for the low and middle-achievement groups. On the preunit concept map, these students utilized good map structure, but did not demonstrate an understanding of the L/G morphemes. On the postunit concept map they showed no improvement with the L/G morphemes, and also created maps that were poorer in structure; they did not utilize appropriate levels of hierarchy and emitted some terms entirely. These concept maps appeared to have been completed hastily. The students verbalized that they did not like the concept maps, so they may have rushed through the postunit maps just to get them finished, causing this unusual decrease in knowledge after instruction.

The low-achieving students demonstrated a higher average percent change in each successive unit. They improved the most in their ability to connect the L/G morphemes and their definitions to their corresponding concepts for treatment unit 2. The middle and

high-achieving students displayed a high average percent change in treatment unit 1. However, in treatment unit 2 the middle and high-achievement groups showed no and slight percent change respectively. This is most likely because both groups scored very highly on the preunit concept map, showing prior knowledge of many of the L/G morphemes.

The concept interviews also included questions regarding students' perceptions of the effects of L/G instruction on their vocabulary understanding. Students' responses were similar for all treatment units and among all achievement groups. Many of the students interviewed said that learning science vocabulary is sometimes difficult for them, but that it is easier if they can break the vocabulary into root words and affixes. One student said, "When I look at a new word I break it apart, and if I know what most of it means I can figure out the rest of it." The students were asked specifically how the L/G instruction affected their understanding of the vocabulary. Several students responded that the L/G instruction did help their understanding. One student said, "If I remember a few L/G words, I can put them together to get a pretty good understanding of what the definition will be." However, most of the students stated that use of their vocabulary flip charts or continued repetition of the terms in class were most helpful to them for increasing their understanding of vocabulary. One student said, "The flip book helps me quiz myself so I can understand it better." These responses indicate that students perceive L/G instruction as helpful to learning life science vocabulary, but not as helpful as other vocabulary instructional strategies.

In summary, the data are inconclusive as to whether or not the L/G instruction was effective in helping students to better understand life science vocabulary. The flip

books used in the nontreatment unit appeared to be of much benefit to the students. Data from the surveys and concept interviews indicate that the L/G instruction did improve students' understanding of vocabulary. However, data from the assessments show no increase in vocabulary understanding due to the L/G instruction.

In order to answer my subquestion on the effects of L/G instruction on students' long-term memory of life science vocabulary, data from postunit and delayed assessments, pre and posttreatment surveys, and postunit and delayed concept interviews were analyzed. Data from the postunit and delayed assessments are compared by achievement group in Table 5 below.

Table 5
Average Scores and Percent Change from Postunit to Delayed Assessment for All Units by Low-Achieving (n=10), Mid-Achieving (n =10), and High-Achieving Groups (n =10) and All Students (N=30)

Group Description	Nontreatment			Treatment 1			Treatment 2		
	Postunit Average	Delayed Average	% Change	Postunit Average	Delayed Average	% Change	Postunit Average	Delayed Average	% Change
Low	20.6	21.3	3.4	26.9	26.3	-2.2	22.5	26.3	16.9
Mid	21.3	34.4	61.5	36.3	36.3	0.0	38.1	36.9	-3.1
High	54.4	67.5	24.1	82.5	78.8	-4.5	71.9	66.9	-7.0
All	32.1	41.0	27.7	48.5	47.1	-2.9	44.2	43.3	-2.0

Table 5 shows that the low-achieving group had the greatest average percent change in treatment unit 2 and a negative average percent change in treatment unit 1. These data indicate that the L/G instruction helped to improve low-achieving students' knowledge of vocabulary in treatment unit 2. Not only did they not forget, they actually increased their knowledge during treatment unit 2, indicating that they continued to think about and use the vocabulary after instruction was completed. The high-achieving students had the most negative average percent change in both treatment units, indicating that the L/G instruction was least helpful to them. Overall, the treatment appears to have

helped the low-achieving students the most for long-term memory of concepts. However, the greatest average percent change for the middle and high-achieving students was in the nontreatment unit, indicating that the L/G instruction did not improve these students' long-term memory of science vocabulary. The large gains in knowledge from the postunit to the delayed assessments were most likely the result of carryover of concepts from the nontreatment unit to treatment unit 1. The biotechnology concepts that the students learned during the two weeks between the postunit and delayed assessments may have helped them to better understand the genetic code concepts.

Data from the postunit and delayed assessments also allowed me to compare the average percent change for questions in the low, middle, and high levels of Bloom's taxonomy. As indicated in Table 6 below, the greatest average percent change for the low and high-level questions was in the nontreatment unit. These data indicate that the L/G instruction did not improve long-term memory for knowledge, synthesis, or evaluation questions.

Table 6
Comparison of Postunit and Delayed Assessment Average Scores and Percent Change According to Bloom's Taxonomic Level (N=52)

Level of Cognition	Nontreatment			Treatment 1			Treatment 2		
	Postunit Average	Delayed Average	% Change	Postunit Average	Delayed Average	% Change	Postunit Average	Delayed Average	% Change
Low	41.9	51.0	21.7	63.9	57.7	-9.7	55.2	53.9	-2.4
Mid	46.2	47.6	3.0	57.2	60.1	5.1	40.9	31.3	-23.5
High	31.7	40.4	27.4	56.7	51.9	-8.5	69.2	58.7	-15.2
All	41.7	48.8	17.0	61.3	57.6	-6.0	53.4	48.8	-8.6

The data for the middle-level questions are more difficult to interpret. In the nontreatment unit, the middle-level questions had the lowest average percent change. The average percent change for these questions in treatment unit 1 was slightly higher, and

was actually the greatest positive average percent change of all cognitive levels.

However, the average percent change in treatment unit 2 was the most negative of all cognitive levels (-23.5). These inconsistent data seem to indicate that the L/G instruction slightly improved students' long-term memory for application and analysis questions in treatment unit 1, but not treatment unit 2.

Pre and posttreatment survey data were also compared to determine the effects of L/G instruction on students' long-term memory of vocabulary. Average responses for the question regarding students' long-term memory of life science vocabulary are compared for low-achieving, middle-achieving, and high-achieving students in Figure 3 below.

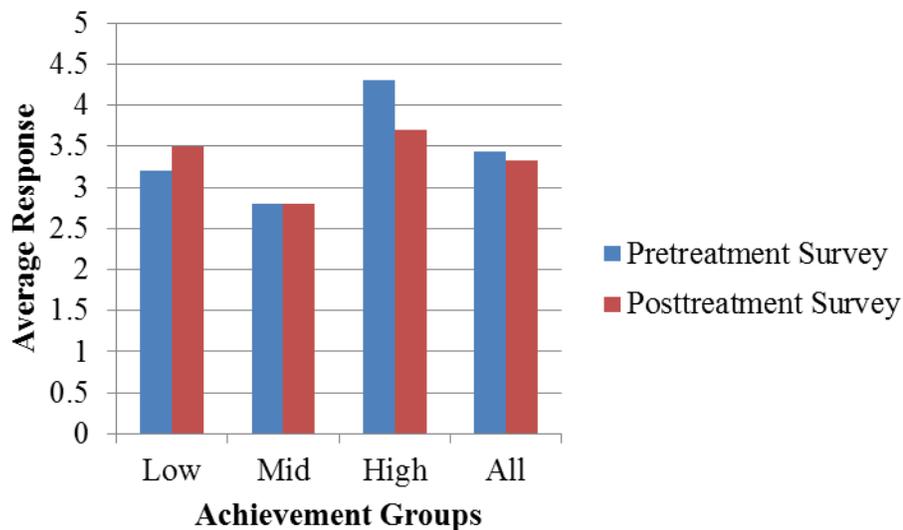


Figure 3. Average response to pre and posttreatment survey question concerning long-term memory of life science words by low-achieving students ($n=10$), middle-achieving students ($n=10$), high-achieving students ($n=10$), and all students ($N=30$). *Note.* 5 = Very Strong, 4 = Strong, 3 = Some, 2 = Very Little, 1 = None.

The average response of low-achieving students was higher on the posttreatment survey than on the pretreatment survey, indicating that these students perceived their long-term memory of vocabulary to have increased during the intervention. The middle-achievement group showed no change and the high-achievement group had a lower

average response on the posttreatment survey than on the pretreatment survey. These data indicate that the L/G instruction did not improve middle-achieving students' perception of their long-term memory of vocabulary and had a negative effect on high-achieving students.

The posttreatment survey also included a question that required students to rate how much the L/G instruction affected their long-term memory of vocabulary. A comparison of the average response for students in low, middle, and high-achieving groups can be found in Figure 4 below. The data show that the middle-achieving group had the lowest average response, indicating that it was least helpful for these students. Figure 4 also shows that the average response was highest for the high-achieving group.

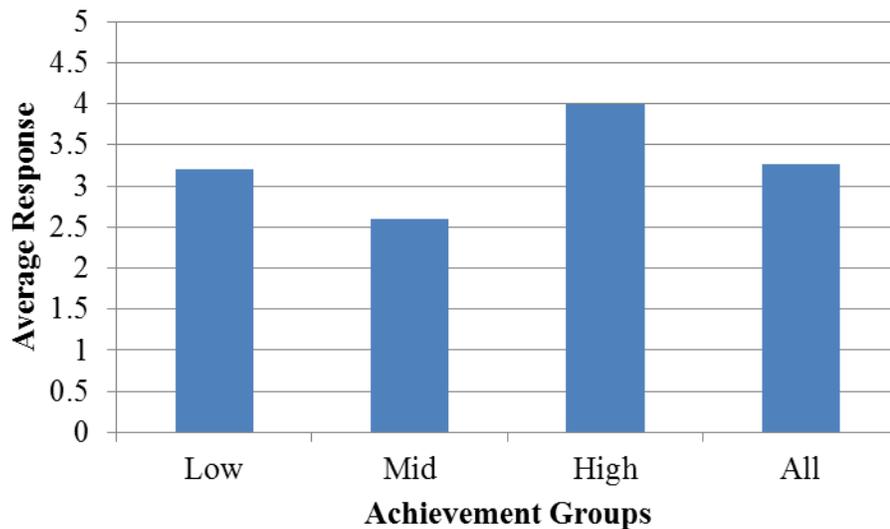


Figure 4. Average response to posttreatment survey question concerning how much L/G instruction affected long-term memory of vocabulary by low-achieving students ($n=10$), middle-achieving students ($n=10$), high-achieving students ($n=10$), and all students ($N=30$). *Note.* 5 = Very Much, 4 = Much, 3 = Some, 2 = Very Little, 1 = None.

These data indicate that high-achieving students perceived the L/G instruction as helpful to their long-term memory, despite the fact that they reported a decrease in long-term memory after the intervention. Some of the students' written responses indicate that

they were not completely confident in their long-term memory of vocabulary, but that the L/G instruction was helpful to them. One student wrote, “Writing down definitions helps, but memory isn’t always permanent. It helps me memorize the vocabulary more than just studying a paper.”

Finally, postunit and delayed concept interview data were analyzed to determine the effects of L/G instruction on students’ long-term memory of science vocabulary. The average postunit and delayed concept map scores and percent change are compared by student achievement group in Table 7 below. The average percent change for the middle and high-achievement groups was lower in both treatment units than in the nontreatment unit. These data indicate that the L/G instruction did not promote long-term memory of vocabulary for these students.

Table 7
Average Scores and Percent Change from Postunit to Delayed Interview Concept Map for All Units by Low-Achieving (n=2), Mid-Achieving (n=2), and High-Achieving Groups (n=2) and All Students (N=6)

Group Description	Nontreatment			Treatment 1			Treatment 2		
	Postunit Average	Delayed Average	% Change	Postunit Average	Delayed Average	% Change	Postunit Average	Delayed Average	% Change
Low	26.5	27.9	5.3	34.3	65.7	91.5	75.0	51.9	-30.8
Mid	33.8	55.9	65.4	71.4	71.4	0.0	98.1	96.2	-1.9
High	55.9	72.1	29.0	58.6	71.4	21.8	100.0	96.2	-3.8
All	38.7	52.0	34.4	54.8	69.5	26.8	91.0	81.4	-10.5

Table 7 also shows that the low-achieving students went from having the lowest average percent change of all achievement groups in the nontreatment unit to the highest average percent change in treatment unit 1. However, in treatment unit 2 they had the most negative average percent change of all achievement groups. These data indicate that the L/G instruction improved low-achieving students’ long-term memory of vocabulary

in treatment unit 1, but not in treatment unit 2. This may be due to carryover of concepts from the nontreatment unit to treatment unit 1.

Students' oral responses to interview questions regarding long-term memory are mixed as well. Many students stated that knowledge of L/G morphemes improved their long-term memory of science vocabulary. One student said, "I can think of the different parts of the word, prefixes and suffixes, and combined, I can know what the whole word means." Other students said that L/G instruction did not affect their long-term memory.

In summary, the data indicate mixed results about the impact of L/G instruction on long-term memory of science vocabulary in low-achieving students. The assessment data show that low-achieving students' long-term memory improved only in treatment unit 2, whereas the concept map data show an improvement only in treatment unit 1. Additionally, one survey question indicates that the L/G instruction was most helpful to low-achieving students. However, one posttreatment survey question indicates that the L/G instruction was most helpful to high-achieving students. These data are inconsistent with the other data for this subquestion.

In order to determine the effects of L/G instruction on students' ability to predict the meaning of new vocabulary, data from pre and postunit assessments, pre and posttreatment surveys, and pre and postunit concept interviews were analyzed. The treatment unit assessments featured a question that required students to predict the meaning of three new words that included one or more L/G morphemes taught during that unit. In the nontreatment unit assessments, the new words contained L/G morphemes that were not explicitly taught, but that were parts of vocabulary words taught during the

unit. Table 8 below shows the average pre and postunit scores for this question for all units compared by achievement groups.

Table 8
Average Prediction Scores and Percent Change from Pre to Postunit Assessment for All Units by Low-Achieving (n=10), Mid-Achieving (n =10), and High-Achieving Groups (n =10) and All Students (N=30)

Group Description	Nontreatment			Treatment 1			Treatment 2		
	Preunit Average	Postunit Average	% Change	Preunit Average	Postunit Average	% Change	Preunit Average	Postunit Average	% Change
Low	3.3	6.7	103.0	5.0	5.0	0.0	8.3	11.7	41.0
Mid	8.3	8.3	0.0	3.3	10.0	203.0	18.3	20.0	9.3
High	18.3	16.7	-8.7	13.3	45.0	238.3	35.0	41.7	19.1
All	10.0	10.6	6.0	7.2	20.0	177.8	20.6	24.4	18.4

Table 8 shows that the middle and high-achievement groups had a higher average percent change during the treatment units than during the nontreatment unit. These data indicate that the L/G instruction did help the middle and high-achieving students to predict the meaning of new vocabulary. The data for the low-achieving group is more difficult to interpret. The highest average percent change for the low-achieving students was during the nontreatment unit, indicating that the L/G instruction was not helpful to these students for predicting the meaning of new vocabulary. However, in treatment unit 2 the low-achieving group showed the highest average percent change of all groups.

The pre and posttreatment surveys included a question that required students to rate their ability to predict the meaning of new vocabulary on a Likert scale. The average response for this question is compared for all achievement groups in Figure 5. The low and high-achievement groups had a higher average score on the posttreatment survey than on the pretreatment survey, indicating that students perceived that L/G instruction helped them to predict the meaning of new vocabulary better.

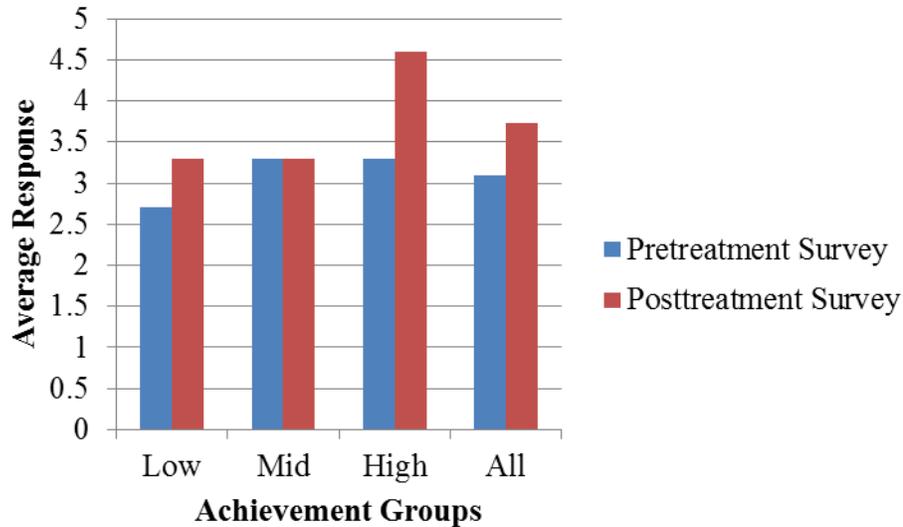


Figure 5. Average response to pre and posttreatment survey question regarding students' perception of their ability to predict new vocabulary by low-achieving students ($n=10$), middle-achieving students ($n=10$), high-achieving students ($n=10$), and all students ($N=30$). *Note.* 5 = Very Much, 4 = Much, 3 = Some, 2 = Very Little, 1 = None.

The posttreatment survey also included a question that asked students how much the L/G instruction affected their ability to predict the meaning of new vocabulary. The average response for this question is compared for all achievement groups in Figure 6.

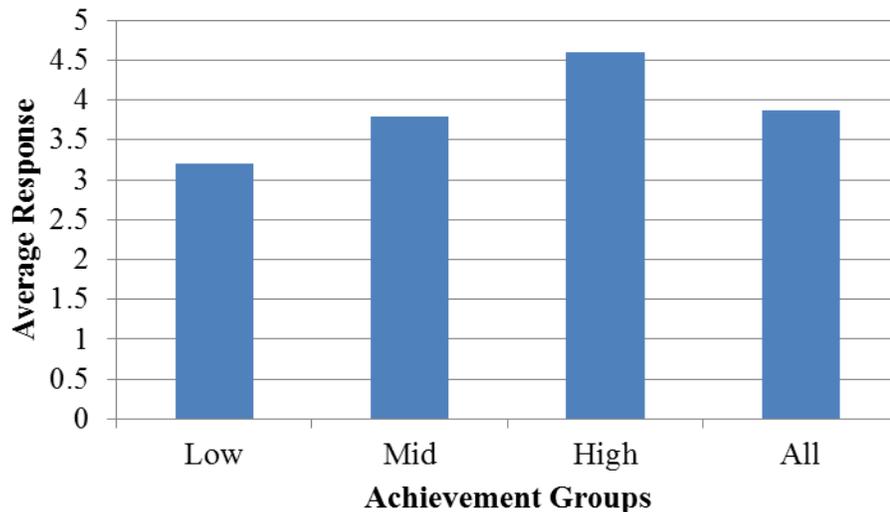


Figure 6. Average response to posttreatment survey question concerning students' perception of how much L/G instruction affected ability to predict new vocabulary by low-achieving students ($n=10$), middle-achieving students ($n=10$), high-achieving students ($n=10$), and all students ($N=30$). *Note.* 5 = Very Much, 4 = Much, 3 = Some, 2 = Very Little, 1 = None.

All groups reported an effect of “some” or greater, with the high-achieving group affected the greatest and the low-achieving group the least. Many of the students commented that knowing the L/G morphemes enabled them to piece together new words and generate a definition.

In addition to the assessments and surveys, concept interviews were used to determine the effects of L/G instruction on students’ ability to predict the meaning of new vocabulary. As part of each interview for the treatment units, students completed a concept map featuring new words comprised of one or more of the L/G morphemes that were taught in that unit. The concept map for the nontreatment unit featured words that included L/G morphemes that were part of the science vocabulary for that unit, but were not explicitly taught. The average pre and postunit concept map scores and percent change for each unit are compared by achievement group in Table 9 below.

Table 9
Average Prediction Scores and Percent Change from Pre to Postunit Interview Concept Map for All Units by Low-Achieving (n=2), Mid-Achieving (n=2), and High-Achieving Groups (n=2) and All Students (N=6)

Group Description	Nontreatment			Treatment 1			Treatment 2		
	Preunit Average	Postunit Average	% Change	Preunit Average	Postunit Average	% Change	Preunit Average	Postunit Average	% Change
Low	79.2	20.8	-73.7	35.4	79.2	123.7	35.4	60.4	70.6
Mid	66.7	43.8	-34.3	60.4	89.6	48.3	100.0	100.0	0.0
High	75.0	68.8	-8.3	33.3	60.4	81.4	95.8	79.2	-17.3
All	73.6	44.4	-39.7	43.1	76.4	77.4	77.3	79.9	3.4

The average percent change of the low and middle-achievement groups was greater for both treatment units than for the nontreatment unit. These data indicate that the L/G instruction did help these students to better predict the meaning of new vocabulary. Additionally, in both treatment units the low-achieving students showed the greatest average percent change. For treatment unit 1, the high-achieving students

showed a greater average percent change than for the nontreatment unit. However, they had a negative average percent change for treatment unit 2. This was due to a decrease in the structural quality of the concept maps, such as fewer levels of hierarchy. The high-achieving students did use the L/G morphemes and their meanings correctly in the pre and postunit concept maps for treatment unit 2. Therefore, these data do not make it clear whether or not the high-achieving students benefitted from the L/G instruction in their ability to predict the meaning of new vocabulary. Additionally, the negative percent change for the nontreatment unit is mostly due to the poor structure of the postunit concept maps. The students' use of hierarchy was poor and they omitted some vocabulary terms and L/G morphemes entirely. Again, they may have rushed through the concept maps due to their dislike of them. Therefore, the nontreatment postunit concept maps may not accurately represent the students' full prediction capabilities.

The concept interviews also included a question that asked students how the L/G instruction affected their ability to predict new vocabulary. The majority of students from all achievement groups responded that they were better able to define new words by piecing together the meanings of the L/G morphemes that comprise them. One student said, "Since I know what L/G words are, if a word would have it I'm able to make sense of what it means."

The assessment, survey, and concept interview data mostly indicate that the L/G instruction had a positive effect on students' ability to predict the meaning of new vocabulary. However, some of the data are inconclusive. The pre and postunit assessment data indicate that the L/G instruction did help middle and high-achieving students to predict the meaning of new vocabulary. I was unable to determine the effects of L/G

instruction on the middle-achievement group from the assessment data. Students' responses to the pre and posttreatment survey questions indicate that the L/G instruction was beneficial to high and low-achieving students. Again, the data for middle-achieving students were inconclusive; some data indicate that the L/G instruction had a positive effect and some data indicated no effect. Finally, the concept interview data indicate that the L/G instruction was helpful to low and middle-achieving students, but the data for high-achieving students were inconclusive.

Data from the pre and posttreatment surveys, peer observations, and my observations and field notes were analyzed to determine the effects of the L/G instruction on students' attitudes and motivation. The surveys included questions that used a Likert scale. Average responses to the survey questions regarding attitudes and motivation are shown in Figure 7 and Figure 8 respectively. In each figure, the average responses are compared for the pre and posttreatment surveys by student achievement group.

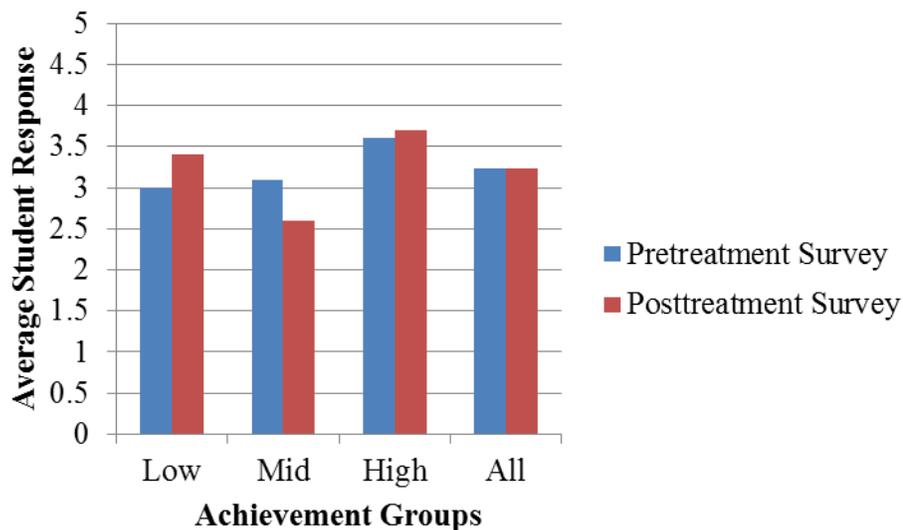


Figure 7. Average response to pre and posttreatment survey question regarding how students felt about learning vocabulary compared among low-achieving students ($N=10$), middle-achieving students ($N=10$), high-achieving students ($N=10$), and all students ($N=30$). *Note.* 5 = Very excited, 4 = Fairly excited, 3 = Some excitement, 2 = Little excitement, 1 = Not excited.

As indicated in Figure 7, the low-achieving group showed the greatest increase in excitement. The middle-achievement group showed less excitement on the posttreatment survey, indicating that the L/G instruction had a negative effect on their attitudes toward learning vocabulary.

As indicated in Figure 8 below, high-achieving students showed a slightly higher level of motivation to learn vocabulary on the posttreatment survey than on the pretreatment survey, indicating that the L/G instruction had a slightly positive effect on their motivation. However, the middle and low-achieving groups showed decreased levels of motivation on the posttreatment survey. Just as with the level of excitement, middle-achieving students experienced the greatest decrease. These data indicate that the L/G instruction had a negative effect on low and middle-achieving students' motivation to learn vocabulary.

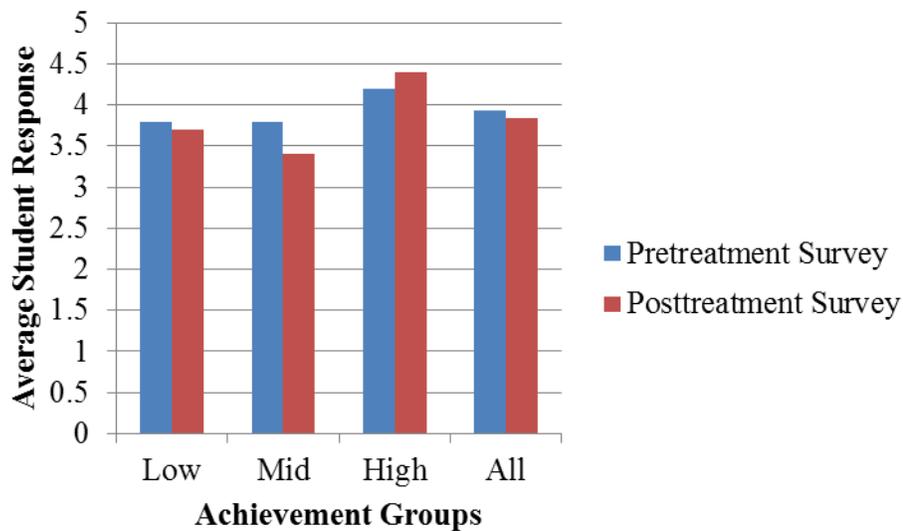


Figure 8. Average response to pre and posttreatment survey question regarding students' motivation to learn vocabulary compared among low-achieving students ($N=10$), middle-achieving students ($N=10$), high-achieving students ($N=10$), and all students ($N=30$).
Note. 5 = Very Much, 4 = Much, 3 = Some, 2 = Very Little, 1 = None.

The posttreatment survey also asked students, how has the L/G vocabulary instruction changed the way you feel about learning life science vocabulary? Another question was, how has the L/G vocabulary instruction changed your level of motivation to successfully learn life science vocabulary? The average responses are compared by achievement group in Figure 9 below. For both questions, low-achieving students indicated the greatest change and middle-achieving students the least. Many students commented that the L/G instruction made learning science vocabulary easier and more enjoyable. Some students stated that the L/G instruction did not significantly change their attitudes regarding vocabulary instruction.

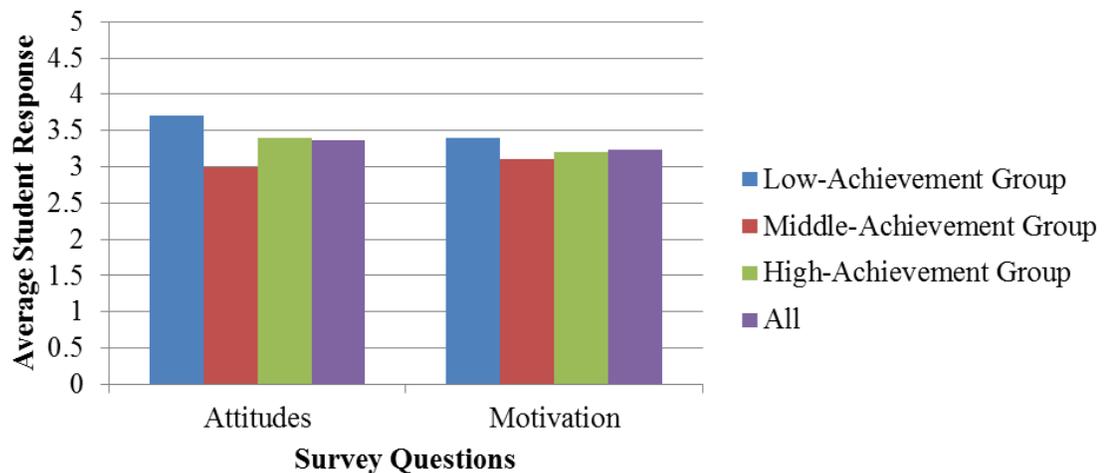


Figure 9. Average response to postunit survey question concerning how much L/G instruction changed the attitudes and motivation of low-achieving students ($N=10$), middle-achieving students ($N=10$), high-achieving students ($N=10$), and all students ($N=30$). *Note.* 5 = Very Much, 4 = Much, 3 = Some, 2 = Very Little, 1 = None.

Field notes from my observations during vocabulary instruction provided data about students' participation, engagement, attitudes, and motivation. Observations were conducted once every three days for 10 minutes each time. My responses for questions using a Likert scale were averaged for each unit and are shown in Figure 10.

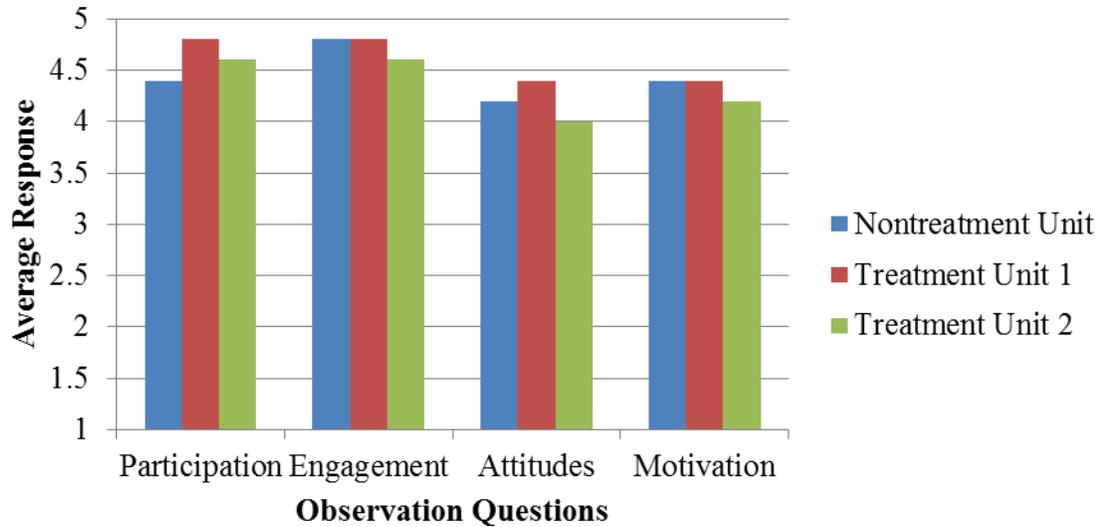


Figure 10. Average response to observation questions regarding students' participation, engagement, attitudes, and motivation towards learning vocabulary during the nontreatment unit ($n=5$), treatment unit 1 ($n=5$), and treatment unit 2 ($n=5$). *Note.* 5 = Strong, High, or Very Positive, 4 = Moderate, 3 = Neutral, 2 = Slightly, 1 = None or Negative.

Figure 10 shows that students' participation and attitudes were higher in treatment unit 1 than in the nontreatment unit. Students' engagement and motivation remained the same for both units. The data show a decrease in all four categories during treatment unit 2, with attitudes, engagement, and motivation reaching their lowest point during the intervention. There was a decrease in participation, but it still remained higher than during the nontreatment unit. These data indicate that the L/G instruction had a positive effect on students' attitudes and no effect on their motivation during treatment unit 1, and a negative effect on both during treatment unit 2. My field notes indicate that students' initial excitement over the L/G instruction was due to its novelty. As the intervention wore on, students' excitement declined and they did not enjoy writing extra definitions. However, they did seem to enjoy making predictions of the science vocabulary definitions throughout the entire intervention.

In addition to the student surveys and my observations, three peer observations were conducted to determine the effects of L/G instruction on students' attitudes and motivation. The observations featured questions that used a Likert scale. The peer responses to these questions are compared by unit in Figure 11 below.

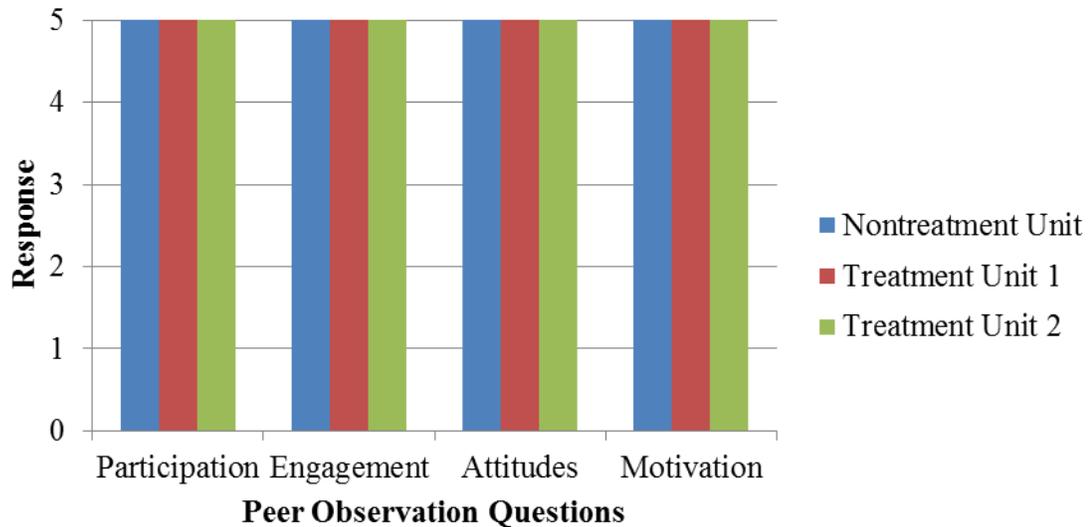


Figure 11. Response to peer observation questions regarding students' participation, engagement, attitudes, and motivation towards learning vocabulary during the nontreatment unit ($n=1$), treatment unit 1 ($n=1$), and treatment unit 2 ($n=1$). *Note.* 5 = High or Strong, 4 = Moderate, 3 = Neutral, 2 = Slightly, 1 = None.

For each observation, students' level of participation and engagement were rated as strong or high. The students also maintained positive attitudes and high motivation throughout the intervention. When describing students' participation and engagement, one peer commented, "Students were leaning forward, writing actively and listening with interest." Regarding students' attitudes and motivation, one peer stated, "By asking as well as responding to questions, it was apparent to this observer that the students are interested in learning the science vocabulary." These comments give further indication that students' attitudes were positive and their motivation to learn the vocabulary was high.

In summary, the data are inconclusive regarding the effects of L/G instruction on students' attitudes and motivation. The survey data indicate that the L/G instruction promoted positive attitudes in low and high-achieving students, but resulted in more negative attitudes for middle-achieving students. The L/G instruction also raised the motivation of high-achieving students, but lowered the motivation of middle and low-achieving students. My observations and field notes indicate that the L/G instruction initially promoted positive attitudes in treatment unit 1, but led to negative attitudes during treatment unit 2. Additionally, the L/G instruction had a negative effect on students' motivation. Finally, the peer observation data indicate that students' attitudes and motivation remained high throughout the intervention.

Data from peer observations, a self-evaluation, and my journaling were analyzed to determine the effects of L/G instruction on my teaching and attitudes to teaching. Peer responses to questions regarding my attitude and motivation to teaching are compared for each observation in Figure 12 below.

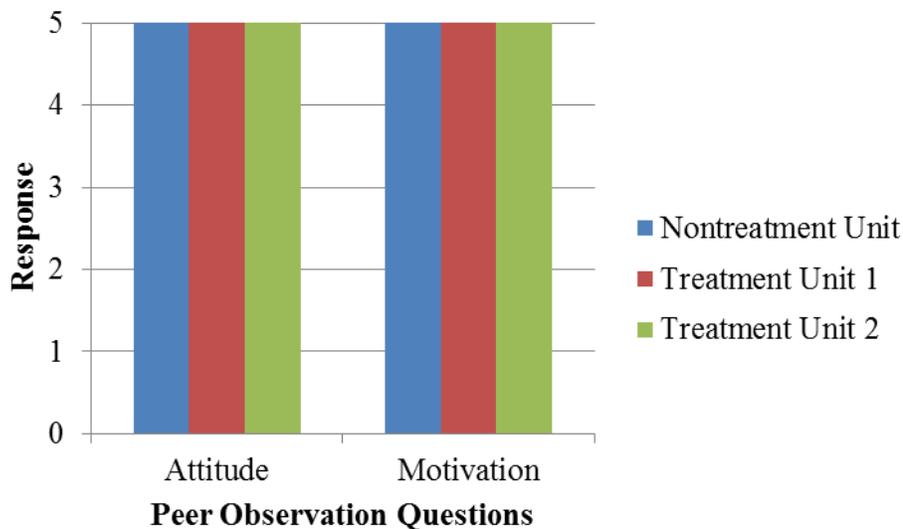


Figure 12. Response to peer observation questions regarding my attitude to teaching during the nontreatment unit ($n=1$), treatment unit 1 ($n=1$), and treatment unit 2 ($n=1$). *Note.* 5 = Very Much, 4 = Much, 3 = Some, 2 = Very Little, 1 = None.

The data in Figure 12 indicate that my motivation was high and my attitudes to teaching remained positive throughout the intervention. One peer commented, “He engages students in a variety of ways, using creativity to reel in their attention, having hands on activities to show them the joy of science, as well as the very structured activities that are needed, such as vocabulary instruction.” Another peer stated, “It is obvious (to the students) that this is important information and necessary for their future success in class.” These comments indicate that my belief in the importance and relevance of the L/G instruction was communicated effectively to the students.

To provide further insight into my attitudes and motivation, I completed a self-evaluation at the end of the intervention. My responses to the four questions utilizing a Likert scale are in Figure 13 below. I reported a moderate level of confidence regarding my teaching. I also responded that I felt slightly pressured to teach content material before L/G instruction.

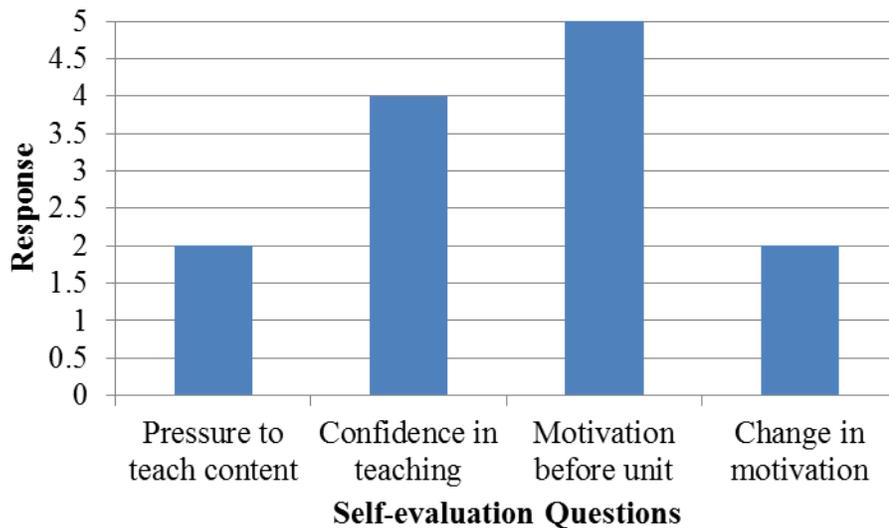


Figure 13. Response to self-evaluation questions ($N=1$). *Note.* 5 = Strong, High, or Very Much, 4 = Moderate or Much, 3 = Neutral, 2 = Slightly or Little, 1 = Very Little or None.

Comments from my journaling expound upon these feelings. Throughout the nontreatment unit my journal comments expressed an eagerness to implement L/G instruction. I wrote, “Transcription and replication would be so much easier for them to understand if I could teach the L/G morphemes now.” During treatment unit 1 my comments indicate a mostly positive attitude toward the L/G instruction. However, towards the end of treatment unit 1 and throughout treatment unit 2 my journaling indicates that I sometimes felt pressured to teach content material over the L/G instruction. This pressure arose when I started falling behind the other sixth grade science teacher. I wrote that, “I enjoy teaching the L/G words, meanings, and examples, but sometimes I would rather skip the predictions.”

Figure 13 also shows that at the beginning of the intervention I was highly motivated to implement L/G instruction. By the end of the intervention, however, I was slightly less motivated. My journal comments indicate that this decrease in motivation is partly due to the pressure that I was feeling from falling behind in my curriculum. Additionally, my confidence in the effectiveness of the L/G instruction in promoting vocabulary understanding seems to have decreased. I wrote, “It doesn’t seem to be as helpful as I thought it would be. However, maybe I am just planting seeds that may grow throughout the students’ lives.” I began to feel that the L/G instruction may not be extremely beneficial to vocabulary understanding immediately, but I still believed that continued L/G instruction over years would be very helpful.

In summary, the data from the peer observations indicate that my attitudes toward teaching remained positive throughout the intervention. However the self-evaluation and my journaling indicate that my attitude toward the L/G instruction declined during the

intervention. This decline was partly due to pressure from falling behind in my curriculum and because I did not perceive the L/G instruction to be as helpful to students' understanding as I thought it would be.

INTERPRETATION AND CONCLUSION

In carrying out this project and analyzing the data, I have learned much about the effects of L/G instruction on sixth-grade students' understanding of life science vocabulary. The survey and concept interview data show that the L/G instruction increased students' vocabulary understanding. However, the assessment data show the opposite. These conflicting data make it difficult to answer my focus question conclusively. However, it is obvious that the students perceived the L/G instruction to be helpful to their vocabulary understanding.

One factor that could have affected the assessment results is the level of difficulty of the vocabulary in each unit. Students' low preunit assessment scores in the nontreatment unit indicate that the genetic code vocabulary was difficult for them. Their higher scores on the biotechnology and evidence for evolution preunit assessments indicate that these vocabulary terms were not as difficult for them, or that the students had greater prior knowledge.

Additionally, there was some carryover of concepts from the genetic code unit to the biotechnology unit, but there was little or no carryover of concepts to treatment unit 2. This most likely caused the high percent change between the nontreatment postunit and delayed assessment scores and the low percent change between the postunit and delayed

assessments and concept maps for treatment unit 2. In an ideal situation, it would be best for the vocabulary in each unit to be equal in difficulty and completely discrete.

However, the demands of my school district's science curriculum did not allow me to choose units more consistent in difficulty or different in subject matter.

Another factor is that the students did not seem to grasp the full usefulness of learning L/G morphemes. Throughout the intervention, questions on assignments required students to reflect on how their knowledge of particular L/G morphemes affected their understanding of a particular science vocabulary term. In most cases the students did not reflect very deeply, simply stating that memorizing small parts of a word made it easier to remember the meaning of the whole word. They did not reflect on the conceptual link between science vocabulary and the L/G morphemes that they are derived from. In essence, the students may not have utilized the etymology to its full value, as advocated by Sarma (2004, 2006).

This project has also yielded information about the effects of L/G instruction on students' long-term memory of vocabulary. According to the data, the L/G instruction seemed to improve the long-term memory of low-achieving students only. Additionally, this improvement was inconsistent across both treatment units. A possible explanation is that since low-achieving students typically have the most difficulty with vocabulary retention, they may have utilized the L/G morphemes more heavily than the middle and high-achieving students. In actuality, I cannot fully explain the discrepancy between these data and the literature (Graves, 1986; Otterman, 1955). It is possible that because the students did not make strong conceptual links among the L/G morphemes and science

vocabulary, as stated earlier, they were reduced to remembering the L/G morphemes as disparate words instead of as parts of larger words.

The data are more optimistic in regards to the effects of L/G instruction on students' ability to predict the meaning of new vocabulary. In general, the data indicate that all students benefitted from the L/G instruction to some degree, with the most evidence for the middle-achieving students. One possible explanation is that the students relied completely on the L/G instruction to help them with vocabulary prediction because they had no other strategy to help them with it, whereas, with understanding and long-term memory of vocabulary the students could choose to utilize other study and memorization strategies.

However, I think that the students benefitted the most from the predicting aspect of the L/G instruction because it was presented in class such a way that they could not fail. Whenever the students were predicting the meaning of new vocabulary I stressed to them that any prediction was a good one, as long as they were using the L/G morphemes. Having no fear of failure, the students really enjoyed predicting the meaning of new vocabulary terms and were excited to share them aloud. This experience of success may have put a more positive light on this use of the L/G instruction. In turn, this may have prompted the students to utilize the L/G morphemes more on the prediction sections of assessments and concept interviews than on the understanding sections.

Finally, the project provided much insight into students' attitudes and motivation and my teaching and attitude to teaching in regards to vocabulary instruction. My observations showed that the students enjoyed using the L/G morphemes to predict the definitions of new vocabulary terms. Most of the other data suggest that the L/G

instruction had little effect on students' attitudes and motivation. Some data indicate a slightly positive effect, but other data show a slightly negative effect. There is even some indication that students' attitudes improved a little in treatment unit 1, but declined in treatment unit 2. As with many new strategies, the students may have been initially excited. However, as the novelty wore off, the students found the L/G instruction no more exciting than the traditional vocabulary instruction.

Likewise, my attitude to the L/G instruction was initially very positive. Partway through the treatment, however, I began to fall behind the other science teacher in the curriculum and felt pressured to teach content material over the L/G instruction, much like the attitudes of teachers described by Fang et al. (2008). I also fed off of the students' subtly declining excitement. As the assessment data were collected, I became less convinced of the effectiveness of L/G instruction in promoting student understanding of vocabulary. As explained by Guskey (1986), this belief negatively affected my attitudes.

One thing that I have learned regarding the overall purpose of the project is that 10 weeks is too short a time to effectively evaluate the effects of L/G instruction on student learning. I believe that a short-term study such as mine may not yield results sufficient to affirm or discredit L/G instruction. This is because factors that would significantly affect a short-term study, such as the novelty of the intervention, the vocabulary being more difficult in one unit than another, and carryover of concepts among units, would not produce drastic effects in a long-term study. As suggested by Rasinski et al. (2011), L/G instruction should begin in elementary school and continue through high school. A study over the course of several years would provide more insight into the true effects of continued L/G instruction on students' vocabulary learning.

Additionally, this project did not study the effects of implementing L/G and MA instruction in conjunction with instruction in contextual analysis on student learning, as advocated by Baumann et al. (2003) and Baumann et al. (2002). Further study could determine whether these strategies, when used together, promote student understanding and long-term memory of science vocabulary, and improve their ability to predict the meaning of new vocabulary. Their combined effects may also change students' and teachers' attitudes and motivation in regards to vocabulary instruction.

In analyzing the data for this project I identified one change that I would make to the data collection instruments. When designing the concept maps for the interviews, I set a maximum point value for each one based on the number of vocabulary terms and L/G morphemes that were specifically listed for students to include. Some students scored 100% on both preunit and postunit concept maps. The maximum point value did not allow students to demonstrate their full capabilities in using L/G morphemes. If I were to do it again, I would encourage students to add in other vocabulary and L/G morphemes that they know and not have a pre-defined maximum point value. Additionally, I would try new strategies to promote more positive student attitudes towards concept mapping.

VALUE

The results of this project have implications for my teaching and for my students. The data show that the most beneficial application of L/G instruction is to aid in predicting the definitions of new vocabulary terms. Additionally, the students enjoyed this aspect of the treatment greater than any other. In light of these results, I will continue

to teach L/G morphemes and encourage the students to use them for predicting new vocabulary definitions. I will incorporate this vocabulary acquisition strategy into my arsenal of regularly used teaching strategies. The students will continue to develop and define their skills at prediction using new L/G morphemes. However, I will not rely heavily on L/G instruction to aid in student understanding or long-term memory of vocabulary. These skills may one day benefit from L/G instruction, but probably only after its long-term continued application.

Moving forward, I have learned that my project topic is actually much more complicated than I perceived it to be at the beginning of the project. It is now apparent that a teacher may not see immediate measurable effects from L/G instruction on learning. I believe that further research could be conducted after a pervasive L/G instruction program is in place across several grade levels. My next step will be to collaborate with my school district's secondary literacy coach and my science department colleagues in the middle and high schools in an effort to promote continued L/G instruction beyond sixth-grade. I will also encourage elementary teachers to begin L/G instruction at early grades.

I believe that my results could be used as a starting point for other classroom researchers. The treatment strategies and data collection instruments that I developed were research-based and could be adapted for any subject. However, I do not feel that my results are generalizable to other classrooms or schools. My results were not consistent with the literature, possibly due to uncontrollable factors specific to my classes and curriculum.

The most interesting component of this project was that the students thoroughly enjoyed the vocabulary prediction exercises. I mentioned this to a reading teacher and she said that her students enjoy predicting meanings of words as well. I was also surprised that the students already had some experience breaking multimorphemic words down into their prefixes, suffixes, and root words. This strategy was also taught in reading class. In light of my school district's current literacy initiative, it seems appropriate to collaborate with reading teachers to gain a greater understanding of the vocabulary acquisition strategies that they use. By using consistent strategies, we may better promote vocabulary learning and understanding.

The most challenging thing for me was carrying out an intense year-long project while holding a full-time job and meeting other pre-existing obligations to my family, friends, and church. At times I experienced great anxiety, which manifested itself physically as well. I learned that I no longer have the luxury of devoting all of my time and energy to one task, as I did with my education in college. Completing this project has prompted me to seek a balance in meeting all my obligations, and to manage long-term commitments more wisely.

In conclusion, I have learned much about myself and my students that will make me a better teacher and person. L/G instruction, though the focus of this project, is but one strategy of many that I use to help students learn. My understanding of how students learn and their attitudes to learning that were gleaned from this project will carry over to many of my teaching strategies, making me a more conscientious teacher. The students' understanding of how they learn will hopefully carry over to other classes and make them more conscientious learners.

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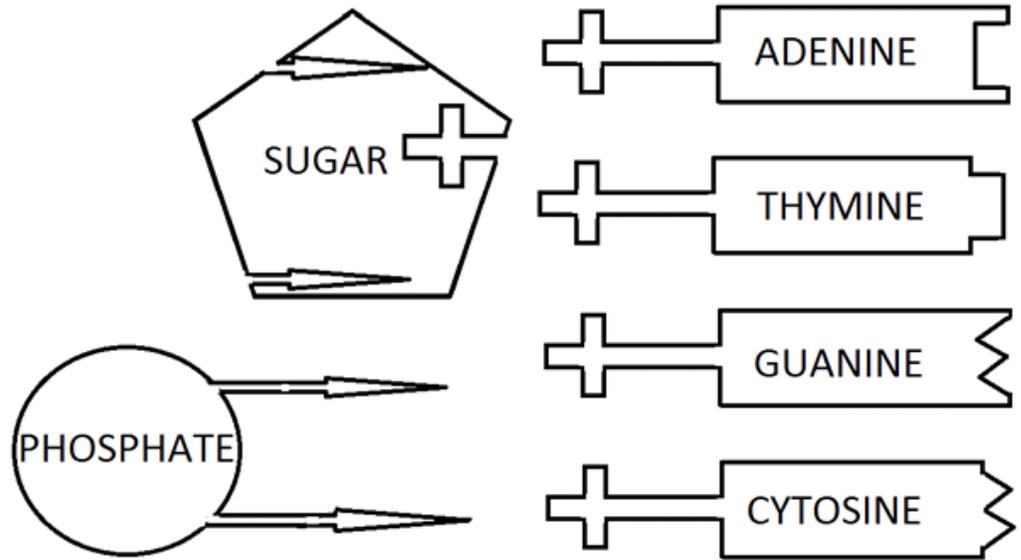
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APPENDICES

APPENDIX A

DNA PUZZLE PIECES



APPENDIX B

DNA GRAPHIC ORGANIZER

NAME: _____

Period: _____

DNA GRAPHIC ORGANIZER

1.) Label the empty boxes on the DNA diagram below.

2.) What is the shape of a DNA molecule? _____

3.) Circle a **nucleotide**.

4. What is the darkly shaded section called?

What are the lightly shaded sections called?

What is the darkly shaded section called?

phosphate	sugar	Adenine	_____	_____	
phosphate	_____				_____
phosphate	sugar	Cytosine	_____	_____	
phosphate	_____				_____
phosphate	sugar	Thymine	_____	_____	
phosphate	_____				_____
phosphate	sugar	Guanine	_____	_____	
phosphate	_____				_____

APPENDIX C

STUDENT SAMPLE NONTREATMENT UNIT VOCABULARY FLIP CHART

this shape describes the structure of DNA. It has 2 "sides" with "rungs" in the middle like a twisted ladder.

Double Helix

Sugar-phosphate backbone

Nitrogen base

Nucleotide

Protein Synthesis

Transcription

mRNA

Amino Acid

Translation

Mutation

APPENDIX D

VOCABULARY AND L/G MORPHEME WORD LIST

UNIT	LIFE SCIENCE VOCABULARY	L/G ROOTS AND AFFIXES
Nontreatment unit: The Genetic Code	nucleotide sugar-phosphate backbone nitrogen base mRNA protein synthesis transcription translation amino acid double helix mutation	none
Treatment unit 1: Practical Applications of Genetics and Biotechnology	gene splicing cloning DNA electrophoresis DNA fingerprinting DNA extraction biotechnology genetically modified organisms selective breeding	klon gen bio logy elektro phoresis tion extractus tekhno organon ism
Treatment unit 2: Evidence for Evolution	relative dating radiometric dating vestigial structure homology structural homology developmental homology common ancestry fossil half-life evolution Paleozoic Era Mesozoic Era paleontology	vestigium alis/al homo fossilis radius evolvere structura zoe mesos palaio era

APPENDIX E

STUDENT SAMPLE TREATMENT UNIT 1 CONCEPT MAP

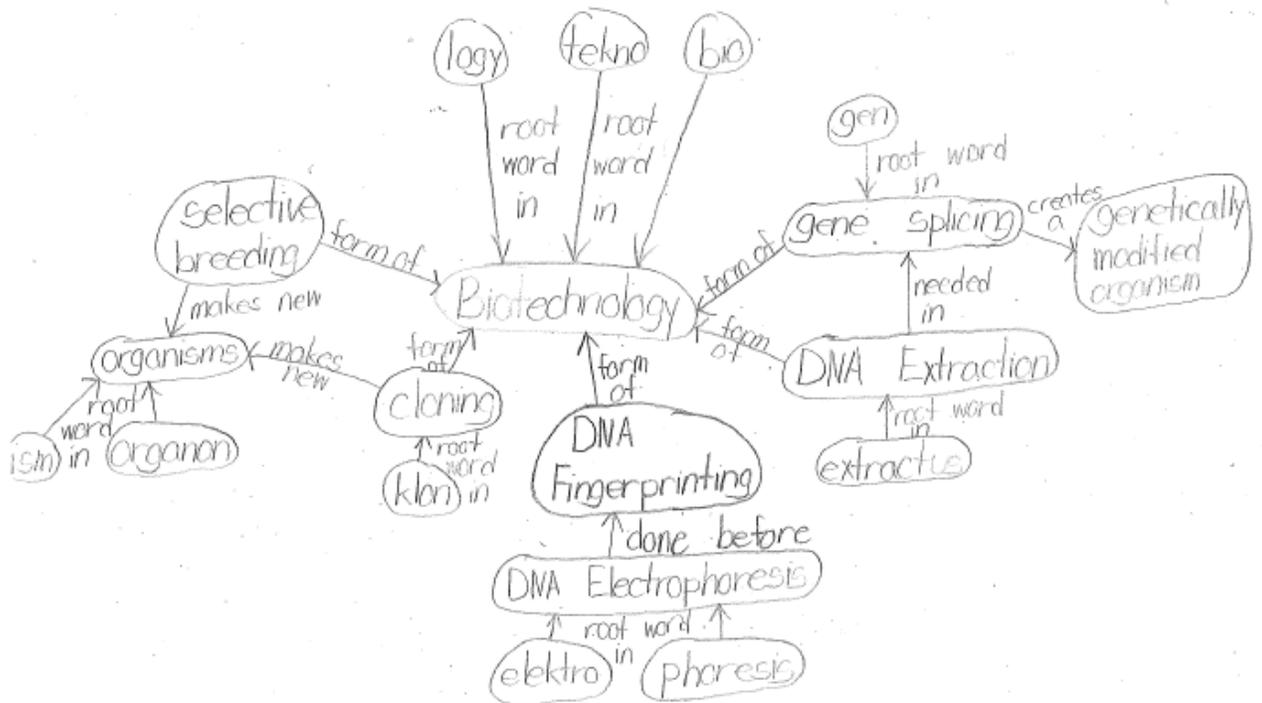
1.) Create a concept map to show your understanding of the relationship among the science vocabulary words and Latin/Greek word parts. Include all words in the boxes below. Make sure to use arrows to connect word bubbles/boxes and to write a word or two on each arrow to describe the relationship between the words connected by it.

Science vocabulary:

selective breeding	DNA extraction	biotechnology	DNA electrophoresis
DNA fingerprinting	cloning	genetically modified organism	gene splicing

Latin/Greek vocabulary:

gen	bio	klon	logy	elektro	extractus	tekno	organon	ism
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APPENDIX F

STUDENT SAMPLE NATURAL SELECTION LESSON

L/G MORPHEME WORD TREE

APPENDIX G

STUDENT SAMPLE TREATMENT UNIT 1 VOCABULARY

AND L/G MORPHEME FLIP CHART

Science Vocabulary

Selective Breeding

DNA extraction

Biotechnology

DNA electrophoresis

DNA fingerprinting

cloning

genetically modified organism

Gene Splicing

Latin/Greek Words

extractus

tion

bio

logy

tekhno

elektro

phoresis

klon

gen

organon

organon

ism

APPENDIX H

DNA EXTRACTION FROM STRAWBERRIES LAB

NAME: _____

Period: _____

DNA EXTRACTION FROM STRAWBERRIES LAB**SCIENTIFIC QUESTION:** Can we extract DNA from a strawberry?**RESEARCH:**

One of the reasons strawberries work so well for demonstrating DNA extraction is that they are soft and easy to smush. Also, ripe strawberries produce enzymes (proteins) that help to break down the cell walls to release the DNA. Another reason is that they have a lot of DNA. The native British wild strawberry is diploid - it has two sets of chromosomes like humans. However, the most commonly grown strawberry, *Fragaria ananassa*, is octoploid with eight sets. This makes it good for demonstrating DNA extraction - with eight copies of each chromosome, strawberries are packed full of DNA.

The detergent in the shampoo helps to dissolve the cell membrane and break down the organelles. The salt helps to separate DNA from the other proteins in the cells. DNA is not soluble in ethanol. When molecules are soluble, they are dissolved in the solution and are therefore not visible. When molecules are insoluble, they clump together and become visible. The colder the ethanol, the less soluble the DNA will be and the more it will clump together and be visible. This is why it is important for the ethanol to be kept in a freezer or ice bath.

HYPOTHESIS: We will / will not (circle one) be able to extract DNA from the strawberry.

MATERIALS: (per pair)

- Ziplok bag
- 1 strawberry
- Graduated cylinder
- DNA extraction liquid (soapy, salty water)
- Filtering apparatus: wire mesh, funnel, test tube
- Ice cold ethanol
- Stirring rod

PROCEDURE:

1. Put the strawberry into the Ziplok bag and smush for two minutes. You need to **completely** crush the strawberry. You do not want this mixture to be really bubbly. The less bubbles the better.
2. Measure 10 ml of DNA extraction liquid with the graduated cylinder. Pour it into the bag.
3. Smush for another minute. Be careful not to make too many soap bubbles.
4. Place the wire mesh over the funnel and put the funnel in the test tube.

5. Open the bag and pour some of the mixture through the mesh and allow it to filter into the test tube. **Allow only about 3 ml of liquid to filter through into the test tube.**
6. Next, Mr. Shotts will carefully pour ethanol into the test tube filling it to 8.5 ml.
7. The ethanol and soap mixture will form separate layers. Watch for the development of several large air bubbles that have a white cloudy substance attached to them **in between the two layers**. The cloudy substance is DNA!
8. Take the stirring rod and spin and stir it like you're making cotton candy. If you tilt the test tube, you'll get more DNA.
9. Pull out the DNA. It will look like mucus or egg white. As it dries, it will look like a spider web. The fibers are millions of DNA strands!

CONCLUSIONS:

1. My hypothesis was correct / incorrect (circle one).
2. What did the DNA look like? _____

3. How did your knowledge of the Latin/Greek words *extractus* and *tion* affect your understanding of the process of DNA extraction? _____

4. What was "drawn out" during the DNA extraction?

5. In the experiment, there was a solution of salt, soap, and water. Explain the purpose of the soap and salt to extracting the DNA. _____

6. Critical Thinking: Now that you have extracted DNA from the Strawberry, what would you, the young scientist, do with the "snot"? _____

7. A person cannot see a single cotton thread 100 feet away, but if you wound thousands of threads together into a rope, it would be visible. How does this statement relate to our DNA extraction?

8. What would be some scientific reasons for extracting DNA from human cells?

APPENDIX I

DNA FINGERPRINTING LAB

Name: _____

Period: _____

Crime Scene Investigation: DNA Fingerprinting**Scientific Question:** Who committed the crime?**Research:**

In courtrooms across the country, a genetic technique is being used to help solve crimes. As you know, no two people have the same fingerprints. Therefore detectives routinely use fingerprints found at a crime scene to help identify the person that committed the crime. Similarly, no two people, except for identical twins, have the same DNA. Therefore, DNA from samples of hair, skin, and blood can be used to identify a person. The technique of using DNA to identify a person is called *DNA fingerprinting*.

DNA fingerprints are made through the process of *DNA electrophoresis*. Samples of DNA are taken from all suspects to compare and from DNA found at a crime scene. Proteins called restriction enzymes cut each DNA strand into fragments, or small pieces, like tiny scissors. They only cut at certain places in the DNA sequence. An electrical current then separates the fragments of DNA by their size to form a pattern of bands. Because each person's DNA sequence is unique, each person's pattern of bands is unique as well. Therefore, the DNA fingerprint from the sample found at a crime scene can be compared to the DNA fingerprints of the suspects to determine which one matches.

Procedure: A crime has been committed and evidence collected. Your group will work as crime scene investigators (C.S.I.) to solve the case. A DNA fingerprint has been made from a sample of DNA found at the crime scene. DNA fingerprints have also been made for six suspects. Analyze and compare the DNA fingerprint found at the crime scene to those of the suspects. You may use a hand lens for closer analysis. Report your findings in the results section below.

Materials: DNA fingerprint for sample found at crime scene (bar code)
DNA fingerprints of six suspects (bar codes)
hand lens

Results: The DNA fingerprint of suspect ____ matches the DNA fingerprint from the sample found at the crime scene.

Conclusions: *Answer each question with complete sentences.*

1.) Which suspect committed the crime? How did you determine this?

2.) What makes each person's DNA unique? Be specific. _____

3.) How would your conclusions be affected if the guilty suspect had an identical twin?

4.) Do you think that the DNA fingerprints of a parent and child would show similarities? Why or why not? _____

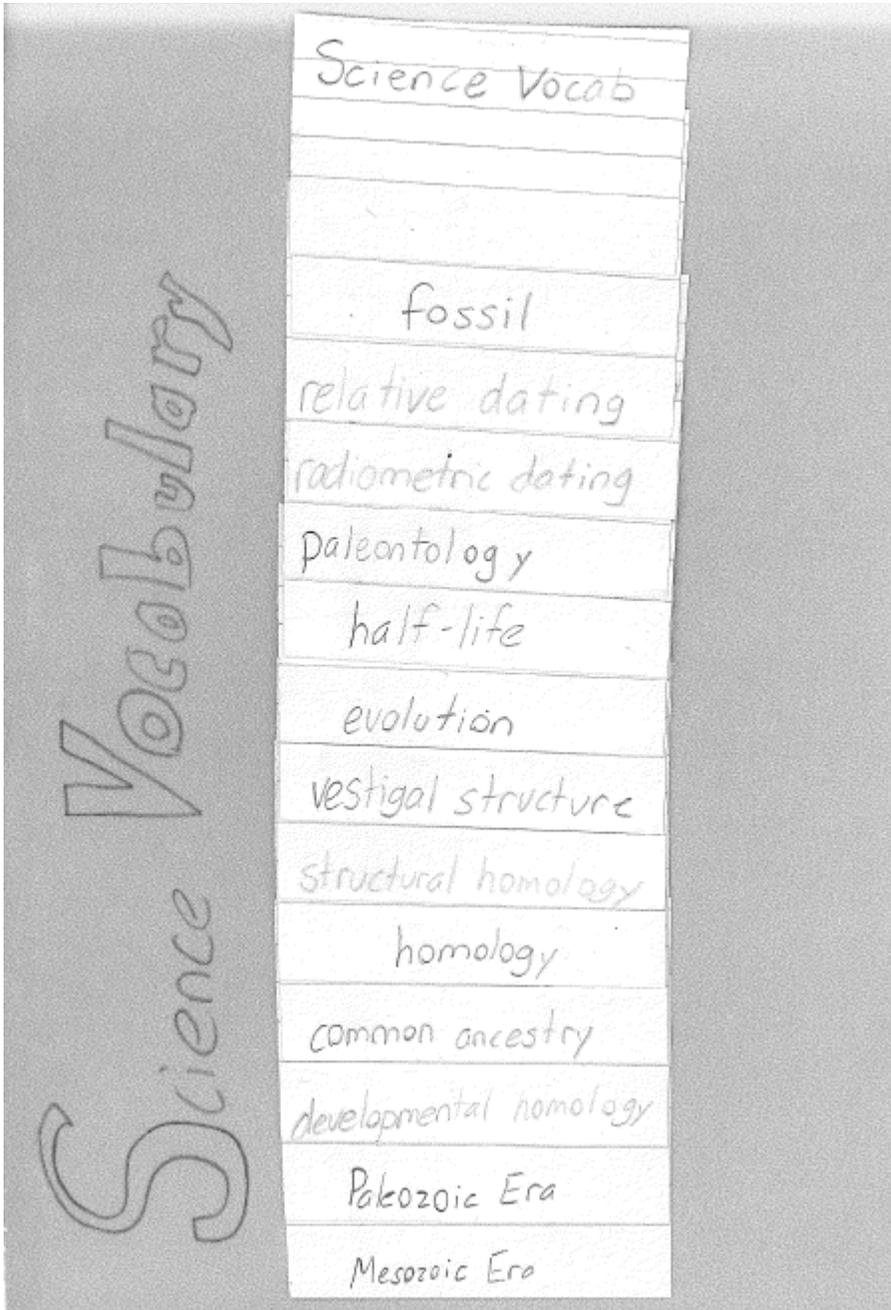
5.) How did your knowledge of the Latin/Greek words *elektro* and *phoresis* affect your understanding of the process of DNA electrophoresis and DNA fingerprinting?

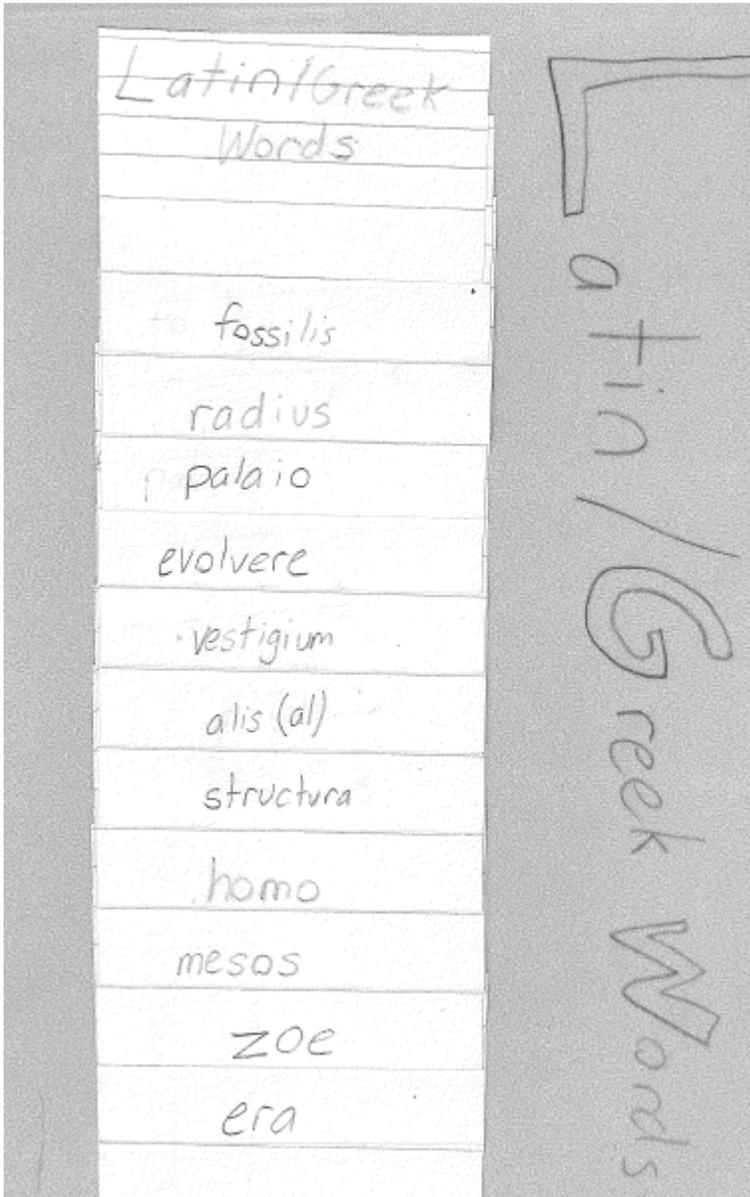
6.) Explain what was “attracted” and what was “being carried” during DNA electrophoresis? _____

APPENDIX J

STUDENT SAMPLE TREATMENT UNIT 2 VOCABULARY

AND L/G MORPHEME FLIP CHART

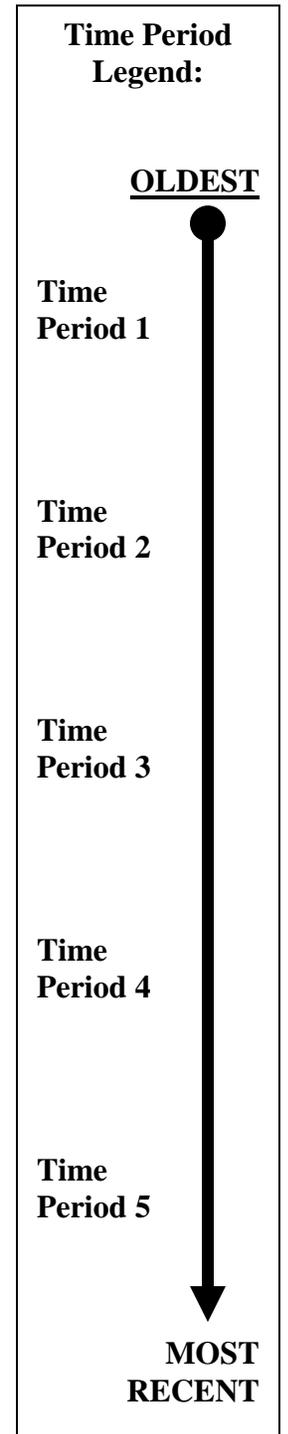




APPENDIX K

TIME TRAVEL LAB GRAPHIC ORGANIZER

<p>Description of environment:</p>	<p>Examples of organisms:</p>
<p><u>Time Period Name:</u></p> <p><u>Time Period Dates:</u> Beginning: End:</p>	
<p>Drawing:</p>	<p>Characteristics of organisms:</p>



APPENDIX L

TIME TRAVEL LAB CONCEPT MAP/ESSAY ASSIGNMENT

NAME: _____

Period: _____

TIME TRAVEL CONCEPT MAP AND ESSAY

QUESTION: How do the changes in living things throughout Earth's history indicate that evolution has occurred?

Now that you have returned from your time travel adventure, you have decided to report your experiences to *National Geographic* for their special issue on evolution! Using your **flip charts** and **graphic organizers**, create a concept map to show your understanding of the relationships among the vocabulary words, the Latin and Greek root words and affixes, and the organisms that you observed on your time travel adventure.

Concept:	Evolution or change
Vocabulary	Paleozoic Era, Mesozoic Era
L/G Morphemes:	palaio, mesos, zoe, era (include their meanings too)
Organisms:	use examples of plants and animals that you observed

APPENDIX M

PREUNIT, POSTUNIT, AND DELAYED UNIT ASSESSMENTS

NONTREATMENT PREUNIT, POSTUNIT, AND DELAYED ASSESSMENT

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

1. Define the following words:

nucleotide-

transcription-

amino acid-

mutation-

ribonucleic acid-

2. What are the two separate components that make up the process of protein synthesis? Explain how these components work together to make a protein.

3. Describe the structure of DNA. How do the individual parts give DNA its unique shape? Explain.

4. How can a genetic mutation result in a physical abnormality? Be specific with your answer. Explain.

5. Predict the meaning of the following words: (THIS QUESTION ON PREUNIT AND POSTUNIT ASSESSMENT ONLY)

subscript-

transmute-

nucleation-

TREATMENT UNIT 1 PREUNIT, POSTUNIT, AND DELAYED ASSESSMENT

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

1. Define the following words:

cloning-

electrophoresis-

biotechnology-

DNA extraction-

genetically modified organism-

2. Compare and contrast between gene splicing and cloning. Be specific with your answer.

3. A farmer wants to grow taller tomato plants so that she doesn't have to bend so far to pick them. How could selective breeding be used to make this possible?

4. A young man that was adopted thinks that he has found his biological father. Which application(s) of biotechnology could he use to determine if this man is his father? Explain your answer.

5. Predict the meaning of the following words: (THIS QUESTION ON PREUNIT AND POSTUNIT ASSESSMENT ONLY)

genealogy-

technical-

organic-

TREATMENT UNIT 2 PREUNIT, POSTUNIT, AND DELAYED ASSESSMENT

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

1. Define the following words:

vestigial structure-

structural homology-

radiometric decay-

evolution-

fossil-

2. Compare and contrast between structural homology and developmental homology. Be specific with your answer.

3. How can vestigial structures and homology suggest common ancestry?

4. A paleontologist has discovered fossils from two different animals in a chunk of rock. Explain all possible methods for how he can determine the age of each fossil.

5. Predict the meaning of the following words: (THIS QUESTION ON PREUNIT AND POSTUNIT ASSESSMENT ONLY)

fossorial-

radiology-

biometric-

APPENDIX N

PRETREATMENT AND POSTTREATMENT SURVEY

PRETREATMENT AND POSTTREATMENT SURVEY

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

Understanding:

____1. What is your level of understanding of life science vocabulary words? (Write the number of your choice on the line.)

5 Very much 4 Much 3 Some 2 Very little 1 None

Explain your answer.

____2. How has the Latin and Greek vocabulary instruction affected your understanding of life science vocabulary? (**THIS QUESTION ON POSTTREATMENT SURVEY ONLY**)

(Write the number of your choice on the line.)

5 Very much 4 Much 3 Some 2 Very little 1 None

Explain your answer.

3. What was the most helpful aspect of the life science vocabulary instruction? Explain.

4. How can the life science vocabulary instruction be improved?

Attitudes and Motivation:

____5. How do you feel about learning life science vocabulary? (Write the number of your choice on the line.)

5 Very excited 4 Fairly excited 3 Some excitement 2 Little excitement 1 Not excited

Explain your answer.

____6. How has the Latin and Greek vocabulary instruction changed the way you feel about learning life science vocabulary? (**THIS QUESTION ON POSTTREATMENT SURVEY ONLY**)

(Write the number of your choice on the line.)

5 Very much 4 Much 3 Some 2 Very little 1 None

Explain your answer.

____7. What is your level of motivation to successfully learn life science vocabulary in this unit? (Write the number of your choice on the line.)

5 Very much 4 Much 3 Some 2 Very little 1 None

Explain your answer.

____8. How has the Latin and Greek vocabulary instruction changed your level of motivation to successfully learn life science vocabulary? (**THIS QUESTION ON POSTTREATMENT SURVEY ONLY**)

(Write the number of your choice on the line.)

5 Very much 4 Much 3 Some 2 Very little 1 None

Explain your answer.

Prediction and Long-term Memory:

____9. How well can you predict the meaning of new life science vocabulary? (Write the number of your choice on the line.)

5 Very much 4 Much 3 Some 2 Very little 1 None

Explain your answer.

____10. How has the Latin and Greek vocabulary instruction affected your ability to predict new life science vocabulary? (**THIS QUESTION ON POSTTREATMENT SURVEY ONLY**)

(Write the number of your choice on the line.)

5 Very much 4 Much 3 Some 2 Very little 1 None

Explain your answer.

____11. Describe your long-term memory of life science vocabulary words. (Write the number of your choice on the line.)

5 Very strong 4 Strong 3 Some 2 Very little 1 None

Explain your answer.

____12. How has the Latin and Greek vocabulary instruction affected your long-term memory of life science vocabulary? (**THIS QUESTION ON POSTTREATMENT SURVEY ONLY**)

(Write the number of your choice on the line.)

5 Very much 4 Much 3 Some 2 Very little 1 None

Explain your answer.

13. Is there anything else that you would like me to know?

APPENDIX O

PREUNIT, POSTUNIT, AND DELAYED UNIT CONCEPT INTERVIEWS

NONTREATMENT UNIT PREUNIT, POSTUNIT, AND DELAYED UNIT CONCEPT
INTERVIEW

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

Understanding: (QUESTIONS 1-6 ONLY ON POSTUNIT CONCEPT INTERVIEW)

1. Is learning life science vocabulary difficult for you? Explain your answer.

2. How has the vocabulary instruction affected your understanding of life science vocabulary?

3. In what ways, if any, has the vocabulary instruction helped you to understand life science vocabulary?

4. How has the vocabulary instruction affected your long-term memory of life science vocabulary?

5. In what ways, if any, has the vocabulary instruction helped improve your long-term memory of life science vocabulary?

6. Is there another question that you think I should have asked? If so, please answer the question that you think I should have asked.

7. Create a concept map to show your understanding of the relationships among these life science vocabulary, Latin and Greek morphemes, and their meanings.

Concept:	The genetic code
Vocabulary:	transcription, mutation
L/G Morphemes:	tion, trans, script, mutatio
Meanings:	write, a changing, across, the action of

Prediction: (THIS SECTION ON PREUNIT AND POSTUNIT CONCEPT INTERVIEW ONLY)

1. When you see a new life science word, is it difficult for you to predict its meaning?

2. How has the vocabulary instruction affected your ability to predict the meaning of new life science vocabulary?

3. In what ways, if any, has the vocabulary instruction helped you to predict the meaning of new life science vocabulary?

4. Create a concept map to predict your understanding of the relationships among these new life science vocabulary, Latin and Greek morphemes, and their meanings.

Concept:	Word predictions
Vocabulary:	subscript, transmutation
L/G Morphemes:	trans, script, mutatio, sub
Meanings:	write, a changing, under, across

TREATMENT UNIT 1 PREUNIT, POSTUNIT, AND DELAYED UNIT CONCEPT
INTERVIEW

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

Understanding:

1. Is learning life science vocabulary difficult for you? Explain your answer.

2. How has the vocabulary instruction affected your understanding of life science vocabulary?

3. In what ways, if any, has the vocabulary instruction helped you to understand life science vocabulary?

4. How has the vocabulary instruction affected your long-term memory of life science vocabulary?

5. In what ways, if any, has the vocabulary instruction helped improve your long-term memory of life science vocabulary?

6. Is there another question that you think I should have asked? If so, please answer the question that you think I should have asked.

7. Create a concept map to show your understanding of the relationships among these life science vocabulary, Latin and Greek morphemes, and their meanings.

Concept:	Practical applications of genetics
Vocabulary:	biotechnology, DNA extraction
L/G Morphemes:	ology, extractus, bio, tion, tekhn
Meanings:	draw out, life, skill or craft, study of, the action of

Prediction: (THIS SECTION ON PREUNIT AND POSTUNIT CONCEPT INTERVIEW ONLY)

1. When you see a new life science word, is it difficult for you to predict its meaning?

2. How has the Latin and Greek instruction affected your ability to predict the meaning of new life science vocabulary?

3. In what ways, if any, has the Latin and Greek instruction helped you to predict the meaning of new life science vocabulary?

4. Create a concept map to predict your understanding of the relationships among these new life science vocabulary, Latin and Greek morphemes, and their meanings.

Concept:	Word predictions
Vocabulary:	genealogy, technical
L/G Morphemes:	ology, al, tekno, gen
Meanings:	related to or like, study of, birth or origin, skill or craft

TREATMENT UNIT 2 PREUNIT, POSTUNIT, AND DELAYED UNIT CONCEPT
INTERVIEW

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

Understanding:

1. Is learning life science vocabulary difficult for you? Explain your answer.

2. How has the vocabulary instruction affected your understanding of life science vocabulary?

3. In what ways, if any, has the vocabulary instruction helped you to understand life science vocabulary?

4. How has the vocabulary instruction affected your long-term memory of life science vocabulary?

5. In what ways, if any, has the vocabulary instruction helped improve your long-term memory of life science vocabulary?

6. Is there another question that you think I should have asked? If so, please answer the question that you think I should have asked.

7. Create a concept map to show your understanding of the relationships among these life science vocabulary, Latin and Greek morphemes, and their meanings.

Concept:	Evidence for evolution
Vocabulary:	radiometric, structural homology
L/G Morphemes:	structura, ology, radius, al, metrum, homo
Meanings:	same, beam of light, measure, study of, related to or like, fitting together or building

Prediction: (THIS SECTION ON PREUNIT AND POSTUNIT CONCEPT INTERVIEW ONLY)

1. When you see a new life science word, is it difficult for you to predict its meaning?

2. How has the Latin and Greek instruction affected your ability to predict the meaning of new life science vocabulary?

3. In what ways, if any, has the Latin and Greek instruction helped you to predict the meaning of new life science vocabulary?

4. Create a concept map to predict your understanding of the relationships among these new life science vocabulary, Latin and Greek morphemes, and their meanings.

Concept:	Word predictions
Vocabulary:	radiology, biometric
L/G Morphemes:	bio, ology, radius, metrum
Meanings:	beam of light, life, measure, study of

APPENDIX P

INSTRUCTOR OBSERVATION PROMPTS

INSTRUCTOR OBSERVATION PROMPTS

Date: _____ Phase of the class: beginning / middle / end (circle one)

1. Describe the posture of the students during vocabulary instruction.

2. What is the level of participation among the student during vocabulary instruction (asking and answering questions, making comments)? (circle one)

5 Strong participation 4 Moderate participation 3 Neutral
2 Slight participation 1 No participation

Explain your answer.

3. What is the overall level of engagement among the students during vocabulary instruction? (circle one)

5 Highly engaged 4 Moderately engaged 3 Neutral
2 Slightly engaged 1 Not engaged

Explain your answer.

4. Describe the students' attitudes to the lesson. (circle one)

5 Very positive 4 Moderately Positive 3 Neutral
2 Slightly negative 1 Very negative

Explain your answer.

5. What is the students' apparent motivation in regard to learning vocabulary? (circle one)

5 Highly motivated 4 Moderately motivated 3 Neutral
2 Slightly motivated 1 Not motivated

Explain your answer.

APPENDIX Q

PEER OBSERVATION PROMPTS

PEER OBSERVATION PROMPTS

Date: _____ Phase of the class: beginning / middle / end (circle one)

1. Describe the posture of the students during vocabulary instruction.

2. What is the level of participation among the student during vocabulary instruction (asking and answering questions, making comments)? (circle one)

5 Strong participation 4 Moderate participation 3 Neutral
2 Slight participation 1 No participation

Explain your answer.

3. What is the overall level of engagement among the students during vocabulary instruction? (circle one)

5 Highly engaged 4 Moderately engaged 3 Neutral
2 Slightly engaged 1 Not engaged

Explain your answer.

4. Describe the students' attitudes to the lesson. (circle one)

5 Very positive 4 Moderately Positive 3 Neutral
2 Slightly negative 1 Very negative

Explain your answer.

5. How would you describe the students' motivation in regard to learning vocabulary? (circle one)

5 Highly motivated 4 Moderately motivated 3 Neutral
2 Slightly motivated 1 Not motivated

Explain your answer.

6. How would you describe my attitude in regard to the lesson? (circle one)

5 Very positive 4 Moderately Positive 3 Neutral
2 Slightly negative 1 Very negative

Explain your answer.

7. How would you describe my motivation in regard to teaching vocabulary? (circle one)

5 Highly motivated 4 Moderately motivated 3 Neutral
2 Slightly motivated 1 Not motivated

Explain your answer.

8. Write down any other observations that you think are important.

APPENDIX R

INSTRUCTOR JOURNALING PROMPTS

INSTRUCTOR JOURNALING PROMPTS

Date: _____

- 1.) What was the topic of today's lesson?

- 2.) How did I incorporate Latin and Greek instruction into my lesson?

- 3.) How well did the students seem to understand today's concepts? Explain.

- 4.) How effective did my Latin and Greek instruction seem to be in teaching life science vocabulary and concepts? Explain.

- 5.) Describe my attitudes in regard to today's lesson and explain.

- 6.) Describe my attitudes specifically in regard to today's Latin and Greek instruction and explain.

- 7.) How could today's lesson be improved to increase students' understanding of the concepts? Explain.

- 8.) How could today's Latin and Greek instruction be improved to increase students' understanding of the vocabulary and concepts? Explain.

APPENDIX S

SELF-EVALUATION

SELF-EVALUATION

1. Describe my attitude in regard to the lesson.

2. How pressured do I feel to teach content material before L/G instruction? (circle one)

5 Strongly pressured 4 Moderately pressured 3 Neutral
2 Slightly pressured 1 Not pressured

Explain my answer.

3. What is my level of confidence regarding my teaching, specifically in regard to L/G instruction? (circle one)

5 Highly confident 4 Moderately confident 3 Neutral
2 Slightly confident 1 Not confident

Explain my answer.

4. Before beginning this unit, what was my level of motivation to teach life science vocabulary? (circle one)

5 Highly motivated 4 Moderately motivated 3 Neutral
2 Slightly motivated 1 Not motivated

Explain my answer.

5. How have the vocabulary instruction strategies changed my level of motivation to teach life science vocabulary? (circle one)

5 Very much 4 Much 3 Neutral 2 Little 1 Very little

Explain my answer.

6. Write down any other important observations.

APPENDIX T

CONCEPT MAP SCORING RUBRIC

Scoring Rubric for Concept Map

Map Component	Possible points	Awarded points	Special things noticed about map
Proposition			
Clear and meaningful to the central topic	2 each		
Beyond given set of terms	3 each		
Not properly linked	1 each		
Vague	1 each		
Branch			
Top	1		
Successive branches	3 each		
Levels of hierarchy (general to specific)	5 each level		
Cross Links	10 each		
Examples	1 each		
Total			
Overall reaction to map and special things noticed.			

Adapted from Novak and Gowin (1984).

APPENDIX U

PROJECT TIMELINE

Project Timeline

January 3 – Nontreatment preunit assessment**Started nontreatment preunit concept interviews**

Teach about the discovery of the structure of DNA

January 4 – DNA structure puzzles

January 6 – Teach structure of DNA

January 10 – DNA structure with K'nex kits

January 11 – DNA replication with K'nex kits

January 12 – 1st observation by colleague

DNA and mRNA compare/contrast graphic organizer

January 13 – Transcription WebLab

January 16 – MLK day off school

January 17 – Translation WebLab

January 18 - Teach about genetic mutations

January 19 – Students research and present genetic disorders

January 23 - Review for quiz

January 24 – Nontreatment postunit assessment**Start nontreatment postunit concept interviews with nonconcept pretreatment questions**

Genetic code quiz

January 25 - Pretreatment survey**January 26 – Treatment unit 1 preunit assessment****Started treatment unit 1 preunit concept interviews**

Teach about selective breeding

January 31 – DNA extraction of strawberries lab

February 2 – DNA electrophoresis of food coloring lab

February 3 – DNA fingerprinting crime scene lab

February 6 – Cloning WebLab

February 8 – 2nd observation by colleague

Teach about genetically modified organisms and food

February 9 - Nontreatment unit delayed assessment**Started nontreatment unit delayed concept interviews****February 10 - Treatment unit 1 postunit assessment****Started treatment unit 1 postunit concept interviews**

February 13 – Biotechnology quiz

Geologic time scale graphic organizer

February 14 - Treatment unit 2 preunit assessment**Started treatment unit 2 preunit concept interviews**

February 15 – Taught about fossils and showed video clips from MSSE paleontology courses

February 17 – Teach about relative dating

February 20 – Presidents' Day no school

February 21 – Relative dating and radiometric dating graphic organizer

February 22 – Radioactive decay lab

February 23 – Vestigial structure activity

February 27 – Treatment unit 1 delayed assessment

Started treatment unit 1 delayed concept interviews

February 28 – Taught about common ancestry and homology

February 29 - Homology coloring worksheet

March 1 – 3rd observation by colleague

Time travel lab

March 6 - Posttreatment survey with L/G treatment questions

Review for quiz

March 7 - Treatment unit 2 postunit assessment

Started treatment unit 2 postunit concept interviews

Evidence for evolution quiz

March 22 - Treatment unit 2 delayed assessment

Started Treatment unit 2 delayed concept interviews