

THE EFFECTS OF CONCEPT MAPS ON STUDENT KNOWLEDGE
OF EARTH SCIENCE

by
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July 27, 2011

TABLE OF CONTENTS

INTRODUCTION AND BACKGROUND	1
CONCEPTUAL FRAMEWORK.....	3
METHODOLOGY	Error! Bookmark not defined.
Project Treatment.....	Error! Bookmark not defined.
Data Collection Instruments	12
DATA AND ANALYSIS.....	17
INTERPRETATION AND CONCLUSION	37
VALUE	40
REFERENCES CITED.....	44
APPENDICES	46
APPENDIX A: Student Oral Interview Questions.....	47
APPENDIX B: Nontreatment Unit Exam	49
APPENDIX C: Student Journal Topics	52
APPENDIX D: Student Trifold Sample	54
APPENDIX E: Student Assignment Nontreatment Unit.....	56
APPENDIX F: Project Timeline.....	58
APPENDIX G: Likert Survey.....	61
APPENDIX H: Treatment Unit Wordbanks.....	63
APPENDIX I: Treatment 1 Exam	66
APPENDIX J: Treatment 1 Lab Worksheet.....	70
APPENDIX K: Written Survey	72
APPENDIX L: Treatment 2 Exam	74
APPENDIX M: Principal Observation Guide	78

LIST OF TABLES

1. Data Triangulation Matrix	13
2. Common Themes in Preconcept Interviews	17
3. Common Themes in Postconcept Interviews.....	19
4. Comparison of Topic-Specific Terms Used in Journal Entries	29
5. Student Performance, Posttest Compared to Delayed Exam	30
6. Number of Students Reporting That Concept Mapping Was Helpful.....	35

LIST OF FIGURES

1. Pre and Posttest Scores for Student Subgroups	22
2. Average Test Scores for All Students Throughout All Units	23
3. Subgroup Growth Through All Three Units	23
4. Student Responses to Question "Concept Mapping Helped"	27
5. Average Number of Discipline Specific Terms Used.....	28
6. Comparison of Student Performance - Posttest to Delayed Unit Test.....	30
7. Number of Vocabulary Terms Used - Postunit to Delayed Unit Journals.....	32
8. Student Likert Survey Data.....	34

ABSTRACT

Students at my high school have scored their lowest on the Earth science portion of the state proficiency test over the past several years. Because this is a topic I teach to the entire freshman class in my school, my capstone project was dedicated to increasing these test scores. My project involved adding concept mapping to all material assigned during two units of the Earth science unit. Data collected to identify the impact of the concept map came from student journal entries, interviews, and surveys as well as from tests that included multiple-choice questions modeled on the state proficiency test questions; targeted short answer questions were included to provide me with qualitative data. I also used a journal and an interview by my principal in an effort to measure the impact of concept mapping on my time and attitude. The results of the study were mixed. Although postunit test scores were higher following the nontreatment unit, there was significant long-term retention of material by three of the four subgroups. Data also indicate greater retention of vocabulary across all of the subgroups. Finally, the results indicate that concept mapping can be a valuable addition to my teaching repertoire.

INTRODUCTION AND BACKGROUND

The topic of my capstone project was the effect of concept mapping on high school student learning in the Earth Sciences. I chose this topic because proficiency test scores indicate my students have a weakness in Earth science knowledge. Using concept mapping with the concepts I currently teach should help students increase their learning in the Earth sciences and, therefore, produce higher proficiency test scores.

My goal as a teacher is to balance lecture, group discussion, inquiry, and hands-on science activities. I want to reach students of many learning modalities as well as balance student-centered and teacher-centered learning. Also, Earth Science is a field in which my students have a number of misconceptions due to the fact that they have received minimal formal instruction in the field. I have chosen concept mapping for my capstone project because it appears to be a tool that will allow my students to pull new information together from the variety of instructional methods I use; it will also give my students an opportunity to allow for conceptual change to reduce their misconceptions.

I teach 9th grade Integrated Lab Science to students with a diverse range of learning abilities at Pershing County High School in Lovelock, Nevada. Earth Science comprises the second semester of my Integrated Science course. My students have not studied Earth science to any extent prior to their 9th grade year. They enter the 9th grade class with differing amounts of any science in the past; elementary teachers cover science content as they can fit it in. Lovelock is a rural town in North West Nevada.

The community's economy is based on farming and mining. Many Hispanic families make Lovelock home, and this fact is reflected in our student body, which is nearly 30% Hispanic, many of who speak Spanish at home. Also, nearly 70% of our student body meets the requirements for the Free and Reduced Lunch program

With this background in mind, my capstone project focus question was what are the effects of concept mapping on students' understanding of high school Earth Science concepts? My subquestions were as follows: what are the effects of concept mapping on students' performance on multiple-choice questions; what are the effects of concept mapping on student long-term memory of Earth Science concepts; what are the effects of concept mapping on students' approach to learning Earth Science concepts; and what are the effects of this method on my teaching, time, and attitude?

My capstone project occurred during January, February, and March of 2011. My project offered me an opportunity to evaluate the addition of concept mapping to my teaching repertoire. As a science and social studies teacher, the addition of this tool can impact my students in multiple disciplines. It also allowed me to share the impact of concept mapping with other teachers, possibly having a positive impact on my colleagues.

My support team was made up of Dr. Peggy Taylor from the MSSE office, Dr. Reuter, my project advisor, and Jim Bradshaw (reader). I had four colleagues on my team: Valdine McLean, science teacher and MSSE graduate who has been a mentor throughout my career, Sandy Condie, a school psychologist and special education teacher, who agreed to help me analyze my data and proofread my work, Coni Jo Brinkerhoff, an English teacher, agreed to help read my work as well as to serve as a

nonscience person who asked questions as to the format of my design and the meaning of my data, and Russell Fecht, my principal, who agreed to observe my classes and interview me to help address my fourth subquestion.

CONCEPTUAL FRAMEWORK

In this conceptual framework, I will give a brief background of concept mapping. I will then link research related to concept mapping with my project focus question of students' understanding concepts, as well as discussing the effects mapping can have on student performance on multiple-choice questions, their long-term memory, and their approach to learning. Finally, I will address ways in which concept mapping can impact me as an educator.

According to Heinze-Fry, Crovello, and Novak (1984) a concept map is a "...visual representation of cognitive structure" (p.152). The foundation of concept mapping is constructivist theory, which is based on the idea that learners construct knowledge for themselves, developing their own meaning of a concept by connecting it to prior knowledge (Jonassen, 1991). Taber's (2008) study reinforced that constructivist methods helped students link existing knowledge with new. These methods produce what many researchers refer to as meaningful learning, although Karakuyu (2010) refers to this as sensible learning. Novak (2002) and Novak and Cañas (2008), in their description that references the work of David Ausubel from the 1950's through the 1970's, describe meaningful learning and indicate that it is much more effective than learning by memorizing, also referred to as rote learning. Hsieh and Cifuentes (2006)

support the idea that concept mapping is connected to meaningful learning. They found that the visualization process that mapping requires helped secondary students learn meaningfully. It is this background on constructivism and meaningful learning that makes me believe that adding concept mapping to my repertoire of teaching strategies will increase student learning of Earth Science concepts in my classroom, the focus of my project.

Much research has been done in an effort to identify the effectiveness of concept mapping in the science classroom. Novak (2002) discusses the effectiveness of concept maps over rote learning. In his paper, he describes how the hierarchical nature of concept mapping and the ability of students to identify their misconceptions can lead to meaningful learning. The research supports the effectiveness of mapping as a means of learning new concepts and allowing for conceptual change. Because much of the information in my Earth Science unit is new to my students and due to their misconceptions, his study supports my study focus. Mintzes, Wandersee, and Novak (2001) completed a review of the effectiveness of concept mapping as means of evaluation in the biology classroom. They indicate that the use of maps is effective due to the fact that they allow students to visualize both what they understand and their misconceptions, which supports the effectiveness of mapping in my classroom. Karakuyu (2010), Gerstner and Bogner (2009), and Gerstner and Bogner (2010) conducted research that serves as another indicator. In their studies of secondary students, concept mapping was attached to multiple teaching methods, similar to my project. They found students who mapped performed better on tests than those who did

not map, supporting the idea that concept mapping will be an effective tool for my students.

The Gerstner and Bogner (2009) findings are also pertinent to my first subquestion, which seeks to identify the impact concept mapping may have on student performance on multiple-choice questions. In their study, secondary students who mapped outperformed a control group on multiple-choice tests of post and long-term retention. They found no significant difference between groups that were in student-centered or teacher-centered learning environments, which supports my plan; the differences they found were between groups who mapped and those who did not.

In another study conducted on ninth-grade students, Karakuyu (2010) found test scores of students in physical sciences were consistently higher among students who mapped than those of students who did not map. Although the tests in this study were primarily composed of multiple-choice questions, each test also included open-ended questions, and the study did not break down results based upon question types. Hsieh and Cifuentes (2006) tested the effect of visualization methods (various forms of concept mapping) on eighth-grade life science students. In their research, a control group of students studied from essays in a rote memory form of test preparation while other students were allowed to visualize information that accompanied the same essays. Students were given 30-question, multiple-choice exams. The students in the visualization group outperformed their peers significantly. Asan (2007) in Turkey found similar results with fifth-grade students.

The Gerstner and Bogner (2010) study is also relevant to my second subquestion, addressing the impact concept mapping may have on student long-term

memory of Earth Science concepts. In their study, long-term retention of biology concepts was tested 12 weeks following instruction; the instruction involved a variety of methods, much like my planned unit. Their report had interesting results. Test results indicated mapping helped students to retain information, but it was the quality of student maps, however, that served as the best indicator of the quality of long-term retention. This study serves as indicators that I need to focus on the mapping exercises my students perform to address quality of propositions and appropriate organization. Jacobs-Lawson and Hershey (2002) conducted a study on university psychology students. They indicated that students' retention of material through a semester was greater when students were asked to create concept maps throughout the semester versus student who did not map. These studies lead to my belief that creating concept maps may have a positive effect on a student's long-term memory of Earth Science concepts.

My third subquestion concerns the students' approach to learning Earth Science concepts. In his study, Novak (2002) indicates that students who built concept maps in a high school physics class outperformed those who did not map. He goes on to say that the difference between the two groups became greater as the school year progressed. I believe success begets success. If students are successful using mapping, it can serve as a powerful motivator to continue with the same tool. In the Karakuyu (2010) study, students were given a test that measured motivation and attitude to learning in the physics classroom, which indicated that students allowed to concept map throughout a unit were significantly more motivated to work in the classroom. Hsieh and Cifuentes (2006) found that eighth-grade students who were in a group assigned

mapping exercises with a paper and pencil were more attentive to learning tasks than a control group who did not map. Interestingly, their study also indicated that students asked to map on a computer were less attentive than the control group, possibly due to a lack of computer skills. Finally, I feel if concept mapping produces learning, students will perform better on tests; success on the tests should help motivate students to continue to work.

Up to now, my literature review has focused on the impact concept mapping can have on my students. I will now look at the impact that using concept maps has on the teacher. A study by Liang and Gabel (2005) compared preservice teacher attitudes towards teaching in a conventional, lecture-type setting with those teaching in a constructivist style. Their findings indicate that two-thirds of the teachers liked the constructivist method because it stimulated their thinking and was more interesting to employ in the classroom than lecture. Conlon (2009) investigated the effects of concept mapping on teacher's approach to their work. In an interview following the study, a participant was encouraged by the productivity in his classroom. A second teacher reported the positive student outcomes had garnered the interest of colleagues due to the effects it had on their practice as well as on student learning. The knowledge I have gained about concept mapping as an evaluative tool from studies by Jacobs-Lawson and Hershey (2002) and Asan (2007), among others, leads me to believe this is a powerful tool for evaluating, finding, and correcting student misconceptions. If the maps will aid me in my effort to address student misconceptions in Earth Science, it has the potential of having a positive impact on my teaching.

In summary, concept mapping effectively allows students to learn new material and correct misconceptions. The use of maps also helps students perform better on multiple-choice tests. Studies also indicate that mapping will motivate students' to work in the classroom as well as increasing the long-term memory of Earth Science concepts.

METHODOLOGY

Project Treatment

My capstone project consisted of one unit taught as a nontreatment unit and two treatment units. Data from the nontreatment, where students completed activities *without* concept mapping, was compared to the treatment units, where students completed an abbreviated preunit activity concept map that was updated following each of the unit activities. The nontreatment unit was on the structure of the Earth. The treatment units were on plate tectonics and on earthquakes and volcanoes. The concepts covered were based on the Nevada State Science Standards. 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.

My interviews took place throughout the project with an eight student subgroup made up of two students from the high, middle, and low-achieving students based upon their grades in the first semester. I also selected two special education students (SPED) to include in the subgroup.

The first unit was a nontreatment unit; therefore, there was no concept mapping involved. To begin the unit, I conducted preconcept interviews using the concept

questions in Appendix A. Students then completed a pretest with 10 multiple-choice questions and two brief and targeted open-ended questions. This test is found in Appendix B. Students made a journal entry on their current knowledge of the Earth's structure and where they learned this material. The topics of all student journal entries are found in Appendix C. Next, students completed an activity in which they made a folded paper organizer on the structure of the Earth. This became part of an Earth Science unit tri-fold portfolio, an example of which is in Appendix D. Finally, students worked in groups to create a poster of the Earth drawn to scale with descriptions of layers and processes. The information for this came from readings, student research, and discussion. The worksheet for this assignment can be found in Appendix E. The Earth-to-scale drawing and follow up discussion required three class periods, as indicated by the timeline for the project (Appendix F). The posters were presented to the class on the third and fourth day of the unit. Students read a short passage entitled *The Structure of the Earth* as well as one entitled *A Window into the Solid Earth*. These readings were assigned as homework. Following the unit, students took the same test they took as the preunit test. Finally, I conducted postunit concept interviews with the subgroup, all students took the Likert survey (Appendix G) and responded in their journals as to the value of the exercises in the unit and the impact they had on their ability to answer the questions on the test.

The second and third units in my project were treatment units, treatment unit 1 and treatment unit 2. The intervention involved the addition of concept mapping. Even though I introduced students to concept mapping during the first semester and they were familiar with my expectations on a concept map, I still dedicated pieces of each

lesson to concept mapping theory and the quality of student maps in all discussions. Students were given a word bank at the beginning of each of the treatment units (Appendix H). The word banks were split into three lists, with list one consisting of the more general terms. From list one, students developed a preactivity concept map, which they revised with terms from list two and three as they completed the unit activities. I circulated between groups, making field notes as they adjusted their maps. Following each mapping session, we held a discussion focused on the concept organization and the student propositions. The goal of these discussions was to catch and correct any student misconceptions as well as to help improve student map organization.

Treatment unit 1 was on plate tectonics. Students completed the pretest found in Appendix I. I conducted preunit concept interviews and students completed their preconcept map for this unit from word bank, list one. We completed a trifold drawing piece through lecture that showed ways plates move. This gave the name of the plate boundary, general results of the type of movement, and specific examples that exemplify this movement (Appendix D). Following the trifold piece, students updated their concept maps as I circulated, making field notes on their changes; a class discussion / concept check followed. The lab in this unit was entitled *Map Evidence for Plate Tectonics*, the worksheet for which is included in Appendix J. One assigned reading was titled *Plate Tectonics and Mountain Building* and the other *The Restless Earth*. As in the first unit, each reading was assigned as homework. Students were given time each day following the reading to update their concept maps; class discussion / concept checks followed each map update. Following all unit activities,

students took the posttest for tectonics. Students then completed the written interview questions (Appendix K). At this time, students completed the Likert survey (Appendix G). I also implemented the oral interviews, using the concept and methodology interview questions.

The topic of treatment unit 2 was earthquakes and volcanoes. It included the same components as the other two units, beginning with a preunit interview and test. The test students took as a pre and posttest, as well as a delayed assessment, is found in Appendix L. They completed a preunit concept map, using the terms in list one of the second set of terms (Appendix H). As in treatment unit 1, following each of the activities, students revised their concept maps, adding to them words from lists two and three. A class discussion/concept check followed each mapping exercise. The activities within this unit included two trifold pieces, one depicting the anatomy of an earthquake and the other illustrating a subduction zone. The lab in this unit was one in which students analyzed evidence to determine the characteristics of magma that lead to explosive versus effusive volcanoes; Students also completed a short activity on the Ring of Fire. Once again, following each activity, students updated their concept maps and we held a discussion focused on catching misconceptions and improving student propositions. The two readings in this unit included two pieces, each titled *Earthquakes*. The readings were assigned as homework. Students updated their concept maps each day. Following the postunit test, students completed the survey and the interview questions. I also implemented the oral interviews, which focused on both concepts and methods.

Fourteen days following *each* unit, students took the tests as delayed unit assessments and completed a journal entry; student concept interviews took place at this time, as well.

Data Collection Instruments

My capstone project took place with my ninth grade Integrated Science students. There were 52 students in the project. I teach two sections of this ninth grade science; it is the only science class offered for freshman in my high school. Because I have the entire freshman class, I have the opportunity to teach them a large portion of the required state proficiency standards. In Nevada students take the proficiency test during the spring of their sophomore year. My colleague and I have basically split the high school science standards in half in an effort to teach all standards in the first two years of high school. I have chosen to dedicate much of the second semester of the Integrated Science course to Earth Science. This is a subject students haven't studied in depth prior to the ninth grade. Each section has a high percentage of Hispanic students. This year, these students have performed at a level representative to that of the class as a whole; therefore, they were not separated as a subgroup.

One section has seven students with special needs; each of these students has an Individualized Education Plan (IEP). The Special Education teacher is in the room with them. In my treatment units, these students received extra time to complete assignments. They also had readings and questions from the multiple-choice exams read to them. This final modification matches the modification that will be made for them on the state proficiency exam. I have chosen two members of this subgroup to be included in observations and interviews. To meet the diverse needs of the students

within my classroom, I created units that present material in a variety of modalities, hence, my focus on reading, writing, drawing, and hands-on (lab) work.

The data I collected from my students to measure the impact of concept mapping for the capstone project is laid out in Table 1, my Data Triangulation Matrix. In an effort to address student growth as related to my focus question, I utilized pre and postunit tests, information from student concept interviews, and field notes reflecting student modifications to their initial concept maps, misconceptions they corrected, and their propositions. My pre and postunit assessments were modified multiple-choice exams with the multiple-choice portion formatted similar to the Nevada State Proficiency Test questions. I modified these by having students explain why they selected their answers. This modification gave me qualitative data that helped me analyze student growth after each unit.

Table 1
Data Triangulation

Project Questions	Data Source		
	1	2	3
Focus Question: What are the effects of concept mapping on students' understanding of Earth science concepts?	Pre and postunit assessment	Field notes of concept map adjustments	Pre and Postunit Concept Interviews
Sub question 1: What are the effects of concept mapping on students' performance on multiple-choice questions?	Comparison of Pre test with Post unit MC questions as well as delayed unit assessment	Pre and postunit Interviews, student survey	Student Journal entries using prompts

Sub question 2: What are the effects of concept mapping on students' long-term memory of Earth Science concepts?	Post and delayed unit interviews	Delayed unit assessment compared to the postunit assessment; focus on explanation and vocabulary	
Sub question 3: What are the effects of concept mapping on students' approach to learning Earth Science concepts?	Journal entries using prompts – nontreatment and treatment units	Student interviews – nontreatment and treatment units	Student Likert Survey – nontreatment and treatment units
Sub question 4: What impact will incorporation of this method have on my teaching, time, and attitude?	Teacher reflection journal using prompts (through nontreatment and treatment units)	Teacher planning time-log	Interview with Principal Fecht based upon his observations

Along with multiple-choice questions, the pre and postunit and delayed assessments included two open-ended questions. The open-ended questions on the unit test were directed to higher order thinking with the goal of applying knowledge to solve problems and/or make predictions. Along with these tests, I made field notes that monitored changes made by the students on their concept maps. I focused on changes made to the hierarchical structure of their maps and the clarity of their propositions. Even though I observed all students as they made modifications, I focused my field notes on the eight students in my interview subgroup. Finally, I used a post unit interviews, focusing on the concepts, with the eight student subgroup (Appendix A). Interview data served as qualitative data for my focus question.

The written survey was also helpful to me in addressing subquestion one which related to the impact of concept mapping on student performance on multiple-choice questions. Questions 4, 5, and 6 were targeted to this subquestion. Comparing student performance on pretest and posttest multiple-choice questions, as analyzed using the mean score on each question, served as quantifiable evidence in an effort to address this sub question. Finally, I had students make journal entries with prompts that allowed them to express how they viewed the impact of mapping on their ability to answer the questions with the main entry being journal question five (Appendix B).

Subquestion two was directed towards identifying the impact concept mapping would have on student long-term memory of Earth Science concepts. The results of the delayed unit assessment that was given 14 days after the postunit assessment, for which students did not study, as compared to the postunit test served to answer this question. Explanations of students' choices as well as short-answer questions were important here, as they gave me an indication of how well students were applying vocabulary and concepts to these issues and how well they were remembering concepts.

In analyzing these tests, I compared the mean score on each and I looked for relevant vocabulary in each of the explanations. I counted the terms correctly used by one member of each student in the subgroup to assess the correct use of appropriate vocabulary. This allowed for a comparison of these answers from one test to the next which gave me a picture of how well students remembered the material. Students were interviewed, once again, following the delayed unit exam. The same students were interviewed through the entire study. These interviews were compared to their postunit

interviews as qualitative data, helping me to understand the impact of my intervention on long-term memory of concepts.

In an effort to assess the impact of the concept mapping activities on student approach to the Earth Science activities and materials (subquestion three), I developed the Likert survey (Appendix G). The questions are designed to have the students self assess the impact activities had on their approach to learning. Survey results were assessed question-by-question by weighing student responses (a 1 was worth 1 point, a 2 worth 2, etc) and calculating a value for each question. I also calculated the mode for each question. From the weighted scores, I looked for patterns in the data. The survey does not mention mapping as an activity. Because mapping is the main difference between the three units (nontreatment vs. intervention), these data can serve as an indicator of how concept mapping affected student attitudes towards the project.

I included two open-ended questions on the survey to have the students add any thoughts they might want me to know. These written responses provided qualitative data. Finally, journal topics 2 and 5 allowed students to express their attitudes towards mapping and the impact it had on their learning.

For qualitative data related to subquestion four, I kept a journal with prompts in which I tracked my attitude towards concept mapping and its impact on my students. I also tracked the amount of time I spent analyzing student work throughout the nontreatment and the treatment units. Finally, my principal, Russell Fecht, volunteered to observe my class one time during each unit. He used the observation sheet (Appendix M), which we created together as a guide. He coupled his observations with an interview to help me determine the impact of this treatment on my time and attitude.

DATA AND ANALYSIS

In addressing my focus question concerning the effects of concept mapping on understanding concepts, I utilized pre and postunit concept interviews, pre and postunit modified multiple-choice exams, and my field notes on the adjustments students made to their concept maps throughout the treatment units.

A summary of student preunit interview responses can be found in Table 2. Overall, the preunit interviews made it clear that students had misconceptions from the past as well as a lack of specific knowledge. Key indicators of this include the idea that the Earth's interior is "a magnet" but an inability to expand on the reasoning for that and the idea that the Earth's plates include only the continental crust. The preunit interviews for the second treatment unit reflected misunderstandings to a lesser extent quite likely due to the fact that the two previous units had tangentially covered some of these vocabulary and concepts.

Table 2
Common Themes in Preunit Interviews

Achievement Group	Nontreatment Unit Structure of the Earth	Treatment Unit 1 Plate Tectonics	Treatment Unit 2 Volcanoes and Earthquakes
High	There are three layers: Core, Mantle, Crust Interior is hot. Unsure why hot or the effects of the heat. Magnetic? (unsure how)	Plates move Lack of certainty of why Pangea was when all continents were together. Seem to think plates are the land we live on.	Earthquakes caused by plate movement. Heat from the core causes movement of plates. (used "convection currents") Volcanoes form when plates collide Unsure why volcanoes are different from each

			other.
Medium	The interior is hot. There are layers (one student said four, one said three). It gets <i>more red</i> as you work toward the center. The interior is magnetic.	Unsure as to the meaning of the word 'tectonics' Know the plates move, unsure why or how. All continents were together once (Pangea used by one student) Seem to think plates are the land we live on.	Earthquakes caused by plate movement. Heat from the core causes movement of plates. One referred to convection, the other mentioned magma comes from the core.
Low	One student not agreeable. Interior is hot, causes volcanoes. (one student – "red") Magnetic	Both students cooperative Identified that the Earth has plates. Unsure of "tectonics". Earthquakes mentioned twice by one student. Seem to think plates are the land we live on.	Heat from the core causes movement of plates. Volcanoes form when plates move. Earthquakes take place on Continental plates (one student)
Special Education	One student was very knowledgeable, reflecting much of what one student in the middle achieving group. Magnets in the interior protect us. Hot and red	Tectonics? Seem to think plates are the land we live on. The plates move over the ocean.	Heat from the core causes movement. Volcanoes form when plates move. Earthquakes take place on Continental plates (one student)

Postunit interviews, as represented in Table 3, indicate a growth of students in their knowledge of all topics. One indicator is the use of appropriate vocabulary throughout the interview. Students made a much greater attempt to use the vocabulary, especially those from the word banks, correctly while being interviewed. Examples include the reference to specific types of plates in reference to the causes of earthquakes and volcanoes as well as the names of specific types of plate movement

when discussing plate movement. Also, there was a clear shift from the core being a magnet to the core serving as the source for Earth's magnetic field.

The use of vocabulary in the postunit interviews leads me to believe concept mapping increased student knowledge. Most students reported, in interviews and surveys, that they "knew the terms better" following the treatment units. In some cases they utilized the vocabulary to a greater degree following each treatment unit. This was most clear with the students in the medium achievement subgroup. Each student responded with some enthusiasm and seemed intent on answering the questions completely using appropriate vocabulary, as exemplified by the description of "Nevada is being stretched along a transform fault forming mountains." Each student in the middle group as well as many other students also mentioned their concept maps in answering the concept questions.

Table 3
Common Themes in Postunit Interviews

Achivement Group	Nontreatment Unit Structure of the Earth	Treatment Unit 1 Plate Tectonics	Treatment Unit 2 Volcanoes and Earthquakes	Trend
High	There are many layers based on density. (Named them) Interior is the same temperature as the sun. Heat is left over from formation of the Earth and from fission.	Plates move ride on convection currents. Density plays a role in what happens when plates meet. Plates can move three ways (named them and motioned with hands). Quakes,	Earth quakes and volcanoes are from specific plate movement Earthquakes come from all types of movement. Epicenter / Focus located properly P / S waves travel at different speeds. Land waves destroy 2 types of	Recognition that there is more complexity to the structure than they had realized. Use of vocabulary throughout. Enthusiasm about lava/ magma

	<p>Iron core spinning in the outer core produces the magnetic field around the Earth. (One student) We know this from the movement of waves through the planet. (One student – “Indirect evidence”)</p>	<p>volcanoes, Tsunamis result from motion. Mountains come from all types of movement; Nevada is being stretched forming mountains. Continents have been together a few times. There are two types of plates (both named them) Heat at the core is the source of the movement</p>	<p>volcanoes (named both) Magma and Lava have significant differences</p>	<p>differences.</p>
Medium	<p>There are four main layers. (Named them) The layers are based upon density. The heat is left over from the formation of the Earth. Since we can see it we use evidence to identify the structure.</p>	<p>Plates can move three ways (one student could name them and motioned with hands; one knew two of three). Quakes, volcanoes, Tsunamis result from motion. Nevada is being stretched along a transform fault forming mountains. Continents have been together a few times. There are two types of plates (both named</p>	<p>Volcano and earthquakes come from plate movement Epicenter / Focus located properly P / S waves travel at different speeds. Land waves destroy 2 types of volcanoes (named both) Magma different than lava</p>	<p>Use of vocabulary to a greater degree in treatment units 1 and 2. Descriptions from nontreatment seemed to be more colorful. Enthusiasm in answering.</p>

		them) Heat at the core is the source of the movement.		
Low	There are more layers than we know. (One named them, one did not try) The layers are based upon weight (One – Density) The heat is left over from the formation of the Earth. Since we can see it we use evidence to identify the structure.	The plates move three ways. (One student named all three, one didn't appear to try.) The heat in the center of the earth moves them. There are two types of plates. (Both named them) Plate movement is destructive (earthquakes, volcanoes).	Heat from the core causes movement of plates. Volcanoes and quakes happen when plates move. Equake waves have three types (One named them) P / S waves travel at different speeds.	Use of vocabulary to a greater degree in treatment 1. Both students lacked enthusiasm during treatment 2 interview.
Special Education	There are more layers than we know. (One named them, one did not try) The Earth is hot from the time it formed (one student)	The plates move three ways. (One knew two names, one knew Transform) The heat in the center of the earth moves them. There are two types of plates. (Both named them) Plate movement is destructive (earthquakes, volcanoes).	Heat from the core causes movement of plates. Volcanoes form when plates move. There are two types of volcanoes (one student) Earthquakes take place on Continental plates (one student) Magma is different than lava	Increase in use of vocabulary especially in treatment unit 1. Expressed differences between magma and lava clearly.

As was the case with the interviews, student responses to the short-answer questions as well as the explanation for each question showed a greater use of vocabulary in the two treatment units. For the most part, student answers to the short-answer questions on the posttest were noticeably shorter responses, but each sentence included specific ideas connected to the vocabulary. Pretest responses showed less vocabulary.

Figure 1 presents student performance data on the multiple-choice exams, broken down by subgroup and Figure 2 presents the whole-class average test scores from the multiple-choice portion of tests taken throughout the project.

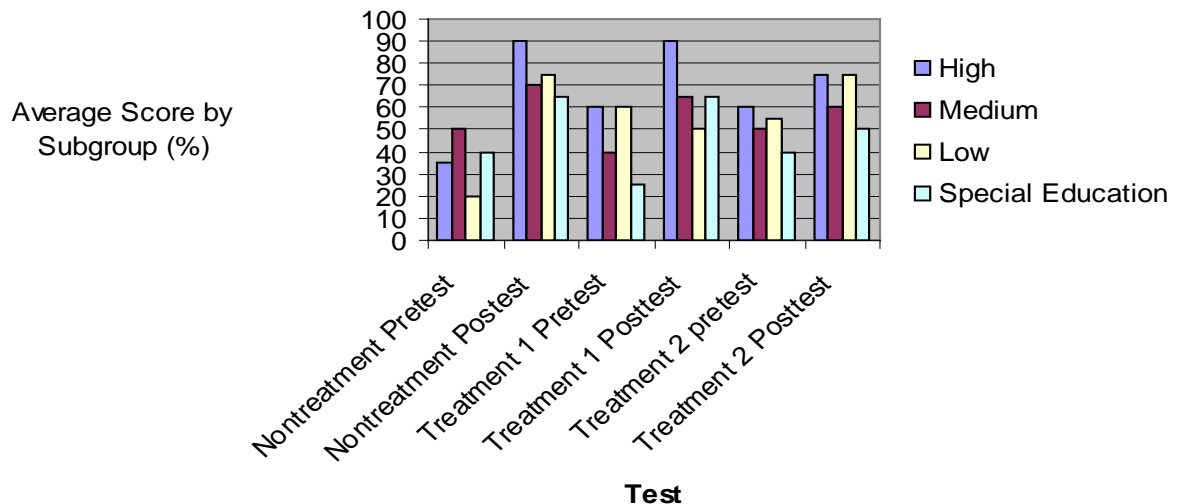


Figure 1. Multiple-Choice Exam Scores for All Pre and Posttests Broken Down by Subgroup, ($n=2$ students per subgroup).

Note. High, medium and low refer to student performance subgroup and special education refers to the subgroup of special education students.

Test averages indicate student knowledge of Earth science increased throughout all three units. The data indicate that students did not differ greatly in their growth from the nontreatment unit to the treatment units. From a quantitative

standpoint, percent difference from preunit to postunit test averages was 34% in the nontreatment unit, 25.5% in treatment unit 1, and 21.9% for treatment unit 2.

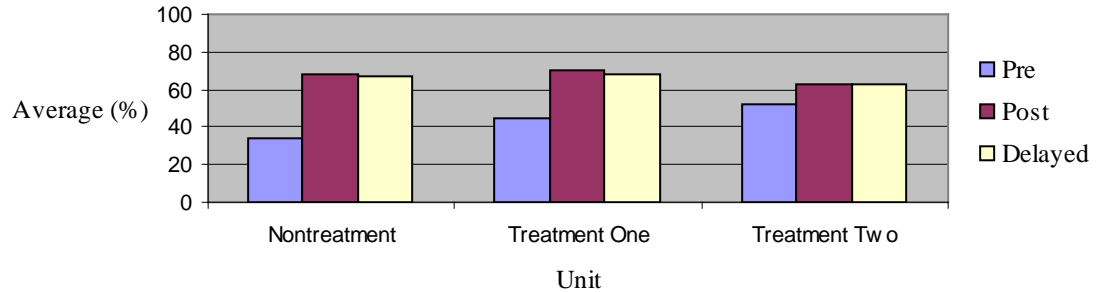


Figure 2. Average Test Scores for Students throughout All Units, ($N=52$).

Note. Pre refers to the preunit test; post refers to the postunit test, and delayed refers to the delayed unit test (14 days following instruction).

The data presented here seem indicative that the concept maps were not more effective than the activities during the nontreatment unit. It seems to show, however, that the treatment did not negatively affect student performance.

Multiple-choice test score growth data through the three tests show mixed results when broken down by subgroup as shown in Figure 3.

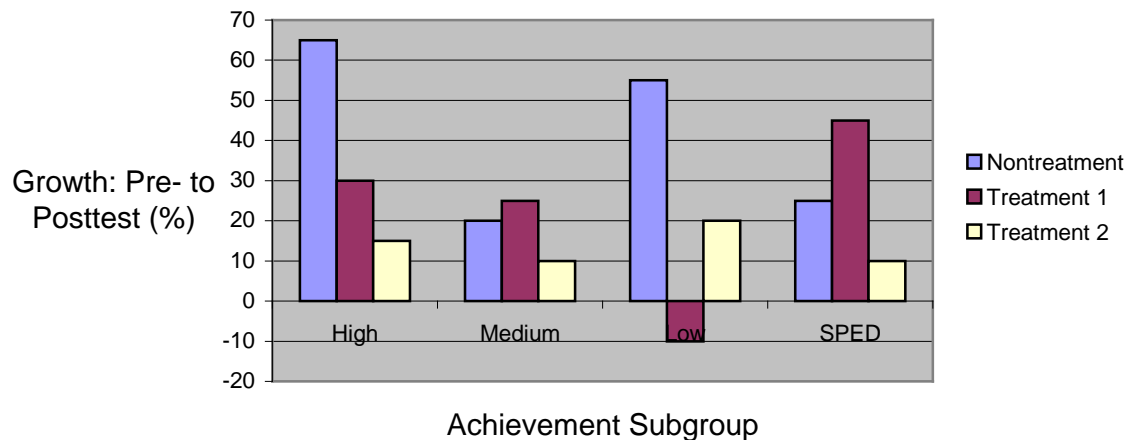


Figure 3. Subgroup Growth through All Three Units, ($N=8$).

Note: Nontreatment refers to the unit which did not include concept mapping. Each treatment unit (Treatment 1 and Treatment 2) included concept mapping. SPED refers to the Special Education subgroup.

The data show the greatest growth (pretest to posttest) occurred during the nontreatment unit for two subgroups, the high (65%) and the low (55%). The medium and special education subgroups showed their greatest growth during the first treatment unit (25% and 45% respectively). I noted that the low-achieving group shows a decrease in treatment unit due to one member of the subgroup scoring 2 out of 10 on the test. Furthermore, he left the short response and the explanation piece of the test blank. These serve as indicators that he was not giving the test a full effort; therefore, the data for that subgroup and test are probably not reliable.

Field notes on concept mapping taken throughout the two treatment units indicate a weakness among the students in their understanding of mapping. Throughout the first treatment unit, I reminded students about the nature of hierarchies (general to specific) as well as the idea of creating meaningful propositions. Because I was continually in the mode of teaching mapping, I feel my field notes reflected less about student understanding of the concept as much as the daily mapping input I would give them. With that in mind, I found the information gathered from field notes to be limited. Students made greater changes to the structure of their maps following the lecture and construction of the trifold piece in each of the treatment units. This appeared to be due to the use of vocabulary in the trifold pieces and the explanation that accompanied it. I noticed students keeping track of the words as they felt comfortable with them. Even though all words were placed on the initial map, students did focus on those concepts they knew and those they did not know. I spoke to one student while he was making adjustments and he reported that he changed his words to those that “go together because they were all mixed up.” When I looked at what he meant, I noted

“Hierarchy!” in my journal. This observation showed me that the trifold construction was productive and my constant reminders about “general to specific” may have been working. I did make notes about students focusing on clarifying the propositions as the unit went on. An example is the change one student made between the words convergent and subduction – from “causes” to “Oceanic and Continental result in...” These changes show a greater connection between the vocabulary words and the concepts, which is similar to my results in the written responses to test questions and the interview.

In an effort to address the impact of concept mapping on student performance on multiple-choice tests, I analyzed student test scores, student interview data and student journal entries. As previously presented, Figures 1, 2, and 3 indicate a mixed impact on student test scores when compared to nontreatment scores, Figures 1 and 3 do indicate a limited improvement in performance following the treatment units among students in the medium and special education subgroups.

The apparent relationship between concept mapping and vocabulary was a consistent theme across the subgroups. In preunit interviews students reported that concept mapping was a good tool for learning vocabulary terms. They related to the units from earlier in the year when concept mapping was employed. One student in the high-achieving subgroup also referenced her fourth grade teacher using mapping during her water unit. She said that she still remembers the terms that teacher utilized from her map drawing. When I asked her to expand on the idea of the map drawing, it seems she meant a standard concept map. A common comment throughout the preunit interviews was, as stated by one of the special education students as well as one student of the

medium achieving group that concept mapping helped them “remember the words on the test.”

Following each treatment unit, I interviewed each member of the subgroups. Five of the student in the subgroups specifically mentioned the fact that they focused on vocabulary. When discussing the concept maps, comments such as “It helped me put words I did know with the words I didn’t.” were common. My first, second, and fourth interview questions were targeted towards the effects concept mapping had on student performance on multiple-choice tests. Most students replied to question one positively. The two students in the low subgroup replied positively, with one comment following treatment unit 1 that “it made me think about the words.” Of the students in the middle subgroup, one replied negatively to the question, stating that she did not know how to “put the definitions together.” The other student in the middle subgroup, following treatment unit 2, replied that the maps did help him to “get it” a little more. When I asked him to elaborate, he said he just understood the material better. I think the idea of ‘getting it’ works as a positive indicator of the impact of concept mapping. Both of the students with special needs replied that the mapping exercise was positive in helping them. Following each treatment unit, they referenced the idea that the maps were helpful in “memorizing” the vocabulary. This, it turns out, was the term used by the special education teacher while working with them on their maps. In the high-achieving subgroup, both students stated it helped them see how the vocabulary was “connected”. In response to the second question, the students in each subgroup referenced the fact that the vocabulary became their focus due to the concept map. The fourth interview question relating to the pieces of the information that stood out after completing the

concept map. In one case, four of the students reflected back on the ways plates move, the focus of the second treatment unit and the piece that was tied to a drawing exercise for the trifold organizer. This stood out to me as an indicator that the mapping and drawing exercises may work well together. All but one of the students had a solid piece of content as an answer to this question. One of the students in the low subgroup repeated that the map helped with “all of it”, which may indicate his desire to be done with the interview more than anything. Along with the subgroup interviews, I supplemented the data on the effects of concept mapping on student performance on the test by asking them the question “Did concept mapping help you on the test?” following each of the treatment units. The results are in Figure 4. These data indicate most students felt that concept mapping was helpful, with the responses following treatment unit 1 being more positive by five students.

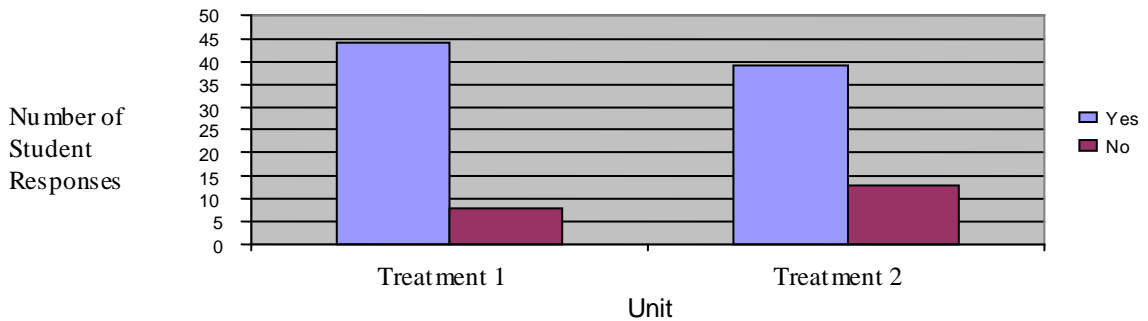


Figure 4. Students’ Responses to Statement “Concept mapping helped me on the test.”, (N=52).

Finally, as I tried to assess the impact of concept mapping on student performance on multiple-choice tests, I assessed student journal responses following each of the units. As I read the entries, it became clear that there were significant differences between the preunit and the postunit entries. For the most part, student preunit entries were very brief, which may have been indicative of a lack of knowledge

or a lack of effort. The postunit entries generally included much more vocabulary with the terms used appropriately. The entries made by one special education student and both of the students in the low-achievement group had limited sentence structure, but showed an effort to use the vocabulary to a much greater extent than in the preunit entries. Two student's responses to the nontreatment postunit entry included a picture similar to the one they drew in the activity for that unit while no subgroup entries following either treatment unit included a drawing. When I considered responses to interviews and survey results, in an effort to evaluate the impact that mapping may have had, I chose to compare pre and postunit entries from all three units based upon the correct use of discipline specific vocabulary in the students' entry. I focused the collection of this data on the one student in each subgroup to simplify data collection. These data are presented in Figure 5.

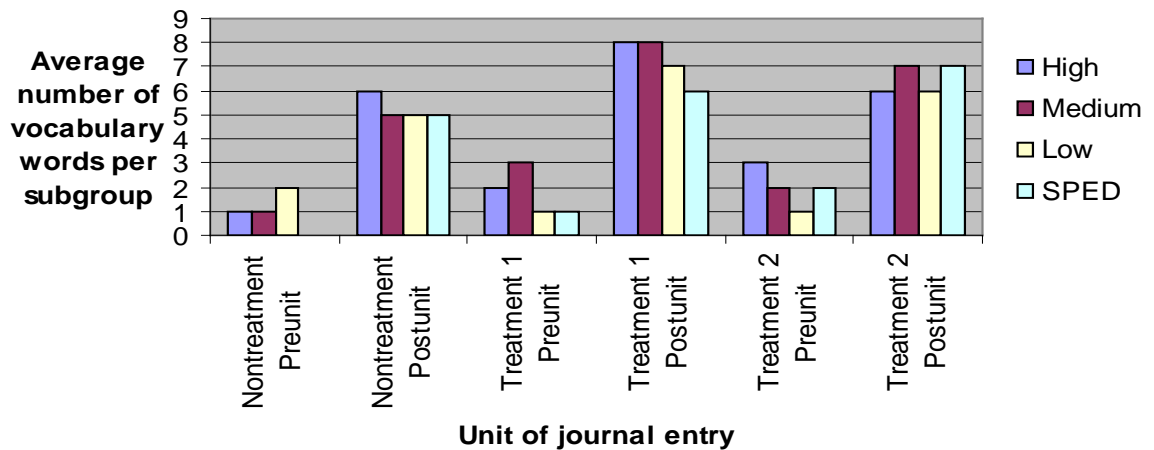


Figure 5. Average Number of Discipline Specific Vocabulary Used in Journal Entries #1, 3, and 6 (Appendix C) among one member from each subgroup ($N=4$). Note: High, Medium, and Low refer to the achievement subgroups; SPED refers to the special education subgroup.

The data indicate that students were more aware of vocabulary in making their journal entries following each unit. All groups in each lesson utilized vocabulary in

their responses to journal prompts after the unit when compared to their preunit responses. The greatest *gain* in the use of these words occurred among students in all groups through treatment unit 1; treatment unit 2 showed the second most. When calculated as a percentage growth, preunit to postunit, however, the students showed the greatest gain following the nontreatment unit.

Table 4

A Comparison of Topic-Specific Terms Used in Journal Entries by Subgroup Representatives, (N =4)

Unit	Preunit Average	Postunit Average	% Growth
Nontreatment	1	5.25	81
Treatment 1	1.75	7.25	76
Treatment 2	2	6.5	69

The qualitative data may indicate the effectiveness of concept mapping in student vocabulary retention while the quantitative seems to indicate otherwise.. It is important that I point out that there were more applicable vocabulary words in treatment unit 1. The lack of a “wordlist” for the nontreatment unit may have affected the data, but students referenced the terms as they were used in the drawing exercise.

I compared postunit and delayed unit assessment scores as well as postunit and delayed unit journal entries in an effort to assess the impact of concept mapping on students’ long-term memory. When considering the impact of the treatment on the delayed unit tests, the percent change for the median scores for the nontreatment unit dropped 1.47% from posttest to the delayed unit exam, while 3.55% and 0.31 % represent the decrease in median scores for treatment Units 1 and 2 respectively.

Figure 6 shows the posttest and delayed unit scores for each of the three units. While the overall drop was lower for Treatment Unit 2, it also was the unit for which overall scores were the lowest.

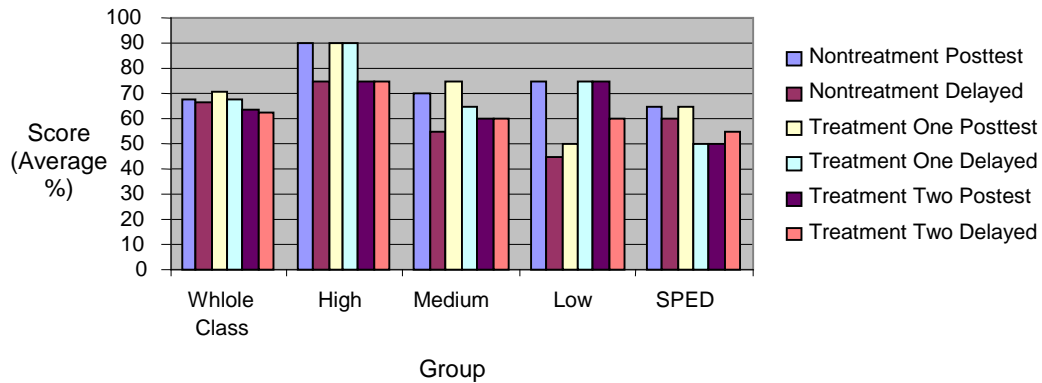


Figure 6. Comparison of Student Performance on Posttest and Delayed Unit Test, ($N=52$ for whole class; $n=2$ for each of the achievement subgroups).

When one analyzes the data for each subgroup, there is some evidence that the treatment was effective. Table 4 includes data from each subgroup. While all groups showed a drop in their scores on the nontreatment unit, there are cases within the subgroups where the treatment scores rose, stayed static, or dropped very little.

Table 5
Student Performance - Posttest Compared to Delayed Unit Exam, ($N=52$).

Description of Data	Nontreatment (%)			Treatment Mean (%)		
	Post	Delay	Change	Post	Delay	Change
High	90	75	-17	82.5	82.5	0
Medium	70	55	-21	67.5	62.5	-7
Low	75	45	-40	62.5	67.5	+8
Special Education	65	60	-8	57.5	52.5	-10

Among the high-achieving subgroup, there was a significant drop within the nontreatment unit but scores did not change in either treatment unit. Likewise, the

medium achievement group dropped much more in the nontreatment unit than in the two treatment units. Within the low-achieving subgroup, there was a very large drop in the nontreatment unit but actually growth in one of the treatment units. This is due to one of the low-achieving students scoring 20% on the posttest and a 60% on the delayed unit test. This probably reflects his effort more than the effectiveness of the treatment or, perhaps the student used the knowledge between the post and delay unit since the scores increased. Within the special education subgroup, the students' scores fell in each of the three units.

In comparing postunit and delayed unit journal entries from the nontreatment as well as treatment units, it became clear that all entries for the delayed unit were shorter compared to the postunit entries. On average among the eight students in the subgroups, the entries for the postunit explanation involved four sentences per student. The delayed unit average was just over two sentences per student. The lack of writing may reflect a lack of knowledge or a lack of effort. The change in the number of sentences per entry is not significantly different between the nontreatment and the two treatment units; there is a significant drop in all cases. There was also a significant drop when analyzing the number of vocabulary terms appropriately applied in the journal entries. These data are presented in Figure 7.

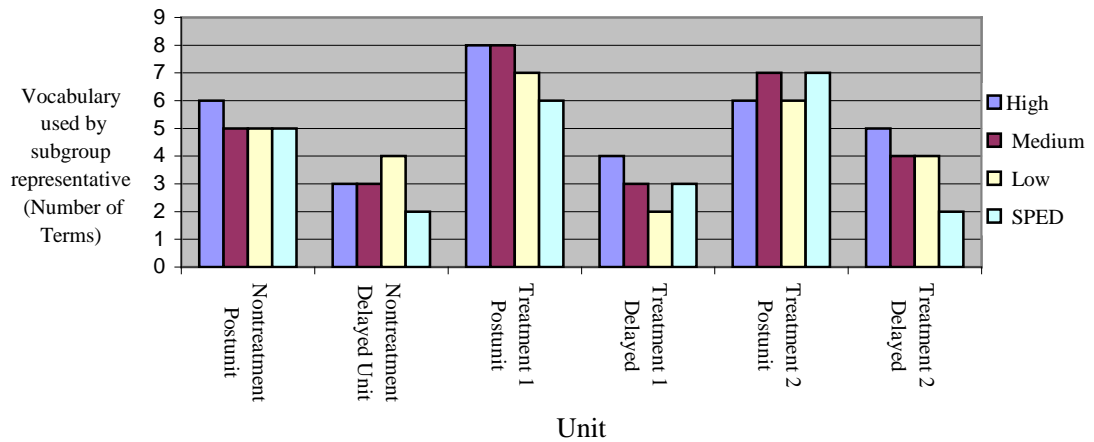


Figure 7. The Number of Appropriate Vocabulary Terms Used by Representative Students in Postunit and Delayed Unit Journal Entries, ($N=4$).
 Note: High, Medium, and Low refer to student achievement subgroups. SPED refers to the Special Education subgroup.

The percentage of terms “dropped” in the nontreatment unit was 43%, while students decreased by 58% in treatment unit 1 and 42% in treatment unit 2. Once again, these data are of limited applicability due to the fact that each unit had different numbers of vocabulary words as well as the fact that the nontreatment unit did not have a specific wordlist associated with it. Nevertheless, this data show that terms that had been used in the postunit journal entry were not applied at the same level in the delayed unit exam across all three units.

While looking for the effects of concept mapping on students’ approach to learning Earth Science concepts, I analyzed student interviews data, journal entries, and the Student Likert Survey. I used student interview questions as a means to evaluate the effects concept mapping had on the students’ approach to learning and considered the ways activities helped students to prepare for tests. Students answered with more enthusiasm after the nontreatment unit than following each treatment unit. Student responses indicated that the poster project that accompanied the nontreatment unit was

much more enjoyable. One member of the high-achieving subgroup had a response that was representative of all eight members of the subgroups when he stated that the "... poster was helpful 'cause he could see it while he answered the questions." The other member of the high-achieving subgroup did point out that the layers of the Earth make a good drawing assignment. She stated that she "couldn't draw some of the other ideas." One student who did respond a little more negatively was a member of the special education subgroup who stated that his poster group was not very helpful. I asked him if it was helpful on the test even though it was not the best group for him and he said that he could picture the drawing on the test. He stated that he had trouble remembering all of the terms, however. When answering this question following the treatment units, students indicated that the exercises helped them know the terms. My notes indicate that students generally seemed to be less enthusiastic when discussing this. Following the second treatment, a student in the medium achieving subgroup did say that the mapping exercise helped him answer the questions better but he did not think it was worth doing anymore concept mapping.

Student journal entries were similar to the interview responses. The poster project in the nontreatment unit was very popular, with students writing that the project enabled them to visualize the layers of the Earth. They felt that this was very helpful to them on the test. One special education student wrote that the picture helped her "think better." Interestingly, a response in her journal following Treatment Unit 1 the same student referenced that the map gave her "something to look at" in preparing for her test. For the most part, students throughout the subgroups discussed the impact of the concept maps on their understanding of the vocabulary after each of the treatment units.

Student Likert Survey results are presented in Figure 8. The average scores represent the average of the product of each student's response and the value of their response, thus a high number reflects a positive response. The mode is the most common response by the students. The data reflect all 52 students that took part in the units. The data are mixed.

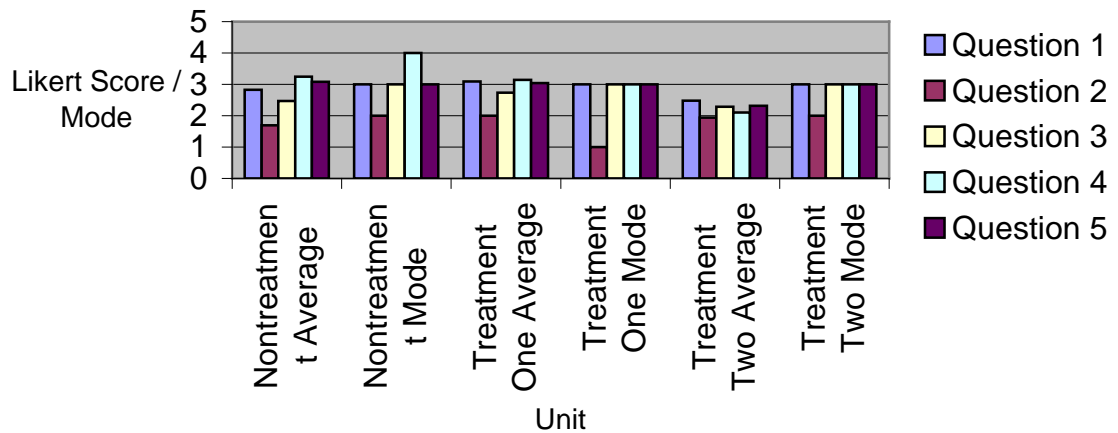


Figure 8. Student Data from Likert Survey – Median and Mode for Each Question, ($N=52$). Question 1- “I focused on the information because of unit activities”; Question 2 – “I read the homework readings twice”; Question 3 – “I looked for the relationships between concepts as I did the activities”; Question 4 – “The activities helped me learn about the topic”; and Question 5 – “The unit activities were ‘worthwhile’ work.”

The highest average to statement 1, measuring the degree to which students felt focused because of unit activities, was for treatment unit 1 while the lowest average was for treatment unit 2. The mode for all three units was *three*. Statement 2, addressing the idea that students read the material twice, was most positively answered in the two treatment units but these averages were quite low, as were the numbers for the mode in all three units. Statement 3 (“I looked for relationships between

concepts...”) was also most positively answered for the two treatment units. The mode for this statement was identical for all three units. Surprisingly, given the enthusiasm students had when describing the activities for the nontreatment unit, the responses to statement 4 (“The activities helped me learn about the topic.”) were fairly close to each other, but the mode reflects the popularity of the poster project. Finally, the idea of worthwhile work, the focus of statement 5, was most positively answered in relation to the nontreatment unit, but Treatment Unit 1 was very close. The mode for this statement was identical across all three units.

Short answer responses to the questions at the bottom of the Likert survey reflected the popularity of the drawing project from the nontreatment unit over the concept mapping. When responding to the question about which activities were most helpful to them, the majority of students (38) wrote that the poster was most helpful to them. The second most popular response was “All of it.” None of the students mentioned that the poster was not helpful when addressing the second question. Table 5 reflects the data related to the treatment. In journal entries following treatment unit 1, the students wrote that the concept map was helpful in 12 of the 52 responses. Nine students mentioned concept maps as being not helpful following the first treatment unit. Following the second treatment unit, 21 students wrote that the concept maps were most helpful and 11 identified that concept mapping was not helpful.

Table 6

Number of Students Reporting in Their Journals That Concept Mapping Was Helpful Versus Those Who Reported That it Was Not Helpful (N=52).

Treatment Unit	Concept Mapping was helpful	Concept mapping was not helpful	Journal entry indifferent to the impact of mapping
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1	12	9	31
2	21	11	20

In addressing the impact that the application of concept mapping had on my teaching, time, and attitude, I looked at my reflection journal, a teacher-planning log that I maintained in my lesson plan book, and an interview I had with my building administrator.

I made several notes in my journal related to what I saw as the limitations to my instruction of concept mapping in the classroom. I focused on the need to develop the idea of a hierarchy among the students. I mentioned, following an opportunity for students to update their maps following a trifold lecture, that the students either did not understand the relationships between the terms or they did not understand mapping. The notes I made during the nontreatment unit included that the students seemed engaged and enthusiastic.

In my log where I tracked my time, I compared the prep time I put into the nontreatment unit and compared it to the treatment units. It indicates that I put twice as much time into each treatment unit. All components of all three units, with the exception of the concept mapping, consisted of material that I have taught for the past 10 years. The fact that the one difference is the concept mapping leads me to believe that the concept mapping took a good deal of time to implement and evaluate. I spent most of the time trying to create meaningful activities for the students to make updates to their maps.

My interview with the principal focused on two things. First, we discussed if I felt that concept mapping was productive for student learning. I had to go back to the idea that the students seemed to focus on vocabulary when mapping, but they liked the drawing unit more. Secondly, we focused on the amount of time it took to complete the units. The demands on our time in the classroom are growing. I am in a position of needing to address a large number of standards so the students are ready for the state proficiency tests. We came to the conclusion that the unit was pretty productive, and he appreciated what he saw in my classroom when he observed.

INTERPRETATION AND CONCLUSION

My goals in completing this project revolved around the whether or not concept mapping would give my students a valuable tool for tying together the Earth Science information I present to them in a variety of ways. Throughout this unit they created drawings, read, and took lecture notes; information was delivered via reading and in lecture, and students worked alone at times and in small groups. Analyses of the data indicate that the greatest overall impact of the method may have been that most students performed better on delayed unit tests following each of the treatment units. Also, there was improvement in student ability to retain and utilize discipline specific vocabulary as evidenced, primarily, by qualitative data.

The mixed results, as indicated by student growth pretest to posttest, on multiple choice tests, show that concept mapping can be a tool used in my classroom, but it is not the one magic bullet that I can apply to help all of my students succeed on the state

proficiency test. Students in the medium achievement subgroup and in the special education subgroup did show greater growth pretest to posttest in the treatment units than in the nontreatment unit.

The data related to long-term retention of information appeared promising. Treatment unit scores dropped much less in the delayed unit exam than those of the nontreatment unit. This is indicative of the effectiveness of the treatment, yet the lack of consistency in the increase from treatment unit 1 to treatment unit 2 as well as the lack of consistency across subgroups indicates the need for further analysis of the mapping procedures during each of the treatment units. Once again, however, the utilization of vocabulary terms in the treatment unit interviews and journal entries does show that the use of concept mapping had an impact on student understanding and retention of discipline specific vocabulary. The ability to apply vocabulary stands to help the students on state proficiency tests.

A detailed look at the data related to the effect that concept mapping had on student approach to learning Earth Science concepts was also mixed. The Likert Survey data indicate that students enjoyed the nontreatment unit to a greater degree, yet they felt more focused during treatment unit 1. The impact that mapping had on student knowledge of vocabulary seems to be at the heart of their approach students will take on future mapping activities. Their response to the fifth question of the Likert Survey, stating that concept mapping was worthwhile work, as well as the idea expressed in student interviews that the mapping exercise was helpful in remembering vocabulary indicates that in the future, students will approach concept mapping exercises as an opportunity to learn.

When I look at the impact that using concept mapping had on my teaching practice, I find that it did not add a great deal of stress to me. In discussing mapping with my principal, we both felt that the increased retention of vocabulary indicated by the data shows that concept mapping provides a pretty good “bang for the buck.” From a teacher standpoint, I know that the impact mapping can have will be greater as I become more effective at teaching the skills required by effective mapping.

If I could change one thing about the project, I would have started with students who were more proficient at mapping; I feel this was the greatest limitation to my study. I had developed mapping skills with the students before beginning this project, as I referenced in my methodology. My notes indicate, however, that too often my students were struggling with the mechanics of mapping. Much of the time spent throughout the treatment units was focused on discussing and developing the concept of hierarchy with the students, a concept I had apparently not fully developed in previous mapping exercises. I found it difficult to further develop hierarchy during the treatment units without using the specific terms on their wordlists as I thought this would bias the results.

A second change I would make would be the inclusion of a subgroup of students for whom English is a second language. Many of these students speak Spanish at home. While they seem to be proficient in their use of English, I found myself wishing I had specific data related to them due to the fact that the project kept leading me to the impact of mapping on student vocabulary development, something I did not anticipate when I organized my study.

Another limitation of the study design was the lack of a wordlist for the nontreatment unit. I wish I had given out a specific list of terms for the unit. This would make the data related to vocabulary growth more reliable. A final change I would make to the project would be inclusion of a large-scale creative piece in each of the units. As designed, each of the units had a drawing, art-based component. As I interviewed the students, it became clear that there was a significant difference between the poster project that comprised the nontreatment unit and the smaller drawing pieces that made up each treatment unit. This difference resulted in students' perception that the three units were not similar. I had intended this project to include three units with the only difference being that concept mapping occurred in the two treatment units. I think the data would be more reliable if the students were allowed the large, creative piece in each of the treatment units.

VALUE

This concept mapping study was valuable to me and my students. In completing the exercises, I was made aware of the limitations of my previous instruction on concept mapping. There were times where I became quite frustrated; as I knew that the lack of student concept mapping skill was affecting the data I collected. To her credit, Dr. Reuter kept trying to get me to improve my mapping technique throughout the past two years and I thought that I had the students doing pretty well. However, given these limitations, I believe that the data indicate that mapping is valuable long term retention of concepts. This makes me believe concept mapping will help them correctly answer

questions on the state proficiency test, one of the goals I have in using concept mapping in my Earth Science unit.

Because of the impact that mapping has on long term retention of concepts, as well as due to the qualitative data related to vocabulary, I will certainly continue to utilize it as a tool in my classroom. I will also integrate concept mapping into my social studies classes.

I was very interested in, and struggled greatly with, my students' lack of ability to organize terms in a hierarchical fashion, a trend that was consistent across all subgroups. After covering the material of both treatment units, I still saw them struggling with the idea of placing words in a general to specific manner. I know that this is a skill that they need to have in completing writing projects as well as developing arguments for their final projects in US History, Civics, and English III and IV. I see my continued use of concept mapping in the subjects I teach as tool that will effectively help me address this issue.

Developing the skills in creating these hierarchies is one of the major pieces I can share with colleagues in discussing my project. I believe that there is a logical skill in developing concept maps. If I can share my findings with colleagues across the curriculum, perhaps we can help all of our students develop these thinking skills thus helping students not only do better on tests, but perhaps develop their problem solving skills as well. I will also share with my colleagues the potential for concept mapping as a tool for developing vocabulary skills among my students.

This study leads me to a jumping off point for further research developing mapping procedures to build on vocabulary proficiency among my students. As

mentioned above, I teach many students who speak Spanish at home. English is not their language of choice. For many of these students, vocabulary outside the realm of “conversational English” is a problem. Science terms are outside of this realm, and vocabulary becomes a major hurdle to their, and many other students, success. I regret my choice of not having English as a Second Language as a subgroup this year because many of these students seem very proficient in English. In developing future lessons, I will keep in mind the impact that mapping can have on vocabulary and I will utilize it throughout the classes I teach.

From a professional standpoint, this project reminded me of my limitations as a teacher in two ways. First, I saw that even though I thought I had instructed my students in concept mapping most of them lacked the ability to map well throughout the project. It is clear that the development of the skills to create hierarchies takes much time and a great deal of practice; this result echos the Gerstner and Bogner (2008) study I read while doing my Literature Review. Similarly, as I did my research for the Literature Review, it seemed that Dr. Novak has dedicated much of his professional life to concept mapping and now I can see why. A second limitation in my teaching practice that became apparent to me was in my ability to analyze my students’ work. Evaluating concept maps forced me to look closely at individual student products with the goal of truly evaluating their understanding and growth throughout each unit. In doing so, I realized that there are many times when I don’t truly evaluate students for what they know – quite often I am correcting work with the goal of assigning a grade. Because of the nature of concept mapping, I am forced to evaluate students. This realization will lead to my use of concept mapping to a greater degree in the future.

Finally, as has happened at times in the past, I feel like I have dropped the ball for students I had in the past and I look forward to doing a more complete job for my students in the future.

REFERENCES CITED

- Abrams, R. (1996). *Meaningful learning: A collaborative literature review of concept mapping*. Retrieved February 12, 2010, from Meaningful Learning Research Group Website <http://www2.ucsc.edu/mlrg/clr-conceptmapping.html>
- Asan, A. (2007). Concept mapping in science class: A case study of fifth grade students. *Educational Technology and Society*, 10(1), 186-195.
- Conlon, T. (2009). Towards sustainable text concept mapping. *Literacy*, 43(1), 20-28. doi:10.1111/j.1741-4369.2009.00504.x.
- Gerstner, S. & Bogner, F. (2009). Concept map structure, gender and teaching methods: An investigation of students' science learning. *Educational Research*, 51(4), 425-438. doi:10.1080/00131880903354758
- Gerstner, S. & Bogner, F. (2010). Cognitive achievement and motivation in hands-on and teacher-centered science classes: does an additional hands-on consolidation phase (concept mapping) optimize cognitive learning at work stations? *International Journal of Science Education* 32(7), 849-870. doi:10.1080/09500690902803604.
- Guastello, E., Beasley, T., & Sinatra, R. (2000). Concept mapping effects on science content comprehension of low-achieving inner-city seventh graders. *Remedial & Special Education*, 21(6), 356-365. Retrieved September 25, 2010, from Academic Search Premier Database.
- Heinze-Fry, J., Crovello, T., & Novak, J. (1984). Integration of ausubelian learning theory and educational computing. *The American Biology Teacher*, 46(3), 152- 156. Retrieved September 25, 2010, from <http://www.jstor.org/stable/4447803>.
- Hsieh, Y & Cifuentes, L. (2006). Student-generated visualization as a study strategy for science concept learning. *Educational Technology and Society*, 9(3), 137-148.
- Jacobs-Lawson, J. & Hershey, D. (2002). Concept maps as an assessment tool in psychology course. *Teaching of Psychology*, 29(1), 25-29.
- Jonassen, D.H. (1991). Objectivism versus constructivism: do we need a new philosophical paradigm? *Educational Technology Research and Development*, 39(3), 5-14.

- Karakuyu, Y. (2010). The effect of concept mapping on attitude and achievement in a physics course. *International Journal of the Physical Sciences*, 5(6), 724-737. Retrieved September 28, 2010, from <http://academicjournals.org/IJPS>
- Liang, L. & Gabel, D. (2005). Effectiveness of a constructivist approach to science instruction for prospective elementary teachers. *International Journal of Science Education*, 27(10), 1143-1162. doi:10.1080/09500690500069442
- Mintzes, J., Wandersee, J., & Novak, J. (2001). Assessing understanding in biology. *Journal of Biological Education*, 35(3), 118-124.
- Novak, J. (2002). Meaningful learning: the essential factor for conceptual change in limited or inappropriate propositional hierarchies leading to empowerment of learners. *Science Education*, 86, 548-571. doi: 10.1002/sce10032
- Novak, J. & Cañas, A. (2008). The theory underlying concept maps and how to construct them, Technical Report IHMC CmapTools 2006-01 Rev 01-2008. Florida Institute for Human and Machine Cognition, 2008. Available at: <http://cmap.ihmc.us/publications/ResearchPapers/TheoryUnderlyingConceptMaps.pdf>
- Powell, K. & Kalina, C. (2009). Cognitive and social constructivism: developing tools for an effective classroom. *Education*, 130(2), 241-250. Retrieved February 24, 2010, from Professional Development Collection.
- Taber, K. (2008). Exploring conceptual integration in student thinking: evidence from a case study. *International Journal of Science Education*, 30(14), 1915-1913. doi: 10.1080/09500690701589404

APPENDICES

APPENDIX A

STUDENT ORAL INTERVIEW QUESTIONS

Student Oral Interview Questions

Selected students were interviewed before school, at lunch, or after school. Students were selected that represented the high performing, medium performing, and low performing subgroups as evidenced by their grades in the first semester.

Student Methodology Questions

The questions below were targeted to identify the impact of the treatment on students.

1. Were these activities helpful to you?
2. In what ways did these activities help you prepare for the test?
3. Should I use any of these activities any more in your class? Why
4. Is there anything else you'd like me to know?

Student Concept Interview Questions

The questions below were targeted to identify student concept knowledge.

Nontreatment unit

1. Describe the structure of the Earth.
2. Why are these layers found in the center of the Earth?
3. How do we know what is in the center of the Earth? Explain.

Treatment Unit 1

1. Describe the theory of plate tectonics.
2. What ways can plates move?
3. What are the results of the plate movement? Explain.

Treatment Unit 2

1. Describe the anatomy of an Earthquake.
2. Are there multiple types of volcanoes? What are they?
3. In what ways are Earthquakes and volcanoes related. Explain.

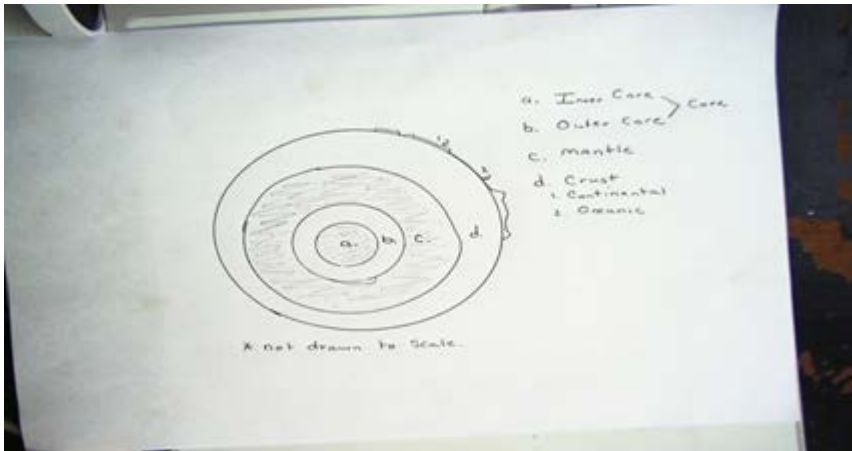
APPENDIX B

NONTREATMENT UNIT
PRE AND POSTUNIT AND DELAYED UNIT TEST

Test – Earth's Structure

Please answer each of the following; remember to explain each answer in the space provided.

Use the diagram below to answer the questions that follow:



1. Which layer in the diagram is the densest?
 - a. Crust
 - b. Mantle
 - c. Inner Core
 - d. Outer Core

- Why / How do you know?

2. Which layer in the diagram is almost completely liquid?
 - a. Crust
 - b. Mantle
 - c. Inner Core
 - d. Outer Core

- Why / How do you know?

3. Which layer in the diagram is the site of movement that creates force, which drives plate movement?
 - a. Crust
 - b. Mantle
 - c. Inner Core
 - d. Outer Core

- Why / How do you know?

4. Which layer in the diagram makes up the largest portion of Earth's mass?
 - a. Crust
 - b. Mantle
 - c. Inner Core
 - d. Outer Core

- Why / How do you know?

5. Which layer in the diagram is responsible for Earth's magnetic field?

- a. Crust
 - b. Mantle
 - c. Core
 - d. None of these.
- Why / How do you know?
6. The lithosphere (crust) is divided into two types – Oceanic and Continental. Which of these is the densest?
- a. Continental Crust
 - b. Oceanic Crust
 - c. They differ by location.
 - d. They are the same.
- Why / How do you know?
7. The Moho forms a boundary between which two layers of the Earth?
- a. the lithosphere and the asthenosphere.
 - b. the crust and the mantle
 - c. the upper mantle and the lower mantle
 - d. the outer core and the lower mantle.
- Why / How do you know?
8. When compared to the asthenosphere, the lithosphere is
- a. rigid
 - b. plastic
 - c..liquid
 - d. the same consistency
- Why / How do you know?
9. The most predominant element that makes up the Earth's core is
- a. oxygen
 - b. carbon
 - c. Manganese
 - d. Iron
- Why / How do you know?
10. Which of the following is most common in the Earth's crust
- a. Iron
 - b. Uranium
 - c. Silicon
 - d. Tungsten
- Why / How do you know?

Short Answer:

1. Why is the Earth composed of layers?
2. What problems exist for scientists who study the center of the Earth and how might they overcome these problems?

APPENDIX C

STUDENT JOURNAL TOPICS

Student Journal Topics

1. Describe the structure of the Earth, including all of the detail you can. Also, include where you learned the information.
2. In what way(s) did the activities in this unit impact your ability to answer the questions on your test? How
3. Describe plate tectonics to the best of your ability. Explain where you learned this information.
4. Describe the affect that the activities had on your learning during this unit. Explain.
5. Did the activities affect your approach to learning the concepts? Which activities had the greatest impact on your learning? Explain.
6. Why do Earthquakes happen? Explain in as much detail as possible. Explain where you learned this information.
7. Explain the forces that create volcanoes. How do you know?
8. Are there different forms of volcanoes? If so, what causes them? Where did you learn this information?

APPENDIX D

STUDENT TRIFOLD SAMPLE

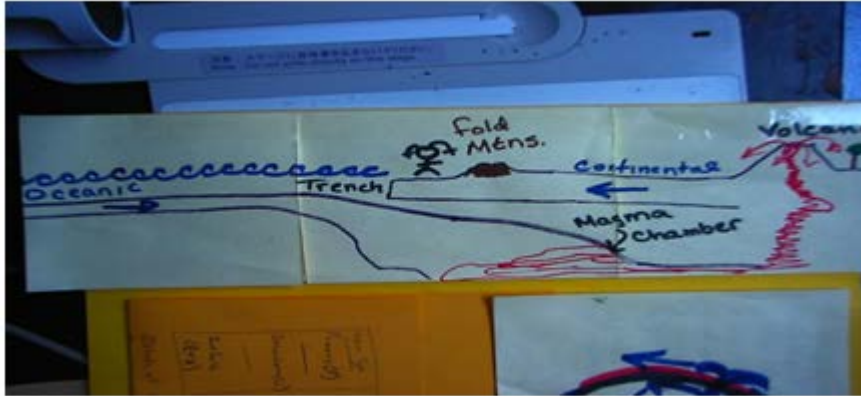


Figure 1. *Treatment unit one trifold component: The ways plates move. Students recorded their notes beneath each flap.*

APPENDIX E

STUDENT ASSIGNMENT – NONTREATMENT UNIT

Earth-to-Scale: Use the sources in the room, including the Internet to complete a drawing of the Earth to scale. Use the paper on the rolls in the corner. Then, complete the following with your group members.

List the sources for your information

1. What was your scale?

2. How big was each of the following using your scale?

- a. Oceanic Crust
- b. Inner Core
- c. Outer Core
- d. Upper Mantle
- e. Lower Mantle

3. Compare each of the following, using specific terms:

- a. Oceanic Crust vs. Continental Crust
- b. Inner Core vs. Outer Core
- c. Lower Mantle vs. Upper Mantle
- d. Outer Core vs. Lower Mantle
- e. Upper Mantle vs. Crust

4. Why are there layers inside the earth?

5. Use the readings to explain how seismologists can tell what the center of the Earth is composed of.

APPENDIX F

PROJECT TIMELINE

Proposed Capstone Project Timeline

Note: Although it is not stated, following each activity and homework assignment will be followed by an opportunity to update concept maps. Principal Fecht will observe one time during each unit with the specific date depending upon his schedule.

My school is on a four day week with each period being 55 minutes in length.

January 24th: Begin project (first day of new semester)

- Students take nontreatment pretest, preunit interviews, and make initial journal entry.
- Begin tri-fold construction lecture with *Structure of the Earth* piece.

January 25th: Complete tri-fold.

- Begin project *The Earth Drawn to Scale*
- Homework reading *A Window into the Solid Earth*

January 26th: Continue project

- Homework reading *The Structure of the Earth*

January 27th: Complete project, discuss and begin presentations.

January 31st: Complete presentations

- Take posttest and make a journal entry, and complete survey.

February 1st and 2nd : Begin intervention unit one

- Pretest and journal entry
- Students complete the preunit concept map.
- Homework reading *Plate Tectonics and Mountain Building*

February 3rd: Lecture and construction of trifold piece: *Ways Plates Can Move*

- Homework reading *The Restless Earth*

February 7th: Lab *Map Evidence for Plate Tectonics*

February 8th: Complete lab, discuss.

- Take treatment unit one posttest.

February 9th: Begin intervention unit two.

- Preconcept map and pretest
- Complete journal entry
- Begin trifold piece *Earthquake anatomy and Subduction in Five Steps*

February 10th: Finish trifold components
- Homework reading *Earthquakes*

February 14th - Lab on volcanic eruptions
- Homework reading *Earthquakes* (2nd reading by same title)

February 15th – Delayed Unit Assessment (nontreatment unit)
- Complete volcanic eruption lab

February 16th – Ring of Fire activity

February 22nd – Wrap up both labs, discussion
- Posttest treatment unit two
- Interview with Mr. Fecht.

February 23rd – Delayed Unit Assessment (treatment unit one)

March 8th – Delayed Unit Assessment (treatment unit two)

APPENDIX G

STUDENT LIKERT SURVEY

Student Attitude Survey:

Please rate each of the following. One means you strongly disagree, two means you kinda' disagree, three means you agree (for the most part), and 4 means you strongly agree.

Survey:

- | | |
|---|---------|
| 1. I focused on the information because of unit activities. | 1 2 3 4 |
| 2. I read the homework readings twice. | 1 2 3 4 |
| 3. I looked for the relationships between concepts as I did the activities. | 1 2 3 4 |
| 4. The activities helped me learn about the topic. | 1 2 3 4 |
| 5. The unit activities were 'worthwhile' work. | 1 2 3 4 |

Which activities were most helpful in helping you prepare for the test? Explain.

Was there any part of the unit that was not helpful to you? Explain.

APPENDIX H

CONCEPT MAP WORD BANKS
FOR USE IN TREATMENT UNITS

Treatment unit one word bank – Plate Tectonics:

Throughout this unit we will use the following words to create a concept map on the topic of **plate tectonics**. Use the words from list one to create your first map. We will add from list two and list three as we complete the unit activities. Use a pencil as we will continue to revise, and remember your proposition.

List One:

Mantle

Continental Drift

Oceanic Crust

Continental Crust

Density

Convection Currents

Fault

Creep

Heat

Supercontinent

Pangea

List Two

Subduction

Divergent

Transform

Convergent

Sea Floor Spreading

Mid Ocean Ridge

San Andreas

Magma

Slab Pull

List Three

Basin and Range

Earthquake

Volcano

Himalayas

Trench

New Crust

Treatment unit two word bank – Earthquakes and Volcanoes

Throughout this unit we will use the following words to create a concept map on the topic of **Earthquakes and Volcanoes**. Use the words from list one to create your first map.

We will add from list two and list three as we complete the unit activities. Use a pencil as we will continue to revise, and remember your propositions!

List One

Epicenter

Strike-Slip

Fault

Focus

Transform

List Two

Effusive

S Wave

P Wave

Subduction

Mountains

Explosive

List Three

Normal Fault

Tsunami

Destruction

Richter Scale

Ring of Fire

Pressure

APPENDIX I

TREATMENT UNIT ONE
PRE, POST, AND DELAYED UNIT ASSESSMENT

Test – Plate Tectonics: Answer the following questions. Please be sure to include your explanation in the space provided.

The diagram below shows four major types of fault motion occurring in Earth's crust.

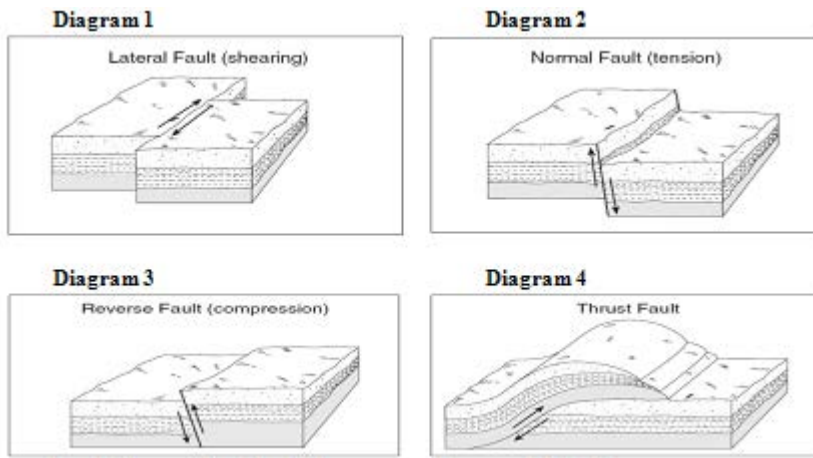


Diagram 1

Diagram 2

http://rpd.net/adm/uploads/nhspe_science/resource_2593.pdf

1. Which type of fault motion best matches the general pattern of crustal movement at California's San Andreas Fault?

- A. Diagram 1
- B. Diagram 2
- C. Diagram 3
- D. Diagram 4

- Why / How do you know?

2. The movement of tectonic plates is thought to be driven by

- A. tidal motions in the oceans.
- B. density differences in the atmosphere.
- C. convection currents in the mantle.
- D. solidification in the core.

- Why / How do you know?

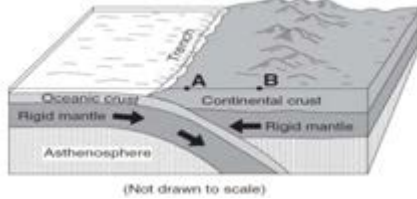
3. Which information indicates that new seafloor rock is forming along the mid-ocean ridge and then moving horizontally away from the ridge?

- A. Most volcanoes are located under ocean water.

- B. The orientation of Earth's magnetic field has remained constant.
- C. Fossils of marine organisms can be found at high elevations on continents.
- D. The seafloor rock becomes older as the distance from midocean ridges increases.

- Why / How do you know?

Use the diagram to answer the following question.



http://rpd.net/adm/uploads/nhspe_science/resource_2593.pdf

4. Which type of plate boundary is shown in the diagram?

- A. Divergent
- B. Transform
- C. Convergent
- D. Universal

- Why / How do you know?

5. This diagram is an example of a(n)

- A. Subduction Zone
- B. Induction Zone
- C. Reduction Zone
- D. Adduction Zone

- Why / How do you know?

6. Which of the following would you NOT find in this region, due to the action in the picture?

- A. Tsunami
- B. Volcano
- C. Transform Faulting
- D. Mountains

- Why / How do you know?

7. Make a prediction based on the following statement: "If there were a planet that had a cool core, or if Earth's interior were to completely cool, what would happen?"

- A. Earth's plates would go back together in a supercontinent.
- B. Earth's plates would move faster in the direction they are going.
- C. Earth's plates would move in the opposite direction.
- D. Earth's plates would quit moving.

- Why / How do you know?

8. The results of plate movement are most obvious at

- A. Rift Zones
- B. Ocean Margins
- C. Plate Boundaries

D. Ocean Floors.

- Why / How do you know?

9. The fact that you find the same _____ on different continents is evidence that continents are moving.

A. Fossils

B. Animals

C. Rocks

D. All of the above.

- Why / How do you know?

10. The plates under the ocean floor are _____ than the continental plates:

A. More dense

B. Less dense

C. Younger

D. Older

- Why / How do you know?

Complete the following:

1. Describe a situation in which the plates on Earth would cease to move. Explain.

2. If you lived on a fault, would you prefer to see continual movement or no movement for a long period of time? Why?

APPENDIX J

TREATMENT UNIT 1 LAB WORKSHEET

Lab Sheet – Map Evidence for Plate Tectonics

Use the maps in your packet to answer the questions:

1. Describe the regions where you see the greatest earthquake density (evidenced by the width and darkness of the bands of dots).
2. Describe the location of other areas where you see irregular belts or lines of quakes.
3. Are the areas in #1 near trenches or ridges?
4. Are the areas in #2 near trenches or ridges?
5. What conclusions can you draw about quake activity on Earth?

Use the maps that show ridges and trenches as well as those that show ridges and trenches to answer the following:

7. Where are most volcanoes located?
8. Are the majority of Pacific volcanoes located near trenches or ridges?
9. On what feature are the Icelandic volcanoes located?
10. What can you conclude about volcanic activities in these regions?

Finally – Hypothesize why the volcanoes of Hawaii formed where they did.

APPENDIX K

STUDENT WRITTEN SURVEY

Written Survey / Interview Questions: Please answer each of the following.

1. Did the concept map help you understand the material? Yes or No and Why
2. Were you more likely to read handouts more thoroughly with the concept map?
Yes or No and Why
3. Were you “looking” for the vocabulary throughout the exercise to a greater extent? Yes or No and Why
4. What pieces of information stood out to you after completing the concept map?
Explain.
5. Did the concept map make the activity more difficult? Yes or No and Why
6. Is there anything else you’d like me to know about this process?

APPENDIX L

TREATMENT UNIT 2
PRE, POST, AND DELAYED UNIT ASSESSMENT

Test – Earthquakes and Volcanoes: Address each of the following. Please be sure to include your explanation in the space provided:

1. When rocks break because of stress, the energy released is in the form of a
 - a. Tsunami
 - b. Volcano
 - c. Earthquake
 - d. Epicenter
 - Why / How do you know?

2. The location where the rock breaks is referred to as the
 - a. Epicenter
 - b. Focus
 - c. Earthquake
 - d. Wave Center
 - Why / How do you know?

3. Which type of wave reaches a location first following an earthquake?
 - a. Primary Wave
 - b. Surface Wave
 - c. Secondary Wave
 - d. They all reach a point at the same time.
 - Why / How do you know?

Use the table below to answer the following questions:

This table shows the difference in arrival times between primary and secondary waves at certain distances from an earthquake epicenter.

Distance (km)	Time (min and sec)	
	Primary Wave	Secondary Wave
1000	0:40	1:20
2000	1:15	2:10
4000	2:00	3:25
6000	2:25	4:10

4. If there is a difference in arrival time of 55 seconds, how far away from the epicenter are you?
 - a. 1000 Km
 - b. 2000 Km
 - c. 4000 Km
 - d. 6000 Km

- Why / How do you know?
5. What happens to the difference in arrival time, as you get closer to the epicenter?
- a. The difference increases.
 - b. The difference decreases.
 - c. The difference varies.
 - d. You can not tell from the chart.
- Why / How do you know?
6. One factor that determines whether a volcanic eruption will be quiet or explosive is
- a. The number of cinder cones present.
 - b. The height of the volcano's vent.
 - c. The amount of water vapor and other gases in the magma.
 - d. The amount of tephra in the magma.
- Why / How do you know?
7. Hot spots occur at
- a. Locations other than plate boundaries
 - b. Divergent plate boundaries.
 - c. Convergent plate boundaries.
 - d. Cinder cones.
- Why / How do you know?
8. Magma and Lava are different in that
- a. Magma and lava are found in two different locations.
 - b. Magma and lava have different chemistry.
 - c. Magma and lava have different gases within them.
 - d. All of the above.
- Why / How do you know?
9. What physical characteristic of magma drives its movement to the surface?
- a. Density
 - b. Volume
 - c. Temperature
 - d. Physical State
- Why / How do you know?
10. Earthquakes and volcanoes can both be attributed to
- a. The different weather patterns of a location.
 - b. The latitude of a location.
 - c. The age of the parent rock in a location.

- d. The movement of tectonic plates near a location.
- Why / How do you know?

Complete the following:

1. What makes earthquake / volcanic eruption difficult to predict? Explain
2. A city like Seattle can be viewed as being a dangerous place to live. Please analyze the natural hazards of such a place.

APPENDIX M

PRINCIPAL OBSERVATION GUIDE AND INTERVIEW QUESTIONS

Mr. Fecht and I created this together. It is primarily created as a tally sheet.

Students on Task	Yes	No
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Distracting Behaviors:

Teacher Focus	Content	Discipline
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Interview Questions:

1. How did the project affect classroom atmosphere?
2. Would you implement any changes?
3. Did the treatment seem worthwhile? Why/ Why not?