

THE EFFECTS OF DIFFERENTIATING INSTRUCTION IN A MIXED-ABILITY
MIDDLE SCHOOL SCIENCE CLASS

by

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ABSTRACT

This study examined the effects of differentiating instruction in a sixth grade earth science classroom. During three lessons within one unit of study, tiered instructional materials were utilized and students were assigned to tiered learning groups. Likert-style surveys, student interviews, teacher observations, open-ended survey questions and unit test scores were used to collect data about the impact on student achievement, engagement and attitudes. Journal entries and teacher observations were used to determine how differentiating instruction impacted the teacher. Differentiating instruction improved the achievement of previously low-achieving students, but had mixed results for other students. Student attitudes were more negative following differentiated instruction. This treatment has mixed effects on student engagement and on the teacher.

INTRODUCTION AND BACKGROUND

Background

I teach sixth and seventh grade science at The Moriah School, which is a Jewish pre-K through eighth grade private school in Englewood, NJ. Englewood is a suburban area located about ten minutes from New York City. One hundred percent of the students at The Moriah School are Jewish and students receive instruction in both secular and Judaic subjects. Eight hundred thirty four students were enrolled in The Moriah School during the 2011-2012 school year and there were 168 staff members. Tuition was \$14,050 and 22% of families received financial assistance. Less than 1% of the student body qualified for free lunch. Students in pre-K through fifth grade attend school from 8:30 AM to 3:30 PM Monday through Thursday and 8:15 AM through 1:30 PM on Fridays. Students in grades six through eight attend school from 7:45 AM to 4:30 PM Monday through Thursday and 7:30 AM through 2:00 PM on Fridays.

I conducted my research in all four of my sixth grade classes. Each class consists of 22-26 students, resulting in a sample size of 94, and I see each class for four forty-minute periods and one thirty-minute period a week. In the sixth grade, students are only tracked by ability for math and Hebrew language. Each of my science classes contains students from all tracks of math and Hebrew language, resulting in a mix of students for whom ability levels range from remedial to gifted. Some students receive additional support services by participating in three support periods a week, in lieu of a Judaic subject, and they are also enrolled in remedial Judaic classes. These students, who participate in a program called *Maximum Support*, are mixed into two of my science

classes, and their case manager comes with them to science class to function as a support teacher.

During the five years that I have been teaching these classes, I have struggled with how to properly engage and effectively teach the diverse group of students that walk into my classroom. I almost always teach the same lesson to all students, even if students are working together in groups. I have noticed that when I teach the same lesson to the entire class, I am rarely engaging all students. I usually feel like I am moving too slowly for some students and too quickly for others. I started to read about differentiated instruction and became interested in using this teaching method in my own classroom.

The purpose of my action research was to determine if differentiating instruction would be an effective way of engaging and more effectively teaching a higher percentage of the students in my sixth grade classes.

Research Questions

My primary research question is: What are the effects of differentiating instruction in my mixed-ability sixth grade science classroom? I also investigated the following sub-questions:

- How does differentiated instruction affect student engagement during class?
- How does differentiated instruction affect students' attitudes about science class?
- How does differentiated instruction affect student achievement?
- How does differentiating instruction affect me as a teacher?

CONCEPTUAL FRAMEWORK

The following literature review examines research done on differentiated instruction, including types of differentiated instruction, and the theory behind differentiated instruction. It also explores how differentiated instruction has the potential to improve student engagement, attitudes, and achievement.

Differentiating instruction involves the modification of the content, process, or products of instruction according to students' readiness levels, interests, and learning profiles. A teacher can choose to modify one or more aspect of instruction according to one or more of the student needs listed above. For example, a teacher can modify the content of instruction according to readiness levels or the product that students will produce based on learner profiles. This philosophy of instruction recognizes the fact that each student in a class is an individual with different learning needs and interests (Heacox, 2002). As

Tomlinson (1999) writes, "Differentiation is an organized yet flexible way of proactively adjusting teaching and learning to meet kids where they are and help them to achieve maximum growth as learners" (p.14).

Since the motivation for differentiating instruction in my classroom stems from the desire to challenge all learners at the appropriate level, I chose to differentiate instruction according to readiness level. Tomlinson (1999) defines readiness as, "a student's entry point relative to a particular understanding or skill" (p.11). Each student in a classroom has different background knowledge and skills for each particular task. In this method of differentiation, instruction is designed in order to accommodate the varying levels of readiness that exist in a classroom. The idea of differentiating

instruction according to readiness level is based on research that shows that the best learning occurs when students are presented with work that is moderately challenging. If an assignment or task is too difficult for a student, that student is likely to shut down or give up. On the other hand, if a task is too easy, they may end up in a “relaxation mode” where little learning takes place. Students should feel that assignments they are given require work and effort, but that if they put effort in they will be able to succeed (Tomlinson, 1999). Differentiating instruction according to readiness level allows this type of instruction to take place.

One method that can be used to differentiate instruction according to readiness level is called tiered learning. Tiering instruction by readiness level involves presenting the lesson content at varying levels of difficulty while using the same process for all students in the class. During a tiered lesson, students work in homogeneous cooperative groups that are teacher- assigned. Teacher assignment is based on a student’s readiness level for that specific lesson and therefore students may end up in different tiers for different lessons. For example, tiers may be based on reading level for one lesson and on experience with lab equipment for another lesson. Frequent formative checks and teacher observations are used to determine group placement for each learning activity (Heacox, 2002). Adams and Pierce (2003) caution that tiered instruction should involve tiering the level of complexity and not the amount of work that each group receives.

Adams and Pierce (2003) describe several examples of tiered science lessons that they have used. In one sample lesson elementary students were divided into tiered groups based on their level of reading comprehension. Each tier read a book that was appropriate for their level of reading comprehension, but each group was working on the

same key concept. In another tiered lesson, one tier of students was asked to investigate which objects a magnet can attract while a higher tier was asked to find out if the size of a magnet affects how strong it is. Both groups were learning about the concept of magnetism, and both groups were learning through a hands-on investigation. However, one tier was working with a concrete concept, while the other group was working with a more abstract concept. Ideally, these two groups would have the same amount of work to complete and the task would also take approximately the same amount of time. All students ultimately reach the same learning goal, but get there in different ways.

White (2006) writes about ways in which he has tiered both an inquiry activity and an independent project. He describes an inquiry activity during which students are asked to develop their own testable questions and then develop and carry out an experiment about heart rate. Students who have demonstrated readiness for this task develop their questions with little or no teacher assistance. These students work independently on creating their procedures and carrying out their experiments. Conversely, students who have not yet demonstrated proficiency in these skills work with the teacher separately in order to develop a testable question and an experiment. Members of the group help each other, and the teacher provides guidance when needed. These students all carry out the same experiment and share data with each other, allowing the teacher to provide the proper amount of scaffolding and to increase student skill level. White also tiers a project called “Disease Book” by assigning students diseases of varying difficulty. This makes it more likely that each student will feel challenged by the assignment, but not overwhelmed.

The use of tiered learning groups is appropriate for my middle school science classroom. According to Jorgenson, Cleveland and Vanosdall (2004), the students in a middle school classroom are at various developmental stages. Some students are still concrete learners, while others are able to think more abstractly. This can affect a student's ability to make inferences or understand the relationship between variables. Students who have already reached Jean Piaget's *formal operations* stage may be able to design controlled experiments and understand the periodic table, while students who are still in the *concrete* stage may find these tasks very difficult. As Jorgenson, Cleveland and Vanosdall (2004) write, "A one-size-fits-all, text-based approach to science does not readily accommodate the wide developmental differences between students" (p.5). These authors also argue that middle school students have an "increased sense of independence" and a "need for social interdependence" (p.2). Differentiating instruction by placing students into tiered groups addresses these two needs by allowing students to work in cooperative groups that foster a sense of independence.

Much research has been conducted about the effectiveness of small group instruction and its impact on student achievement, attitude, and effort. Lou (1996) conducted a meta-analysis of such research. According to this study, within class grouping can be used to address many challenges such as: large class size, mainstreaming of special needs students, untracked classes, and a decrease in enrichment programs for gifted and talented students. This meta-analysis analyzed studies that compared within class grouping to no grouping and homogeneous versus heterogeneous grouping. Results for within class grouping versus no grouping, which were taken from fifty one studies

that involved over 16,000 students, indicate that students learning in small groups achieved more than students learning in whole class instruction. Groups that were made up of 3-4 students, as opposed to 5-7 students, showed the most significant gains in achievement. Low, middle, and high-ability students all showed achievement gains from small group instruction, but the low-ability students showed the most significant gain. Additionally, within class grouping raised achievement levels the most in science and math instruction compared to other subjects. This type of grouping also lead to a significant gain in achievement for grades four through six. This meta-analysis also found that students who participated in grouping had a more positive attitude about the subject matter. Since I will be implementing a small-group instructional method in a sixth grade science classroom, I am hopeful that I will see similar gains in achievement and attitude.

Differentiated instruction has the potential to improve student engagement, attitudes, and achievement. Beecher and Sweeny (2008) write about one elementary school that tracked the effectiveness of implementing a school-wide differentiation and enrichment program over the course of eight years. At the time of the study, 45% of the school population was on free or reduced lunch and 30% of the students were English language learners. Teachers were trained in differentiation techniques and began to develop differentiated units of instruction and differentiated lesson plans. For example, they utilized texts from varying reading levels and placed students into small groups based on their needs and interests. As a result of differentiation and enrichment, there was school-wide improvement in achievement, attitudes and level of engagement across all subjects. For example, the achievement gap between high and low socio-economic groups dropped from 62% to 10%, and all ethnic groups showed improvement in

achievement. The dramatic results of this study indicate that differentiation can be used to improve student achievement, attitudes, and engagement, even in the most challenging circumstances.

Differentiation is based on the idea that each student walks into the classroom with his/her own interests, learning style and readiness level. When a teacher takes these factors into consideration and designs instruction accordingly, there is great potential for improving student attitudes, engagement, and achievement.

METHODOLOGY

Treatment

In order to answer my research questions, I differentiated instruction in all four of my sixth grade earth science classes ($N=94$). The research methodology for this project received an exemption by Montana State University's Institutional Review Board (Appendix O) and compliance for working with human subjects was maintained. My sample consisted of 39 females (41%) and 55 males (59%) between the ages of eleven and twelve. The sample included one male who is visually impaired, one female who is hearing impaired, and one female with a degenerative neurological disorder. Sixth grade students have science for forty minutes a day Monday through Thursday and thirty minutes every Friday. Prior to the sixth grade, students at The Moriah School meet with a science teacher once a week for hands-on science activities. Students do not take assessments or receive a grade in science until the sixth grade.

According to Diane Heacox (2002) instruction should be differentiated at exit points, which she defines as "times during the teaching of a unit when your curriculum diverges and various students 'exit' the common instruction and activities because their learning needs differ from the core group" (p. 62). I identified three "exit point" lessons in the Inside Earth unit from the *Issues and Earth Science* (SEPUP, 2006) curriculum, published by Lab-Aids and SEPUP. My treatment involved differentiating these lessons by placing students into tiered learning groups. In this application of differentiated instruction, students are placed into groups based on their readiness for specific lesson content or skills. Each group is then provided with instructional materials and tasks that match their readiness level. Group membership changed from lesson to lesson, based on student needs. Student work, formative assessments, and teacher observations were used to determine group placement.

The first lesson that I differentiated was *Activity 40: The Continental Puzzle* (SEPUP, 2006). I differentiated instruction by grouping students into high, middle, and low tiered groups and by using tiered instructional materials. Students were assigned to tiered groups based on my classroom observations about readiness for higher order thinking and ability to follow a procedure with minimal teacher support. Students placed in the highest tier worked on an assignment involving higher order thinking skills, while students in the middle and lower tiers worked on the original version of the text-book lesson. Students requiring the highest level of teacher support when following a written procedure were placed in the lowest tier in order to facilitate maximal teacher interaction and support.

On the first day of this lesson I informed students that I would be assigning them to new tables for Activity 40. In my first two classes of the day I handed each student an index card with his or her name, a shape and a number. The shapes corresponded to each tier and the numbers represented what table students should work at. However, students quickly picked up on the fact that many students who are normally viewed as "smart" all had the same shape and one student even said "all the smart kids have triangles on their cards." I, therefore, did not use this method with my other two classes. Instead, in the other classes, I placed a piece of paper on each table listing the names of students who should be sitting there.

Once students were divided into groups and seated at their new tables, students in the higher tier were given a color copy of the map shown below (Figure 1) and a packet (Appendix A). They worked in groups of two to four to answer the questions in their packet about the map. The questions were intended to model the process that Alfred Wegener went through when developing the idea of continental drift. For the first set of questions, students had to identify the locations of the *Glossopteris* fossils, coal beds, glacier marks and folded mountains shown on the map. After reading information about the evidence depicted on the map, they were asked to write down what was strange about the locations of these geological features. This set of questions required students to apply what they had read to their observations about the map. For example, students read that *Glossopteris* was an ancient plant that grew in warm, wet places; however, the map showed fossils of *Glossopteris* in present-day Antarctica. The final question asked students to develop a hypothesis that would explain all of the observations that they had made about the map.

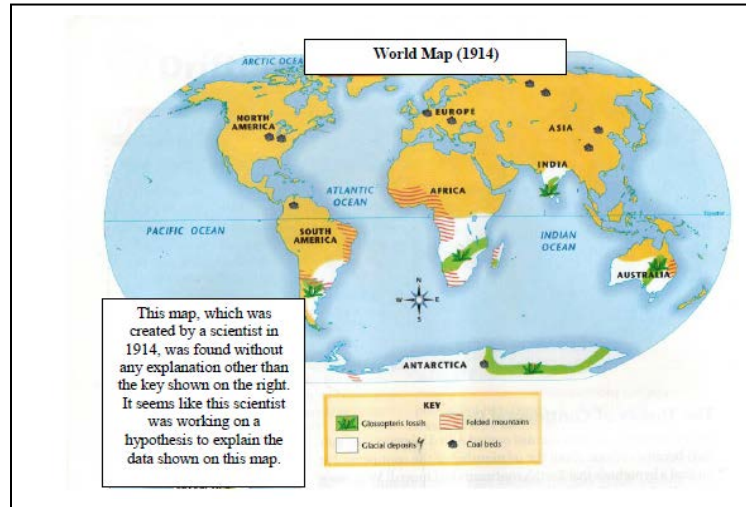


Figure 1. Map of evidence for continental drift (Adapted from Prentice Hall, 2000, p. 30).

Students in the other tiers followed the procedure in the *Issues and Earth Science* (SEPUP, 2006) text book (Appendix B). During this procedure students looked at a world map and listed the names of the seven continents that exist today. They were then instructed to piece together the puzzle shown below (Figure 2) in order to create a model of how the continents were arranged billions of years ago. After putting together the puzzle, students looked at a handout entitled *Earth's Surface Through Geological Time* (Appendix C) and were asked to describe how Earth's surface has changed over billions of years. They also used the “Key to Symbols on World Puzzle” (Figure 3) and listed the evidence, such as the locations of certain fossils, which the puzzle provided about how the arrangement of the continents has changed over time. I reviewed the procedure with students from the lower tier as the other groups began their work. This version of the learning activity focused more on modeling and observation and did not require students to apply their knowledge to answer questions or to develop a hypothesis.

All of these tasks fell into the knowledge and comprehension categories from Bloom's Taxonomy.



Figure 2. Pangaea puzzle (Taken directly from SEPUP Teacher's Guide, 2006, p. D-55).

Key to Symbols on World Puzzle	
	<i>Glossopteris</i> , an extinct fern-like plant that could grow to 3.7 meters (12 feet) in height
	<i>Mesosaurus</i> (MESS-oh-saw-rus), an extinct freshwater reptile about 0.5 meters (2 feet) in length
	<i>Cynognathus</i> (sy-nog-NAY-thus), an extinct land reptile about the size of a wolf
	<i>Lystrosaurus</i> (liss-tro-SAW-rus), an extinct land reptile about 1 meter (3 feet) long
	Mountain ranges that have similar rock layers

Figure 3. Key to symbols on world puzzle (Taken directly from SEPUP, 2006, p. D-24).

I collected student work at the end of the period, and noticed that most of the students in the higher tier had misunderstood many of the questions in the packet. The next day at the beginning of class I asked students to return to their groups from the day before. I gave students in the higher tier another handout (Appendix D) containing more detailed instructions for how to complete the packet from the day before, and I asked them to sit at tables toward the back or side of the room. Students were also instructed to

self-check each question before moving on to the next one. I had the answers hanging up on a bulletin board to enable self-checking.

While students in the higher tier were working, I reviewed answers to the previous day's work with students from the middle and lower tiers. I read each question out loud, asked students to share their answers, and wrote the correct answers on the board. Students in the middle tier then continued working on the activity while I reviewed the procedure with the students in the lowest tier. Due to the small size of my classroom, some students from the higher tier found it difficult to concentrate on their own work while I was working with the other students. In some classes, students from the higher tier elected to complete their work in the hallway, where it was easier to concentrate. At the end of class, I collected the packets from the students in the higher tier.

The second lesson that I differentiated was *Activity 44: Mapping Plates* (SEPUP, 2006). The first day of this lesson did not involve any differentiated instruction, and the entire class followed the procedure from the text-book and completed the same activity. However, I decided that some students would benefit from receiving a differentiated version of the analysis questions found at the end of the lesson. On the second day of the lesson, some students received a copy of the original text-book questions (Appendix E), while others received a modified version that contained more scaffolding (Appendix F). The original and modified questions are shown in Table 1 below.

Table 1
Activity 44 analysis questions

Original Analysis Questions	Tiered Analysis Questions
No glossary provided.	Glossary provided: <u>Plate</u> = a section of the lithosphere. Earth's lithosphere (crust and upper mantle) is broken into pieces, and we call each piece a plate. <u>Plate boundary</u>=a place where there is a crack in Earth's lithosphere. This is the border, or crack, between two plates. <i>*If you are confused about either of these words, please tell Mrs. Kinsberg BEFORE you answer the analysis questions.</i>
1) Are the sizes and shapes of the continents the same as the sizes and shapes of the plates? Support your answer with a specific example from Student Sheet 44.2.	1) Look at student sheet 44.2 (the map). a) Are the plates the same shapes and sizes as the continents? b) Support your answer by writing about one specific continent that is or is not the same shape as the plate that it is a part of.
2) What is the relationship between earthquakes, volcanoes, and plate boundaries?	2) Write down the correct sentence on your paper: a) Volcanoes and earthquakes occur in random places all over the world and they have nothing to do with plate boundaries. b) Volcanoes and earthquakes usually occur on or close to plate boundaries. c) Volcanoes and earthquakes usually occur far away from plate boundaries. d) Earthquakes usually occur on or near plate boundaries, but volcanoes occur in random places all over the world.
3) In Activity 36, "Storing Waste," you learned that Nevada has the fourth highest number of earthquakes per year in the U.S. Which state would you predict to have a higher risk of earthquakes: Washington or Texas? Why?	3) In Activity 36, "Storing Waste," you learned that Nevada has the fourth highest number of earthquakes each year in the U.S. Look at the picture below and your world map. Find America on your world map. (Remember to answer the questions in full sentences.) a) Which state is closer to a plate boundary, Washington or Texas? b) Do you think that Washington gets more earthquakes or that Texas gets more earthquakes? c) Explain why.
4) In Activity 40, "The Continent Puzzle," the country of India was a separate puzzle piece. Use the information on Student Sheet 44.2 to help you explain why.	<u>Challenge Question:</u> When we used puzzle pieces to model Wegener's idea of continental drift, the country of India was on its own puzzle piece. Find India on your world map. (If you do not know where it is, ask Mrs. Kinsberg to show you.) Why do you think India was on its own puzzle piece?

At the beginning of class I told students that they would be completing the analysis questions independently and handing in their answers at the end of class. I gave out “test folders,” which students normally use for privacy while taking tests, so that students would be less likely to notice if the person working next to them had a worksheet that looked different from their own. Students were informed that they were working with test folders so that they could concentrate on their own work.

After all students handed in their worksheets, I reviewed the answers with the class. Since both versions of the worksheet asked the same questions, just worded in different ways, I was able to review the answers with all students at once by referring to each question in general terms, as opposed to reading it out loud word-for-word. For example, for the first question I said: “The first question asked you if the shapes of the plates are the same as the shapes of the continents. Who would like to share their answer? Can anyone give an example of one continent that was not the same size and shape as the plate that it is part of?” Since students did not have their worksheets or answers in front of them, they were all able to participate equally in the conversation without noticing that they had worked on slightly different versions of the analysis questions.

The third differentiated lesson involved a tiered reading assignment about plate motion. This lesson was selected for differentiation because the students in my classes have a wide range of reading comprehension skills. I consulted with the sixth grade English teacher, two support teachers and the sixth grade history teacher when assigning students to tiered groups. They helped me determine the difficulty level of the text-book reading (Appendix G) and gave me a list of students who they thought would require an

easier version of the reading. The modified version (Appendix H), which I created, contained a glossary on the side of each page, simpler language, and fewer details about some topics. All students completed the same notes worksheet (Appendix I) while reading.

When students walked into the room at the beginning of this lesson, a chart, similar to Table 2 below, was on the Smartboard. Each table in the room was numbered so that students could efficiently find their new seats. The groups were not listed on the chart in any particular order and were also assigned a random color. This made it less likely for students to notice that groups were tiered, rather than random.

Table 2
Activity 45 tiered groups

<u>Table 1</u>	<u>Table 2</u>	<u>Table 3</u>	<u>Table 4</u>	<u>Table 5</u>	<u>Table 6</u>	<u>Table 7</u>
<u>*All names</u>	<u>have been</u>	<u>changed.</u>				
Molly	Sara	Rivka	Lucy	Aaron	Moshe	Eitan
Nancy	Jonathan	Tom	Seth	Esther	Jeremiah	Yossi
Marcus	Bobby	Joey	Olivia	Jill	Goeff	
Avi	Karen		Gabe			

After students were at their new tables, I handed out the notes worksheet to the whole class and explained how to complete it. Students were informed that they could choose to work independently, in pairs, or as a whole table as long as they stayed at their assigned tables. I then walked around the room and handed out the reading packets. In order to make the tiering less noticeable, both versions of the reading had the same cover page and the same final page. While students were working, I circulated around the room to answer any questions and to check on student progress, spending a greater amount of

time with students who needed more support. Once students had completed the reading, I collected the booklets and we reviewed the worksheet as a whole class.

Data Collection

I used a variety of data collection techniques in order to answer my research questions. These methods are outlined in Table 3 below.

Table 3
Data Collection Matrix

Research Question	Data Source One	Data Source Two	Data Source Three
Main Question			
What are the effects of differentiating instruction in a mixed-ability 6 th grade science classroom?	All data sources mentioned below will be used to answer the overarching research question.		
Sub Questions			
How does differentiated instruction effect student engagement during class?	Teacher observations	Likert-style engagement surveys	Semi-structured interviews conducted in focus groups
How does differentiated instruction affect students' attitudes about science class?	Open-ended survey questions	Likert-style attitude surveys	Semi-structured interviews conducted in focus groups
How does differentiated instruction affect student achievement?	Unit test grades for non-treatment and treatment units	Student generated artifacts	Formative assessments (CATs)
How does differentiating instruction affect me, as a teacher?	Teacher journal	Observations made by other teachers	Semi-structured interviews conducted in focus groups

Each method of data collection provided me with insights about my research questions. The Likert scales provided me with data that was more easily quantifiable, while the surveys, interviews, and teacher journal provided me with richer qualitative data. The use of multiple methods of data collection for each research question allowed me to triangulate my data, improving the validity and reliability of the data collected. All surveys and questionnaires were administered before and after treatment so that changes could be tracked.

In order to measure changes in student attitudes, I administered a Likert-style attitude survey to all students before and after treatment (Appendix J). Some students were absent on the days the survey was given, resulting in a sample size of 89 pre-treatment and 82 post-treatment. Before students began filling out the survey, I informed them that their responses would not have any impact on their grades. I also reassured them that I would not get offended by negative responses, and that I would not be sharing their surveys with any other teachers or students. I calculated an average attitude score for each student based on survey responses. Average attitude scores ranged from one to four, with one representing a very negative attitude, and four representing a very positive attitude. Question six was not included when calculating student averages. This is due to a design flaw in the survey that I only noticed after administering the survey.

Several Likert statements on the attitude survey were followed by the question “Why?” allowing students to explain why they selected their answer. Student responses to these open-ended survey items provided me with more insight about the factors contributing to student attitudes. These responses allowed me to differentiate between

changes in attitude that were caused by the treatment and changes that were caused by other factors.

The final item included on the attitude survey was a checklist about the difficulty of science class. Students were asked to place a check mark next to the statement that best described how they felt about the difficulty level of science class and to explain their answer. One goal of this study was to challenge each student at the correct level, represented on the survey by the phrase “just right.” This survey question allowed me to check if students felt more or less challenged during the differentiated lessons. Student explanations provided me with more insight about the factors, such as pace and difficulty of content, that contributed to their attitudes.

In order to measure changes in student engagement, I administered the *Engagement vs. Disaffection with Learning Student-report* (Wellborn, 1991) to all four of my science classes. This survey has an internal consistency (Cronbach’s alpha) of .61 - .85 and a test-retest correlation of .53-.68. Some students were absent on the days the survey was given, resulting in a sample size of 88 pre-treatment and 79 post-treatment. Before administering the survey, I informed students that their answers would not have any impact on their grades. I emphasized that I wanted them to be honest so that I could make science class more enjoyable. I also reassured students that no other teachers or students would see their answers. When students encountered a word or statement that they did not understand, I clarified the statement for the entire class. Student responses indicating a high level of engagement were given a score of four, while responses indicating a very low level of engagement were given a score of one. An average engagement score was then calculated for each student.

I interviewed two groups of students ($N=30$) in order to find out more about student attitudes and engagement. The students for each focus group were randomly selected from all four of my science classes, and each focus group session lasted for approximately thirty five minutes. Before beginning the interview, I informed students that I would be the only one listening to the recording, and I encouraged students to answer questions honestly. I also reassured them that their responses would not have any impact on their science grade. Both focus groups were interviewed post-treatment. Interviews were recorded on audio tape and later transcribed. Interview questions can be found in Appendix N.

In order to determine how differentiating instruction affected me, I kept a teacher journal and interviewed two support teachers who are in my classroom during two of my sixth grade classes. I recorded reflections in my journal about planning differentiated and non-differentiated lessons and about teaching those lessons. I interviewed the two support teachers about what they observed during differentiated and non-differentiated lessons. The data contained in my teacher journal, and observations of my teaching made by the support teachers, helped me determine how differentiating instruction affected me, as a teacher. The multiple perspectives that I received from these data sources enabled me to see the impact on multiple aspects of my teaching, from planning time to classroom management.

The variety of data collection methods that were used throughout this research improved my confidence in my research findings. The combination of quantitative and qualitative data collected allowed me to answer my research questions and to understand the reasons behind the results.

DATA AND ANALYSIS

Effects On Student Achievement

One goal of this research was to find out how differentiating instruction in my classroom would affect student achievement. In order to answer this question, I compared student test scores from the Rocks and Minerals unit test (Appendix L) to the scores on the Inside Earth unit test (Appendix M). I did not differentiate instruction during the Rocks and Minerals unit, but the Inside Earth unit contained three differentiated lessons. The average grade on the Rocks and Minerals unit test ($N=94$) was ninety with a standard deviation of 7.94. The average grade on the Inside Earth unit test ($N=94$) was 85.25 with a standard deviation of 11.21. Figure 4 shows how many students scored in each grade range on both tests.

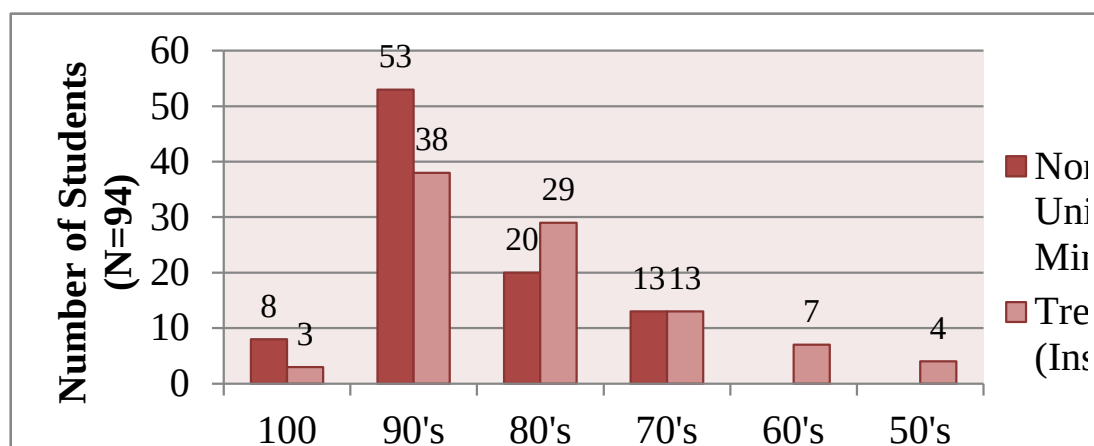


Figure 4. Unit test grades, ($N=94$).

Sixty five percent ($n=61$) of students earned a grade of 90 or above on the Rocks and Minerals test, while only 44% ($n=41$) of students fell into this category on the Inside Earth test. Additionally, no students earned grades below a 70 on the Rocks and Minerals test, while eleven students had grades lower than 70 on the Inside Earth test.

Students scored an average of 4.8 points lower on the Inside Earth test. Figure 5 shows the change in unit test grades.

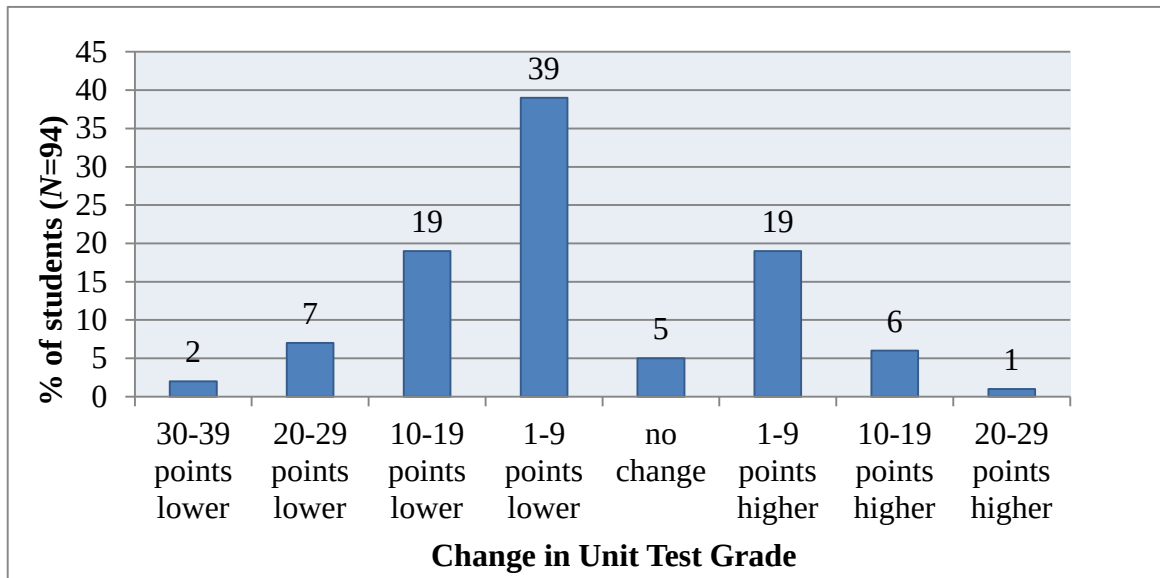


Figure 5. Change in unit test grades, (N=94).

The Inside Earth unit was slightly more difficult than the Rocks and Minerals unit. Most of the concepts in the Rocks and Minerals unit were taught through hands-on observations of rock and mineral samples. Students were mainly taught about concepts that they could directly observe, such as the identifying characteristics of each type of rock. During the Inside Earth unit, on the other hand, students were taught about geological processes that occur over millions of years. The unit also included scientific concepts, such as mantle movement, that students were not able to observe. However, survey responses indicate that only eight percent of students felt that the Inside Earth unit was more difficult than the Rocks and Minerals unit.

Sixty eight percent ($n=64$) of students had a lower grade on the Inside Earth test, 5% ($n=5$) had the same score on both tests, and 27% ($n=25$) of students had a higher score on the Inside Earth test. This data indicates that differentiated instruction did not

improve achievement for most students. However, sixty two percent of students who scored in the 70's on the Rocks and Minerals test had a higher unit test grade following treatment, as shown in Table 4 below. This group of students was more positively impacted than higher achieving students. More specifically, seventy five percent of students who had previously scored in the 90's and sixty five percent of students who had previously scored in the 80's had lower grades on the unit test following differentiated instruction.

Table 4
Change in unit test scores following treatment

Non-treatment Unit Test Score	% (number) of students		
	Score Increased	Score Decreased	No Change in Score
70-79	62 (8)	38 (5)	0
80-89	30 (6)	65 (13)	5 (1)
90-100	18 (11)	75 (46)	7 (4)

Thirteen students (14%) had Inside Earth unit test scores that fell below one standard deviation. All of these students had higher scores on their Rocks and Minerals unit test. All of the students who fell below one standard deviation also received the modified (lower tier) analysis questions for *Activity 44: Mapping Plates* and none of them were placed in the higher tier for *Activity 40: The Continental Puzzle*. Three of the students (23%) received the unmodified text-book reading for *Activity 45: Understanding Plate Boundaries* and the remainder received the modified (lower tier) version of the reading.

There are a variety of possible reasons why these thirteen students had low scores on their Inside Earth unit test. I consulted with the sixth grade English teacher when placing students into tiered groups for *Activity 45: Understanding Plate Boundaries* so that I could assign students to groups based on their level of reading comprehension. However, it is possible that the three students (23%) who were given the regular textbook reading may have struggled with the science concepts contained in it.

Four of the students (31%) who fell below one standard deviation were participants in the Maximum Support program during this study, and one student joined the program later in the school year. Students in the Maximum Support program have IEPs (Individualized Education Plans) and have been classified as having a learning disability. The Maximum Support program is the highest level of support that a student can receive in the middle school. These students receive a copy of all class notes and completed worksheets prior to assessments, they have a support teacher in the classroom with them, and they receive two hours of resource room support per week. The Inside Earth unit test was not modified for the Maximum Support students, and the abstract nature of some of the concepts may have been too challenging for some of these students. One of the support teachers was absent for the tiered reading lesson, and all four of the Maximum Support students who fell below one standard deviation were from that class. They may not have received enough support during the tiered reading lesson, leading to a lack of understanding about some concepts. There were also more vocabulary words on this test than there were on the Rocks and Minerals test, which may have made it more challenging for these students. Two of the Maximum Support students from this group periodically resisted assistance from the support teacher and from me. These two

students ranked the difficulty of the Inside Earth unit of study as “easy,” indicating that they may not have had an accurate perception of the difficulty of the unit. Two other students who fell below one standard deviation also ranked the difficulty of the Inside Earth unit as *easy*, and one other student ranked it as *very easy*. This may have led them to inadequately prepare for the assessment.

Five (38%) of the students who fell below one standard deviation on the Inside Earth unit test also fell below one standard deviation on the Rocks and Minerals unit test. Two of these students have challenging situations at home that may have prevented them from studying for the unit test. One of the other students is a participant in the Maximum Support program, who indicated that the Inside Earth unit was *very hard* for her. She was aware of the difficulty of the material, and this was reflected in her unit test score. The tiered materials may not have accommodated her specific learning needs.

The remaining two students (Student C and Student D) who also fell below one standard deviation on the Rocks and Minerals test differ from each other. Student C is a male who was frequently disruptive during both the differentiated and non-differentiated units of instruction. He was given the modified (lower tier) text-book reading during *Activity 45* and he was very upset about the fact that I had placed him in a “stupid group.” This student was resistant to receiving help and did not take advantage of opportunities to raise his Inside Earth unit test grade. Student D is a female who scored ten points lower on the Inside Earth unit test than she did on the Rocks and Minerals unit test. Student D was dealing with social challenges throughout the year and had to switch classes due to bullying. This may have affected her concentration during class. Student D ranked the difficulty of science class as *just right* and had a slightly positive attitude about science

class following differentiated instruction. It is possible that Student D thought she knew the material and did not study enough for the Inside Earth or Rocks and Minerals unit tests or that she does not have good study skills.

Fifteen students had scores on the Inside Earth unit test that fell above one standard deviation. Nine of these students (60%) participate in a selective math and science enrichment program called E2K. All nine of these students were placed in the higher tier for *Activity 40: The Continental Puzzle* and they all received the unmodified (higher tier) analysis questions for *Activity 44: Mapping Plates*. One of the nine E2K students was given the modified (lower tier) text-book reading for *Activity 45: Understanding Plate Boundaries* based on a recommendation made by the sixth grade English teacher. Fourteen of these students (93%) scored above a ninety on the Rocks and Minerals unit test. Student B, who had an 83 on the Rocks and Minerals unit test, is described in more detail below.

Only two (13%) of the students (Student A and Student B) who's scores fell above one standard deviation ranked the difficulty level of science class at *just right*. Neither of these two students participates in the E2K math and science enrichment program, and neither of their unit test scores fell above one standard deviation on the Rocks and Minerals unit test. Student A is a male who was placed in the lower tier for all three differentiated lessons. For *Activity 45: Understanding Plate Boundaries*, he was in the same group as two students who scored in the fifties on the Inside Earth unit test. I noted in my journal that Student A did not have a negative attitude about being given a modified reading, as opposed to the two other students in his group who had a negative

attitude about receiving the modified reading. He scored seven points higher on the post-treatment unit test than he did on the Rocks and Minerals unit test.

Student B is a female in the same class who is a hard worker and she is almost always on task during class. Student B's score on the Inside Earth unit test was seventeen points higher than her score on the Rocks and Minerals unit test, and she is the only student in this group who scored below a ninety on the Rocks and Minerals test. On the post-treatment attitude survey, her score fell above one standard deviation, indicating that she had a very positive attitude about science class. Student B was placed in the regular tier for the first and second activity. I noted in my journal that while working on the unmodified analysis questions for *Activity 44: Mapping Plates*, Student B raised her hand because she did not understand the second question. I responded by handing her a copy of the modified (lower tier) questions, and she was able to complete the remaining questions successfully. Differentiated instruction seems to have had a positive effect on the achievement of these two students.

Differentiated instruction had a more positive impact on achievement for students who had previously earned grades in the seventies than it did for students who had previously earned grades of eighty and above. Despite the fact that only eight percent of students indicated that that the differentiated unit was more difficult than the non-differentiated unit, assessment scores indicate that the differentiated unit of instruction may, in fact, have been more challenging. It is also possible that some of the higher achieving students did not adequately prepare for the Inside Earth unit assessment due to their perception that the material was very easy. Because of the many differences that

existed between these two units of study and the unit assessments, it is difficult to conclude to what degree the differentiated lessons affected student achievement.

Effect on Student Engagement

Another goal of this research was to find out how differentiating instruction would impact student engagement. For the purposes of this study, student engagement is defined as the degree to which students are involved in the learning process. Observable behaviors indicating engagement included participating in class discussions, being on-task, following instructions, paying attention, working hard, and being enthusiastic about learning. Results from the *How I Feel about School* survey (Appendix K) are one indication of how differentiated instruction affected student engagement. The pre-treatment survey was administered at the conclusion of the undifferentiated Rocks and Minerals unit. Some students were absent the day I gave the survey, resulting in a sample size of 88. Responses indicating a low level of engagement were given a score of one, while responses indicating a very high level of engagement were given a score of four. The mean score on the pre-treatment survey was 2.99 out of four with a standard deviation of .49. The post-treatment survey was given at the end of the Inside Earth unit, during which three lessons were differentiated. Some students were absent the day I gave the survey, resulting in a sample size of 79. The mean post-treatment score was 3.04, with a standard deviation of .47.

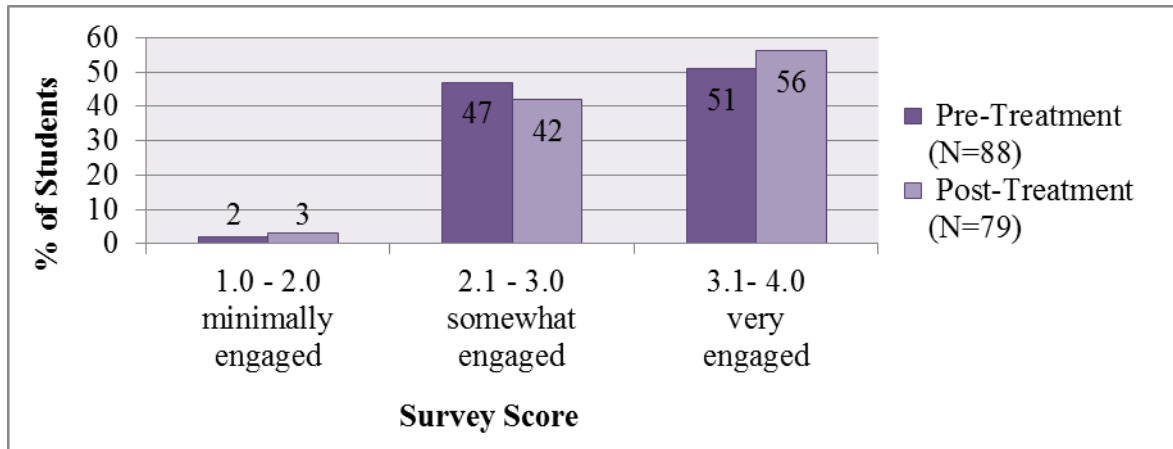


Figure 6. Pre and post treatment engagement survey scores.

As shown in Figure 6, the percentage of students who felt very engaged during class (3.1 – 4.0) increased by 5% following differentiated instruction. In addition, 50% of students (N=74) had a higher score on the post-treatment *How I Feel about School* survey, while 41% had lower scores and 9% had the same score. On average, student scores increased by .05 (1%) and there was a standard deviation of .27. The data from this survey indicate that, on average, students felt slightly more engaged during the differentiated unit of study about the inside of the earth.

I observed varying levels of engagement during differentiated activities. Following the first differentiated activity, I noted in my journal that many of the students who were placed into the high tier seemed engaged with the content. They had to work together to complete the assignment and I observed that they were actively discussing and debating the material within their groups. I wrote, “The students at Table 3 worked well and carefully. They realized that they needed to follow the steps, and they were willing to do it” (Teacher Journal, 3/20). They also seemed enthusiastic about the fact that they were selected for a more challenging activity. Some of the students in the

higher tier, however, required a significant amount of encouragement to engage with the material. They rushed through the work, did not fully read instructions, struggled with working independently and seemed bored with the assignment. I noted the following in my journal about one student, “Student R had no interest in doing the work and still did not push herself at all. I am not sure if I am going to be giving her more challenging work next time” (Teacher Journal, 3/20). Following the same lesson in another class I also wrote, “At one point a student came over and said that he already learned this in third grade and that it was Pangaea. I explained to him that it’s not about knowing the answer, but about how we get to the answer and being able to back it up with the proper evidence” (Teacher Journal, 3/19). However, I observed that this student still put little effort into his work following our conversation. I noted in my journal that he answered almost every question with one word, indicating a lack of effort on the assignment.

I observed a mixed reaction among the students in the middle and lower tiers during this activity. Some students seemed engaged in the lesson. I heard them talking about the lesson content with the other students at their table and I observed that they were following the instructions. However, some students from the middle and lower tiers became less engaged when they realized that other students were given a different assignment. I noted in my journal, “Student A refused to do his work today and made a negative comment about the smart kids getting different work. This student rarely puts any effort into his classwork, so I’m not sure why it mattered to him” (Teacher Journal, 3/19). Many of the students that were placed in the higher tier are in the more advanced math track, and students, therefore, concluded that I had given the smarter students a more challenging assignment. This realization made some students less engaged in their own

work, and I had to actively encourage these students to continue participating in their own assignment. For example, I noted in my journal, “After receiving her index card, Student C said ‘Oh, the triangles are the smart people.’ She said it several times so that other students could hear her. I tried to refocus her attention on the assignment that she had been given” (Teacher Journal, 3/19).

A similar situation occurred when I divided students into groups for a tiered reading assignment. There were two students in one class who felt that they had been placed in the “stupid” group. I recorded the following description in my journal,

At one point, Student A made a comment about being in the "stupid" group. I told him that he was doing the same work as other groups and that he was reading the same information, but that it was just written in a different way. He insisted that his group was the only one to get the lower reading, even though that was not actually the case, and he said he was offended that he was given a different reading. Student A did not complete the work and would not accept any help from me for the remainder of class (Teaching Journal, 4/2).

During the previous differentiated lesson, this student had been willing to accept my help, as noted in the following journal entry. “I was able to work with Student A and Student Z for most of class today. I think that they benefitted tremendously from this support and that they would have been fooling around had I not been able to sit with them. I think that they appreciated the attention” (Teacher Journal 3/19). When these students found out that they had been given a different reading than some of the other students in the class, they apparently felt very insulted. They were so insulted that they would not believe me when I told them that there were other groups in the class who had the same

reading that they had. The use of differentiated materials seemed to have a negative impact on the engagement level of these two students when they thought that they had been given remedial material, rather than the regular learning materials. They did not seem to be as offended when they thought that they were receiving the average learning materials, as opposed to the advanced materials, during the first differentiated lesson. It was very difficult to keep these students engaged in the learning for the remainder of class, and these two students ended up with two of the lowest grades on the unit assessment.

Aside from these two students, however, most students were very engaged during this reading assignment and during the class discussion that followed it. In my teaching journal, only three additional students, out of a total of ninety four, were mentioned as being off-task or not engaged in the activity. Two of these students normally have a support teacher in the room to assist them, but she was absent the day of this lesson. The third student had been absent for three days and had not yet had a chance to catch up. Students stayed on task and successfully completed the reading and corresponding worksheet. When doing a reading as a whole class, there are normally a few students in every class who display behavior indicating that they are not engaged in learning. Examples of being disengaged include being on the wrong page or gesturing across the room to another student. Based on my journal entries, I did not observe any of these behaviors during the tiered reading activity.

I also observed increased engagement from students who are normally minimally engaged in lessons. For example, I wrote in my journal, "Table five was very successful. All students at that table showed a big improvement over their normal work, and were

on-task for most of the lesson” (Teaching Journal, 4/2). I usually do reading assignments out-loud as a whole class to make sure that all students understand the content. Tiering the reading allowed the students to work on the reading at their own pace in groups, rather than as a whole class. I think that this made them more engaged during the lesson because they had to actively engage with the material themselves as opposed to just sitting back and listening to someone else read it. I noted another impact on engagement in my journal,

In my first period class I noticed more participation from some of the lower-level kids during the class review of the answers. I specifically noticed that one student, who rarely participates, was raising her hand a lot. I think these students ended up feeling more confident about their work” (Teaching Journal, 4/2).

Many factors had an impact on student engagement during differentiated lessons. Students who were incorrectly placed into a tier, or who perceived themselves as being incorrectly placed, disengaged from the learning. For example, “Students F and G did not get anything done. The challenging work was way above their level, and they did not understand what to do” (Teacher Journal, 3/20). The social dynamics of each tiered learning group also had an impact on student engagement. After the first differentiated lesson I wrote, “Several students, such as Student D, shut down when they are in the wrong social setting. Other students, like Student E, get very distracted in the wrong setting” (Teacher Journal, 3/19). Differentiating instruction involved changing the normal classroom routine, which also had an impact on student engagement. A support teacher who observed the first differentiated lesson noted,

One of the biggest problems with today's lesson was that the students have gotten used to having instructions on the board when they walk in. Changing the routine by assigning them to new seats at the beginning of class was very chaotic, and it was hard to get some of them refocused. (Teacher Journal, 3/19).

Some students demonstrated increased engagement during differentiated lessons, while others demonstrated a decrease in engagement. Some students demonstrated a high level of engagement during one differentiated lesson, and a lower level of engagement during another differentiated lesson. Based on this study alone, it is difficult to conclude how differentiated instruction impacted student engagement. More thorough observations of student behavior over a longer period of time may yield more conclusive results. Additionally, it may be beneficial to make observations about student engagement once students have become more acclimated to the routines involved in differentiated instruction.

Effect on Student Attitudes

A third goal of this research was to find out how differentiated instruction affected student attitudes about my class. In order to answer this question I administered a pre and post treatment Likert-style attitude survey to students, which included open-ended survey questions, and I conducted student interviews in focus groups. The pre-treatment survey was administered to all four of my science classes at the conclusion of a non-differentiated unit about Rocks and Minerals. Four students were absent for this survey, resulting in a sample size of 90. On the survey, a score of one was used to represent a very negative attitude, and a score of four was used to represent a very

positive attitude. The average pre-treatment score was 2.85 out of 4 with a standard deviation of .57. 9% of students had an average attitude score that was less than two, indicating a negative attitude about science. 44% of students had a score between two and 2.9, indicating a slightly positive attitude. 46% of students had a score greater than three, indicating a very positive attitude.

I administered the same survey at the conclusion of a unit of study about the inside of the earth, which included three differentiated lessons. Several students were absent the day the survey was given, resulting in a sample size of 82. The average post-treatment Likert score was 2.63 out of 4, with a standard deviation of .57. This is .22 (5.5%) lower than the average pre-treatment attitude score. On the post-treatment survey, 15% of students had an attitude score less than two, indicating a negative attitude about science class. 55% of students had an attitude score between two and 2.9, indicating a slightly positive attitude, and 30% of students had an attitude score greater than 3, indicating a very positive attitude about science class.

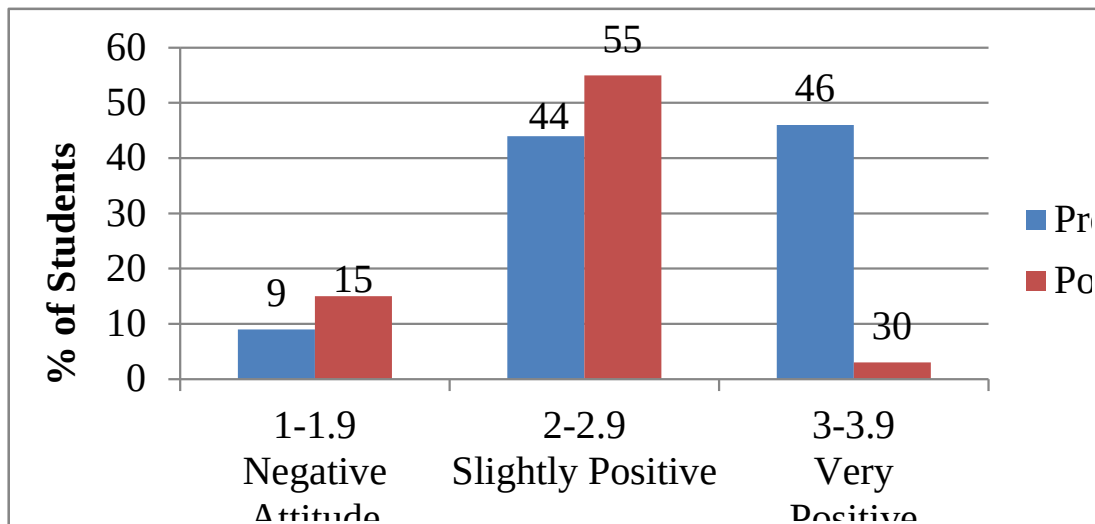


Figure 7. Pre and post treatment attitude scores.

As shown in Figure 7, following treatment, 16% fewer students had a very positive attitude about science class, while 15% more students had a slightly positive attitude about science and 6% more students had a negative attitude about science class. This is consistent with the fact that the overall average attitude score dropped by 5.5% following treatment. Additionally, only 23% of students had a higher attitude score following treatment, while 68% had a lower score and 9% of students had the same score. This change in attitude may be due to the perceived difficulty of class and the decrease in hands-on activities during the differentiated unit of instruction. Both factors are discussed below.

On the pre-treatment survey, only 36% of students indicated that the difficulty level of science class was “just right” for them. One of my goals when differentiating instruction was to create tiered lessons so that this number would increase. My theory was that properly challenging students would improve their attitudes about my class. However, the percentage of students who felt that the difficulty of class was “just right” decreased by 9% following differentiated instruction, with only 27% of students selecting this answer. Following the undifferentiated rocks and minerals unit, 20% of students indicated that class was “very easy” for them. This number increased to 32% following the unit about the inside of the earth. Sixty four percent of students indicated that the difficulty of both units of instruction was the same, while 28% felt that the inside earth unit was easier and 8% felt that it was harder.

These numbers indicate that despite the fact that I placed students into tiered groups and had them use tiered instructional materials, 73% of students still did not feel properly challenged. It is therefore difficult for me to conclude whether properly

challenging students will improve their attitudes. However, since I have data about student attitudes and perceived level of difficulty, I can compare the attitude scores of students who selected “just right” to those that did not. Despite the fact that this comparison is not specifically a result of my differentiated instruction, it can tell me if there is any relationship between the perceived difficulty of my class and student attitudes.

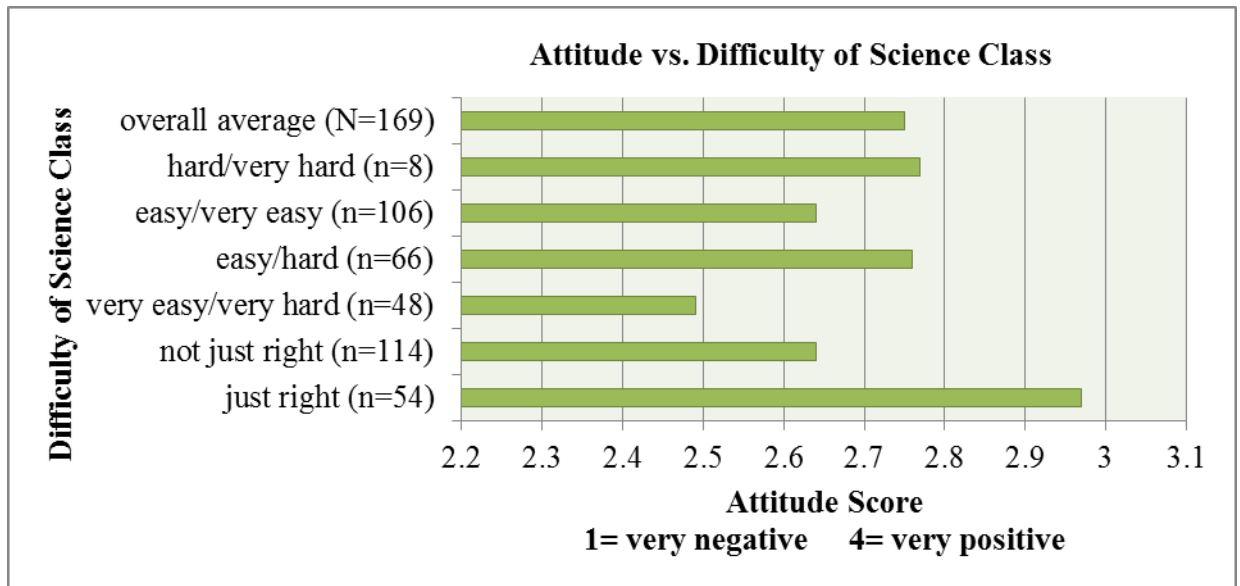


Figure 8. Attitude scores according to difficulty ranking.

I calculated the average attitude scores shown in Figure 8 by compiling the data from both the pre and post treatment surveys. Students who indicated that the difficulty of science class was “just right” had the highest average attitude score, which was 5.5% (.22) higher than the average of the entire sample ($N=169$). In contrast, the average attitude score for students who wrote that the difficulty was *not* “just right” was 2.64, which is 8% lower than the average for students who felt that the difficulty of class was just right. The average attitude score for students who responded that class was either very hard or very easy was the lowest score of any group shown in Figure 9. Based on

this data, there seems to be some correlation between the difficulty of class and a student's attitude about class. Students who feel that class was very hard or very easy had a more negative attitude, while students who felt that class was just right had a more positive attitude. Had I properly tiered instruction by making the difficulty of class "just right" for a higher percentage of students, there is a chance that attitude scores may have been higher.

Some students very clearly communicated that their negative attitude about science class was due to the fact that they already knew most of the information that I was teaching or that class was too easy for them. On student surveys, there were 39 mentions of class being too easy, second only to students writing about the desire for class to be more fun. For example, one student wrote, "What we learn and all the work is sooo easy." During an interview one student said, "Sometimes science is a bit repetitive. Like one day we learn about plates and boundaries, and then the next day we learn about it and the next day too." The parents of some of the most gifted students have also communicated that their children still do not feel challenged in my class.

However, even among the students who indicated that the difficulty of science class was just right, the average attitude score on the pre-treatment surveys ($n=32$) was 3.03, while the average on the post-treatment surveys ($n=22$) was 2.89. This difference indicates that there may be factors, other than the level of difficulty, which impacted student attitudes. What other factors caused this shift? By reading student comments on attitude surveys and interviewing students in focus groups, it became clear that there are many factors, other than the difficulty of class, that contribute to a student's attitude

about a class. A list of these factors, which is based on student comments, is shown in Table 5.

Table 5
Explanations for student attitudes about science class

Explanations for student attitudes about science class:	Times mentioned
Want to have more fun activities such as: videos, projects, experiments, games, group-work, Smartboard animations	67
Class is too easy/ we move too slowly/it is repetitive/I already know it/ I want more of a challenge	39
Content is interesting/we learn new things	21
Content is not interesting	20
Class is boring	12
I am tired	6
Class is fun	5
I don't like class because it is too hard	1

Some students had a more negative attitude about science class following the unit about the inside of the earth because the unit seemed less “fun” to them. On the attitude survey, a response of *usually* to the statement “science class is fun” earned a score of four points, while a response of *never* was scored with one point. The average response to the statement “Science class is fun” dropped from 3.04 pre-treatment to 2.66 post-treatment, which falls in between *rarely* and *sometimes*. Additionally, a lack of fun activities, such as projects and lab-activities, or a desire for more of them, was mentioned 67 times on post-treatment surveys. For example, one student whose attitude score dropped from 3.57 to 2.29 wrote, “Can we please do more projects and experiments?” Another student whose score dropped from 3.14 to 2.00 explained why she rarely likes class by writing,

“Because it has to be more fun (projects).” I asked the students who I interviewed how I could make class more interesting and enjoyable. Out of the twenty students who responded, eighteen mentioned that we should do more “fun” activities, such as projects, movies, skits and lab activities. One student, whose attitude score dropped from 2.14 to 1.86 said, “It’s fun when we have hands on labs and movies. Sometimes it’s like ugh, we’re writing more, and our hands get tired.”

The students were correct about the fact that the unit about the inside of earth had fewer hands on activities and projects. During the Rocks and Minerals unit students participated in hands-on activities with rocks and minerals several times and they worked in groups to create a movie about a mineral using iMovie. During the unit about the inside of the earth, there was one hands-on activity. Students watched two movies and viewed a series of animations about plate movement. The lack of hands-on activities was partially due to the nature of the unit and partially due to my struggle with developing differentiated lessons. I spent so much time trying to figure out how to create the differentiated lessons that I put less time into planning hands-on activities for my students.

Effect on Me

The final purpose of my research was to find out how differentiated instruction affected me. The process of creating and teaching differentiated lessons had both positive and negative impacts on me and my teaching. The first noticeable impact of differentiating instruction was that planning a differentiated lesson took considerably more time than planning non-differentiated lessons. On average, I spend one to two hours when planning for a non-differentiated lesson, and I spent approximately three to

six hours planning each differentiated lesson. I have been teaching the same curriculum for the past three years and I am very comfortable with the lessons. The curriculum comes with student worksheets and I save my own lesson materials from year to year. Planning non-differentiated lessons usually involves looking over my curriculum materials, making sure that any worksheets that need to be copied have been submitted to the copy room, updating any Smartboard or Power-Point slides and preparing lab materials. When I sat down to plan out a differentiated version of these lessons, it took two to three times the amount of time.

This extra time partially stemmed from the fact that planning each differentiated lesson required several steps. I first had to determine which lessons would require differentiation. As I looked over the Inside Earth unit, I tried to think about lessons during which some students would grasp the concepts very quickly while others might require more support and instruction with the same material. I looked for opportunities to challenge the higher level thinkers, who are very rarely challenged in my class. This step alone required much time and thought. I got frustrated several times and had trouble figuring out which lessons to select. Earlier in the year I had intended on differentiating several lessons in the Rocks and Minerals unit. I came up with ideas, but was never able to fully develop the differentiated materials on time. As I tried to come up with ideas for differentiating the Inside Earth unit, I became very nervous that once again I was not going to get the lesson materials developed on time. On March 6th, I wrote the following in an e-mail to a colleague, "I know I have mentioned this a few times, but I am desperate for some help with creating my differentiated lessons. I'm getting close to being at risk of not getting it done on time." I was so used to teaching the same lesson to all students

that I also felt unsure about how to challenge the higher level thinkers properly and how to create a differentiated lesson that would actually work. Now that I am in my sixth year of teaching, I usually feel fairly confident in my teaching abilities. However, I began to feel like I was not a very good teacher because I was having so much trouble coming up with one differentiated lesson.

I eventually sat down with the colleague mentioned above, who is also my mentor, and she helped me select my first lesson for differentiation. We selected a lesson from the regular curriculum that seemed like it would be too basic for some students in the class. We then figured out a way to modify the process for more advanced students so that they would be challenged at higher levels of Bloom's taxonomy while learning the same content. I noted in my journal, "N and I found a map in the old text-book that will allow the more advanced students to model the process that Wegener used when developing his ideas. These students will have to examine Wegener's evidence and then infer that the continents used to be joined together" (Teaching Journal, 3/7). I also wrote in my journal that I felt relieved that I had finally selected a lesson for differentiation.

Over the next several days, I worked on creating the instructional materials for the tiered lesson. This process was once again more time consuming than my usual lesson planning because I wanted to make sure that students would be able to work through the lesson with minimal teacher assistance. After creating the differentiated materials, I then had to determine the criteria I was going to use for placing students into tiered groups and I had to create the tiered groups. Since my students sit at tables of four, I also had to factor in all of the social components when grouping students. I wrote, "Placing students into new groups is very challenging. There are so many social factors

that I have to consider in addition to the readiness levels” (Teacher Journal, 3/13). I then had to ask myself how I was going to manage a differentiated classroom. I articulated these concerns in my journal, “I am having a hard time figuring out how to split the students into groups. I want to hide the tiering as much as possible because I am not sure how students are going to react to it” (Teaching Journal, 3/14).

The next two differentiated lessons that I developed also required a considerable amount of planning time. For example, for the third tiered lesson I rewrote a reading assignment from the regular text-book. On March 30th I wrote the following in my journal, “I spend about two hours last night trying to type up the modified text-book reading. I am happy with where it is at so far, but now I am stressed about getting it done on time and copied for Monday.” Creating this tiered reading required approximately six hours of time. Since the tiering for this lesson was based on reading level, I also spent several prep periods meeting with the sixth grade English teacher and the two sixth grade support teachers to get their input about how to group students.

The time required for planning out so many components for one lesson meant that I spent less time planning out other non-differentiated lessons and that student work that I needed to grade got neglected. I also spent less time planning out my seventh grade lessons, and noted in my journal, “I feel so disorganized right now. Planning the differentiated lessons is taking up so much of my time that I feel like I have not put enough thought into my seventh grade lessons” (Teacher Journal, 3/22). Conversations with two support teachers who are in my classroom on a daily basis confirmed that I seemed more stressed out and disorganized during the week leading up to my first differentiated lesson.

Being successful with a differentiated lesson required me to be extremely organized. During my first differentiated lesson, for example, I needed to have a strategy prepared for dividing students up into new groups, handing out tiered learning materials, and giving instructions to two different groups of students. I was not very successful at this during the first differentiated lesson, and as a result I became frazzled and felt more disorganized. I recorded the following example in my journal, “I started out today’s class with students in their seats from yesterday, but I had two students share their inside earth story books with the class before starting the lesson. Frankly, I needed more time to get the materials ready” (Teacher Journal, 3/20). Later that day I wrote, “The two advanced groups seemed to work better in this class, probably because I was more organized” (Teacher Journal, 3/20). During the next two differentiated lessons, I was more prepared for these challenges. I developed a strategy for making the tiering more invisible and for more efficiently dividing students into groups. All students followed the same set of instructions during these differentiated lessons, and I felt like I was able to help the students who needed my assistance. Following the second differentiated lesson I wrote, “I had to help a few students get started, but I felt like I was able to circulate around the room and help all of the groups” (Teacher Journal, 4/2).

Differentiating instruction also had an impact on the way that I taught class. I struggled during my first differentiated lesson and wrote in my journal “It was difficult to assist all of the students who needed assistance. I wish I had checked on the groups more because I am not sure about the quality of their work” (Teacher Journal, 3/19). On the second day of the first tiered lesson I also wrote, “This was once again a frustrating experience in this class. It was almost unmanageable” (Teacher Journal, 3/20). I had

been hoping that the use of tiered groups would allow me to be more available to students who needed assistance, but this was not the case during the first differentiated lesson.

My management skills improved for the second and third tiered lessons, and both classroom support teachers agreed that the lessons went much more smoothly. During the third tiered lesson, for example, very few students noticed that there were two different versions of the reading. I learned from the mistakes that I made during the first differentiated lesson, and I was much more successful at dividing students into groups during the third lesson. The more organized I felt, the more time I had to work with the students that I had assigned to the lowest tier. With each differentiated lesson that I taught, my level of comfort went up and my level of frustration went down.

INTERPRETATION AND CONCLUSION

This study examined the effects of differentiating instruction in a mixed-ability sixth grade earth science class ($N=94$). The treatment for this research involved differentiating three lessons from a unit of study about the inside of the earth. I differentiated instruction by creating tiered learning materials and assigning students to tiered learning groups. Likert style surveys, free-response survey questions, student interviews, unit test scores and teacher observations, were all used to gather data about the impact of this treatment.

How did differentiating instruction affect student achievement? Differentiating three lessons within a unit of study had a mixed impact on student achievement. Differentiated instruction had the most positive impact on lower achieving students. Thirteen students scored below an eighty on the test following the non-differentiated unit

about rocks and minerals. Sixty two percent ($n=8$) of these students had higher scores on the test following the differentiated unit about the inside of the earth. Differentiated instruction did not have as positive an impact on student achievement for the remaining students. Only 30% ($n = 6$) of students who had scored an 80-89 on the Rocks and Minerals test had higher scores on the Inside Earth test. Similarly, only 18% ($n= 11$) of students who scored 90 or above on the Rocks and Mineral test had higher scores on the Inside Earth test. Overall, 68% ($n= 64$) of my students had lower test scores following differentiated instruction.

There are several factors that may have contributed to this decrease in achievement. The content included in the differentiated Inside Earth unit was more abstract than the content in the non-differentiated Rocks and Minerals unit. The Rocks and Minerals unit included several hands-on explorations with rocks and minerals, while the Inside Earth unit only included one hands-on modeling activity. Data from attitude surveys indicates that only 8% of students felt that the differentiated unit about the inside of the earth was harder than the non-differentiated unit about rocks and minerals. As a result, some students may not have adequately prepared for the Inside Earth unit test. It is, therefore, difficult to determine how much of an impact the three differentiated lessons had on overall student achievement.

In future studies I would gather more data to gain a better understanding of how differentiated instruction affects student achievement. For example, I would assess student understanding of scientific concepts following each differentiated lesson, as opposed to only gathering data from unit test scores. Many factors, such as a student's home environment, can affect success on a unit test. Assessing student understanding

following the differentiated lesson might give me a more accurate picture of how well a student understood the lesson content. In this study I had to make assumptions about why certain students had very low test scores or why their scores increased or decreased. In future studies, I would interview those students to get their perspective about their own achievement. They might be able to tell me that they did not study at all, for example, or that they have trouble memorizing vocabulary words. These interviews would help clarify which students were affected by the treatment, as opposed to other factors. In future studies I would also give students a short questionnaire asking how long they spent studying for the test and how confident they felt about the material. This might provide me with data about which students felt that they already knew the material well from class, and which students had to put in a significant amount of their own time to understand the material. Such a questionnaire may also help explain why some students had high or low test scores.

How did differentiating instruction affect student engagement? Differentiating instruction had a mixed effect on student engagement. The average self-reported student engagement score increased by .05 out of 4 (1%). Only 50% of students reported being more engaged during the differentiated unit, while 41% reported being less engaged and 9% reported being equally engaged. Observed engagement varied by the lesson. Student engagement increased during the tiered reading activity and tiered analysis questions, as evidenced by on-task behavior and participation in class discussions. Several students who usually refrain from participating in class discussions felt confident enough to contribute to the class discussion following the tiered reading assignment. However, differentiated instruction caused some students to disengage from learning. Deviation

from the normal classroom routine and being asked to work with a new group of students may have contributed to disengaged behavior in some students. Additionally, some students disagreed with being placed in a lower tier and disengaged from learning as a result. Other students who *were* placed in the wrong tiered group disengaged because the assignment was too difficult for them.

Most of the above mentioned causes of disengagement can easily be addressed, leading me to believe that differentiated instruction still has the potential to increase student engagement. As I differentiate instruction more frequently in my classroom, I anticipate that students will become more used to the routines involved and with the challenges of working with a new group of students. I also anticipate that I will become better at assigning students to the proper tier and at adjusting student placements when needed.

In future studies, I would gather more data about student engagement. For example, I would ask students to answer open-ended survey questions in order to give me a deeper understanding of the factors impacting student engagement. I would also include more questions about engagement in my focus group interviews, and I would make sure to interview student outliers. I was interested in finding out if students would be more or less engaged during differentiated lessons or non-differentiated lessons. In future studies I would have students complete a self-assessment about engagement at the conclusion of each differentiated lesson and at the conclusion of several non-differentiated lessons, as opposed to waiting until the end of a unit. In order to gain a more accurate picture of student engagement, I would ask another teacher to observe student engagement during differentiated and non-differentiated lessons. Alternatively, I

would video-tape these lessons and then observe student engagement. In future studies, I would also use a rubric in order to make more accurate and quantitative observations of student engagement.

How did differentiating instruction affect student attitudes about science class? Differentiating three lessons during the Inside Earth unit improved student attitudes about science class for a very small percentage of students. Only 23% of students had a higher attitude score following treatment. Sixty eight percent of students had a lower attitude score and 9% had the same score. However, data collected during this study did provide valuable insight about the relationship between the perceived difficulty of class and student attitudes. Based on data from pre and post treatment attitude surveys, I can conclude that properly challenging students can improve their attitude about my class. This conclusion is based on the fact that students who indicated that the difficulty level of science class was “just right” had the highest attitude scores, while students who indicated that the difficulty level of science class was either *very easy* or *very hard* had the lowest attitude scores. Only 27% of students identified the difficulty level of science class as *just right* on the post-treatment survey, indicating that the treatment lessons from this study did not succeed in properly challenging most students.

Based on student interviews and responses to open-ended questions, student attitudes are also influenced by the presence or absence of “fun” activities. It is possible that an increased amount of projects and hands-on activities would have an equal or greater impact on student attitudes than the challenge level of class alone. It is also possible that the positive impacts of properly challenging students by differentiating instruction may be overshadowed by a lack of hands-on activities. More research is

needed in order to determine how a combination of differentiated instruction and hands-on activities would impact student attitudes.

How did differentiating instruction affect me? Differentiating instruction had both positive and negative effects on me. Planning differentiated lessons took me approximately three times longer than planning non-differentiated lessons (Teacher Journal, 3/30). The extra time spent planning these lessons took away from planning time for non-differentiated lessons, raised my stress level, and lowered my confidence level. I included less hands-on activities during the differentiated unit of instruction, and I struggled with learning how to select, plan, and implement differentiated lessons. I was not fully successful in properly tiering instruction, assigning students to tiered groups or managing the differentiated lessons. However, journal entries and interviews with my colleagues indicate that my confidence level rose and my management skills improved with each differentiated lesson. With each differentiated lesson, instruction was also more accurately tiered, and students were more accurately assigned to tiered groups. Despite the fact that differentiating instruction was a challenging experience for me, I am excited to improve my differentiation skills and incorporate it into my instruction more frequently.

There are several questions that I would like to examine in future research. I did not succeed at properly challenging a higher percentage of my students. Nine percent fewer students felt that the difficulty of science class was just right following treatment. How can I ensure that my students are being properly challenged? What types of learning materials and lessons are more challenging for students? How will students respond to being given more challenging material? Many students indicated that the lack

of hands-on activities during the differentiated unit was the cause of their negative attitudes about class. How will incorporating more hands-on activities in science class affect student attitudes, engagement and achievement? How will incorporating differentiated hands-on activities and projects affect student attitudes, engagement, and achievement? Working in tiered learning groups required students to work more independently. How can I improve my students' ability to work more independently? Once they have more independent learning skills, will differentiated instruction have a more positive affect on them and on me? As I become better at differentiating instruction, I would also like to reassess how tiering instruction according to readiness level impacts student achievement, engagement and attitudes.

VALUE

I found this research project to be very valuable in many different ways. I learned a great deal about different methods of differentiation and the multitude of ways that I can incorporate it into my classroom. By implementing this method in my own classroom, I learned which aspects of differentiating instruction are the most challenging for me, and which aspects are the most challenging for my students. I learned several valuable lessons about the importance of: working with other teachers, properly challenging students, incorporating *fun* activities, frequent assessment, and teaching students how to be independent learners. I also developed new learning materials that I plan on using in the future.

One benefit of this project was that it made me more enthusiastic about collaborating with other sixth grade teachers at my school. In order to develop my

differentiated lessons, I had to consult with other sixth grade teachers. This was the first time in my six years of teaching that I worked with the English teacher to determine the difficulty of a reading assignment. Collaborating with the English teacher for a reading comprehension lesson makes sense, and I plan on continuing this practice for future lessons that involve reading for content. I also plan on using the tiered reading materials that I created and I plan on creating more tiered reading materials for other lessons.

Another valuable lesson that I learned from this research is that I am not challenging my students enough. I would like to learn how to better assess the readiness of each student and how to challenge them in the most appropriate way. More frequent assessment might give me a more accurate picture of student understanding and capabilities, which would enable me to challenge each student more appropriately. Differentiating instruction also required me to frequently determine the readiness levels of students for particular lessons. This has caused me to think more thoroughly about what I expect students to know and be able to do for each lesson. I now think about the fact that something as simple as the ability to read and follow a procedure can have a significant impact on student learning.

Student comments on surveys and during interviews reminded me that middle school students have a better attitude about class when they feel like class is fun. My differentiated unit of instruction lacked hands-on activities and projects. Since completing this study, I have already started to incorporate more hands-on learning experiences into my classroom in order to better engage my students and improve their attitudes. Being properly challenged also had a significant impact on student attitudes. I am, therefore, interested in learning how to differentiate hands-on activities and projects.

The results of this study have convinced me to incorporate differentiated instruction into my classroom next year. Despite the many struggles that I experienced when planning and implementing differentiated lessons, I plan on reusing the tiered instructional materials that I developed for this study. This study confirms for me that many students do not feel properly challenged in my classroom and that this has an impact on their attitudes about my class. However, I also recognize that differentiating instruction had some negative impacts on both me and my students. I would like to learn more about differentiating instruction and participate in more professional development about this method of instruction in order to minimize the negative impacts on both me and my students. For example, I would like to learn how to introduce my students to the concept of tiering so that they will not get offended by their group assignments or care as much about which students are placed into each learning group. Introducing tiered learning groups at the beginning of the school year may help students view it as a regular classroom routine. I have also read about activities that can be done with students to help them realize that each individual learns at his or her own pace. I have learned the value of assessing how well I am challenging the students in my classroom, and I am more aware of the fact that each student in my classroom has his/her own learning needs.

This project made me realize that I am still in the process of learning how to differentiate instruction. I cannot just read a few books about differentiating instruction and expect to be an expert at it. I now realize that I need more training and I plan on seeking out professional development opportunities so that I can improve my skills. I anticipate that differentiating instruction will have more positive impacts on both me and my students as I become more comfortable with it.

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APPENDICES

APPENDIX A

ACTIVITY 40: HIGHER TIER

Name: _____ Date: _____

Step One: List Your Observations (You may use an Atlas for these questions.)

1. Where are the glossopteris fossils located? Be specific:

2. Where are the glacial deposits located? Be specific.

3. Where are the folded mountains located? Be specific:

4. Where are the coal beds located? Be specific.

5. Use this space to list any other observations that you would like to make about the map.

Step Two: *This background information may help you understand the map:*

1) Glossopteris Fossils:

A **fossil** is any trace of an ancient organism that has been preserved in rock. *Glossopteris* was a plant that flourished 250 million years ago. According to fossil evidence, this plant had seeds that were too large to be carried by the wind and too fragile to have survived being carried by ocean waves. *Glossopteris* lived approximately 299 million years ago, and the first fossils of this plant were discovered in 1824. Evidence from fossilized tree rings shows that this plant grew during the spring and summer, but not during the winter. Evidence also suggests that this plant shed its leaves every fall. *Glossopteris* fossils were discovered in Antarctica in 1912 by Austrian geologist Eduard Suess and his team of explorers.

2) Glacial Deposits and Striations

Scientists can infer the past locations of glaciers by looking for glacial deposits and scratches on rocks called striations. Continental glaciers are thick layers of ice that cover hundreds of thousands of square kilometers.

3) Coal Beds

Coal forms when large numbers of dead plants in swampy areas pile on top of each other. Over millions of years, sediments layer on top of the dead plants. These types of swampy areas existed in tropical or subtropical areas.

4) Folded Mountains

Areas on the map labeled “folded mountains” represent mountain ranges with very similar characteristics. For example, these mountains are made of the same types of rock, that are the same age and that have very similar folds in them.

Step Three: Answer the following questions.

1. Is there anything strange about the location of these fossils? If yes, what? If not, why not?

2. Is there anything strange about the location of the glacial deposits? If yes, what? If not, why

not?

3. Is there anything strange about the location of the coal beds? If yes, what? If not, why not?

4. Is there anything strange about the location of the folded mountains? If yes, what? If not, why not?

Part Four: Develop a hypothesis to explain your observations.

APPENDIX B

ACTIVITY 40: TEXT BOOK PAGES
(Taken directly from SEPUP, 2006, p. D-23 – D-26)

40 The Continent Puzzle



Volcanoes occur all over the world. How likely is it that volcanic eruptions will occur at Yucca Mountain? To answer this question, it helps to study the past. You will find out more about the history of the earth in the next few activities.

In the early 1900s, Captain Robert Scott, who was from England, explored the continent of Antarctica. In his journal, he described finding plant fossils. These fossils were later identified as *Glossopteris* (gloss-OP-ter-iss), an extinct fern-like plant that grew on earth about 250 million years ago. *Glossopteris* grew in warm, wet areas, and could not have survived in an extremely cold place like Antarctica. How did the fossils of this plant end up in Antarctica?

CHALLENGE

What can rearranging the continents tell you about earth's history?



Captain Robert Scott's campsite in Antarctica.

MATERIALS	
 	For each group of four students 1 set of 7 "World Puzzle" pieces 1 Student Sheet 40.1, "Earth's Surface Through Geological Time"
	For each student 1 completed Student Sheet 39.1, "Ordering Events"

PROCEDURE

Part A: The World Puzzle

1. With your group, carefully examine the location of the world's continents on the map on the next page.
2. Record the names of the seven continents in your science notebook.
3. Compare each World Puzzle piece to the continents on the map. Put a star next to each continent in your list that is represented by a puzzle piece. Then record the name(s) of any additional pieces.
4. Work with your group to arrange your puzzle pieces in locations similar to the ones shown on the world map.
5. Look at the symbols on some of the pieces. The symbols represent types of fossils or rocks found in several locations. The key to these symbols is shown below.

Key to Symbols on World Puzzle	
	<i>Glossopteris</i> , an extinct fern-like plant that could grow to 3.7 meters (12 feet) in height
	<i>Mesosaurus</i> (MESS-oh-saw-rus), an extinct freshwater reptile about 0.5 meters (2 feet) in length
	<i>Cynognathus</i> (sy-nog-NAY-thus), an extinct land reptile about the size of a wolf
	<i>Lystrosaurus</i> (liss-tro-SAW-rus), an extinct land reptile about 1 meter (3 feet) long
	Mountain ranges that have similar rock layers



6. Work with your group to try to place all of the puzzle pieces into a single shape. Work together to decide where each piece belongs.

Remember to listen to and consider the explanations and ideas of the other members of your group. If you disagree with other members of your group, explain why you disagree.

7. In your science notebook, sketch an outline of the final shape of your completed puzzle. Then, draw and label the individual puzzle pieces within your outline.
8. Move the pieces back into positions similar to the location of the continents today. Then slowly move the pieces back together into the single shape.
9. Discuss with your group what this puzzle might tell you about the history of the earth.

Part B: The History of Earth's Surface

10. Ask your teacher for a copy of Student Sheet 40.1, "Earth's Surface Through Geological Time," for your group.
11. Discuss with your group what you think has happened to the land on the surface of the earth during geological time.
12. Compare the outline that you sketched in Step 7 with Student Sheet 40.1. Identify when in earth's history the continents were arranged in a similar way. Record this time period, and the name of the land at this time, next to your sketch.

ANALYSIS



1. Describe what has happened to the land on the surface of the earth over the past 425 million years.
2. There are seven continents and there were seven puzzle pieces. But not every puzzle piece represented a continent. Why do you think this is? **Hint:** Think about how you used the pieces to model changes on the earth's surface.
3. What types of evidence did the puzzle provide about change on the earth's surface?



4. a. Look at the information in Table 1, "Approximate Time Period of Some Extinct Organisms." On Student Sheet 39.1, "Ordering Events," record when each of these organisms lived.
- b. Pangea began to break apart about 200–225 million years ago. Record this event on Student Sheet 39.1.
- c. Which of the extinct organisms listed in the table below lived on Pangea before it broke apart?

Approximate Time Period of Some Extinct Organisms

Extinct Organism	Lived
<i>Glossopterts</i> (plant)	206–250 million years ago
<i>Mesosaurus</i> (reptile)	248–280 million years ago
<i>Cynognathus</i> (reptile)	230–245 million years ago
<i>Lystrosaurus</i> (reptile)	206–248 million years ago

APPENDIX C

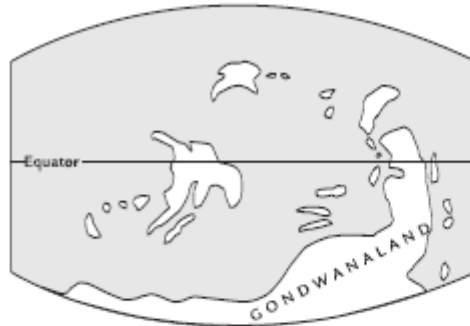
EARTH'S SURFACE THROUGH GEOLOGICAL TIME
(Taken directly from SEPUP Teacher's Guide, 2006, p. D-57)

Name _____

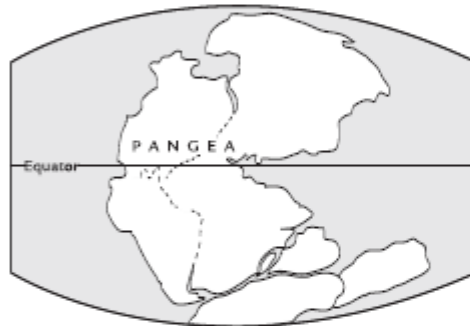
Date _____

Earth's Surface Through Geological Time

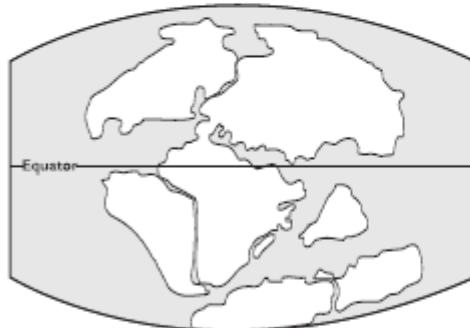
425 million years ago



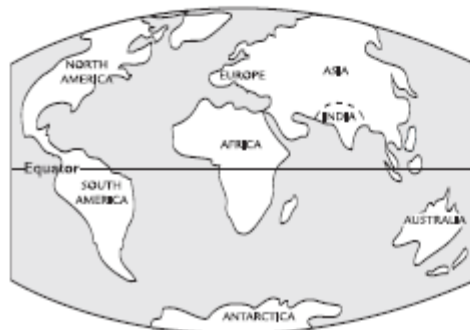
230 million years ago



135 million years ago



PRESENT DAY



APPENDIX D

INSTRUCTIONS FOR HIGHER TIER

***Please read this letter and do what it says
before continuing your work from yesterday.***

Yesterday I heard some of you asking why it was important to list your observations about the map, so I would like to give you a little bit more background information about the map that I had you look at.

Around the year 1914 there was a scientist named Alfred Wegener who looked at a world map and noticed something that many other people had noticed before. You might also notice the same thing if you look at the world map. Ignore all of the evidence that has been added to your map, and just look at the shapes. What do you notice? Record this observation on page one (#5) of your booklet. Scientists always share their observations by writing in full sentences, so make sure that your observation is also in a full sentence. Now make sure to support your observation with a specific example. The example should also be written in a full sentence. **Once you have written this down, find the colored paper that says “Answer #5.” Lift up the flap to find out if your answer was correct.*

Wegener became curious and wanted to know more. He decided to do some research to see what other scientists had to say about his observation. Scientists usually go through this research process any time they want to find out more about something. Wegener learned about the locations of *Glossopteris* fossils, coal beds, folded mountains and glacial deposits from his research. He found out about *Glossopteris* from one scientist, coal beds from another scientist, etc. Wegener found out even more about extinct plants and animals in addition to what is shown on your map. Wegener then put all of this information together. I don’t know if he actually did this, but I always imagine him recording all of this information on a map, just like the one you are looking at. Remember, there was no internet back in 1914 so it was a big deal that Wegener put all of this research together.

Wegener found much of the information that you see on your map very puzzling. The second page of your packet asks you if anything is strange about the locations of the *Glossopteris* fossils. Some of you may remember learning about Pangaea in third grade, but that idea did not exist in 1914. Most people thought that the world always looked the same way that it does today. They thought that the continents have always been in the same place as they are now.

The third page of your packet asks you if you notice anything strange about the locations of the *Glossopteris* fossils. Make sure that you have read page two before you try to answer these questions. When you answer these questions, I want you to imagine that you are Alfred Wegener. What may have seemed puzzling or strange to Wegener about the locations of the fossils, coal beds, glaciers, and folded mountains? Make sure to record your answers in full sentences that another person could read and understand what you wrote. Scientists need to be able to communicate their ideas clearly to other people, and that includes writing in full sentences! **Once you have answered the first question, find the colored paper that is labeled “Answer 1.” Lift up the flap to reveal the answer.*

Now answer questions 2, 3 and 4 on page three. Find the pieces of paper hanging up that are labeled Answer 2, Answer 3, and Answer 4 and check your answers. Make sure to correct any mistakes that you made and remember to communicate clearly by writing in full sentences.

When scientists are confused by what they see, they often come up with an idea to explain all of the things that seem puzzling to them. This is exactly what Wegener did. He came up with one idea that would explain all of the strange things that you see on your map. We sometimes call this idea a *hypothesis*, which is another way of saying an educated guess based on evidence. You have the evidence on your map. Now it's your turn to come up with a hypothesis to explain everything. A hypothesis needs to be written in a full sentence so that other scientists can understand it and test if it is true. If you are having trouble writing your hypothesis, find the piece of paper that is labeled "Hypothesis" for a hint. You will be handing in your hypothesis so that I can read it over.

During this activity you went through the same process that Wegener went through in 1914 (just much faster!). You did some research, made and recorded your observations. Then you examined the data and asked questions about it. You then used the data to come up with a hypothesis. I hope you enjoyed your time walking in the footsteps of Alfred Wegener!

-Mrs. Kinsberg



APPENDIX E

ACTIVITY 44 ANALYSIS QUESTIONS
(Modified from SEPUP, 2006, p. D-40 – D-41)

Activity 44 Analysis Questions

Name: _____ Class: _____ Date: _____

***Answer all questions in FULL SENTENCES on a separate sheet of paper.
Your answers will be collected.***

1) Are the sizes and shapes of the continents the same as the sizes and shapes of the plates?

Support your answer with a specific example from Student Sheet 44.2.

2) What is the relationship between earthquakes, volcanoes, and plate boundaries?

3) In Activity 36, “Storing Waste,” you learned that Nevada has the fourth highest number of earthquakes per year in the U.S. Which state would you predict to have a higher risk of earthquakes: Washington or Texas? Why?



4) In Activity 40, “The Continent Puzzle,” the country of India was a separate puzzle piece. Use the information on Student Sheet 44.2 to help you explain why.

APPENDIX F

ACTIVITY 44: ANALYSIS QUESTIONS B
(Modified from SEPUP, 2006, p. D-40 – D-41)

Activity 44 Analysis Questions

Name: _____ Class: _____ Date: _____

Vocabulary:

Plate = a section of the lithosphere. Earth's lithosphere (crust and upper mantle) is broken into pieces, and we call each piece a plate.

Plate boundary=a place where there is a crack in Earth's lithosphere. This is the border, or crack, between two plates.

*** If you are confused about either of these words, please tell Mrs. Kinsberg BEFORE you answer the analysis questions. ***

Answer all questions in FULL SENTENCES on a separate sheet of paper.

Your answers will be collected.

1) Look at student sheet 44.2 (the map).

- a) Are the plates the same shapes and sizes as the continents?
- b) Support your answer by writing about one specific continent that is or is not the same shape as the plate that it is a part of.

2) Write down the correct sentence on your paper:

- a) Volcanoes and earthquakes occur in random places all over the world and they have nothing to do with plate boundaries.
- b) Volcanoes and earthquakes usually occur on or close to plate boundaries.
- c) Volcanoes and earthquakes usually occur far away from plate boundaries.
- d) Earthquakes usually occur on or near plate boundaries, but volcanoes occur in random places all over the world.

3) In Activity 36, “Storing Waste,” you learned that Nevada has the fourth highest number of earthquakes each year in the U.S. Look at the picture below and your world map. Find America on your world map. (Remember to answer the questions in full sentences.)

- a) Which state is closer to a plate boundary, Washington or Texas?
- b) Do you think that Washington gets more earthquakes or that Texas gets more earthquakes?
- c) Explain why.



Challenge Question: When we used puzzle pieces to model Wegener’s idea of continental drift, the country of India was on its own puzzle piece. Find India on your world map. (If you do not know where it is, ask Mrs. Kinsberg to show you.) Why do you think India was on its own puzzle piece?

APPENDIX G

ACTIVITY 45: TEXT BOOK READING
(Taken directly from SEPUP, 2006, p. D-42 – D-46)

45 Understanding Plate Boundaries



The map below shows the locations of earthquakes and volcanoes on the earth's surface. Today, many of the world's most active volcanoes are located around the edges of the Pacific Ocean, and are often referred to as the "Ring of Fire." You may notice that both volcanoes and earthquakes tend to be concentrated in particular areas. The theory of plate tectonics helps explain this pattern.

CHALLENGE



How does the theory of plate tectonics help to explain the locations of earthquakes, volcanoes, and mountain ranges?

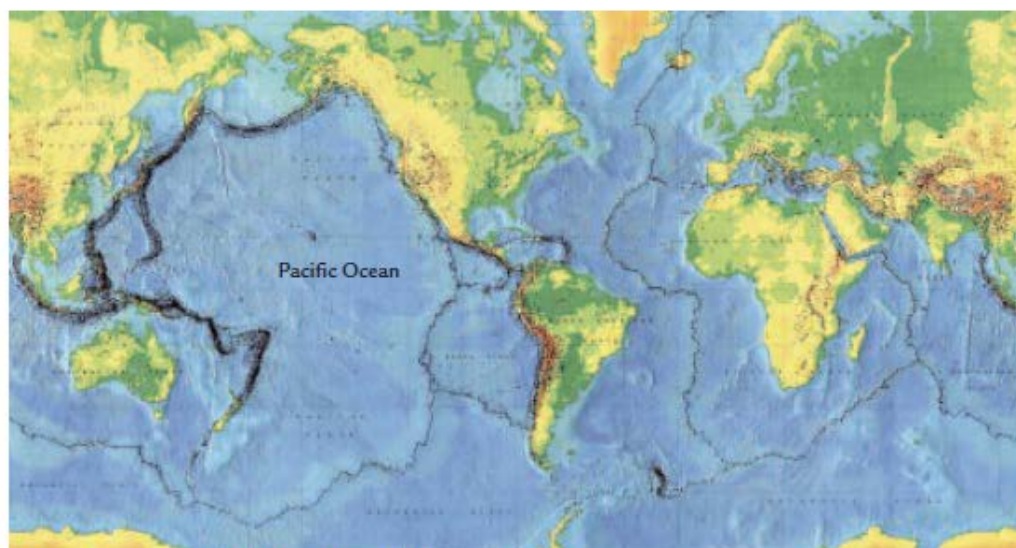


Figure 1: Map of Recent Earthquakes and Volcanoes on Earth
Black dots mark the locations of individual earthquakes and volcanoes.

Understanding Plate Boundaries • Activity 45

MATERIALS



For each student

- 1 completed Student Sheet 44.2, "Plate Boundaries"
- 1 Student Sheet 45.1, "Directed Reading Table: Understanding Plate Boundaries"

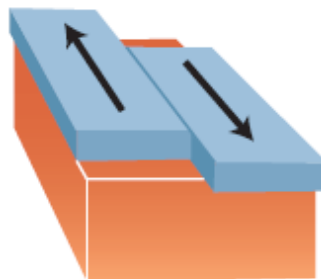
READING

Use Student Sheet 45.1, "Directed Reading Table: Understanding Plate Boundaries," to guide you through the following reading.

Plate tectonics is the theory that the earth's lithosphere is broken into plates that are in constant motion. The edges of these plates may be sliding past each other, spreading apart, or colliding. Over geological time, important processes—such as the formation of mountain ranges, earthquakes, and volcanoes—take place along the boundaries where these plates meet.

Sliding Plates

Geologists call the region where two plates are sliding past each other a **transform** boundary. Earthquakes are common along transform boundaries. There is a lot of pressure between the plates as they try to move past each other, and this pressure is only released when large pieces of rock along the boundary crack or shift their position. People can sometimes feel the vibrations caused by these movements and call them earthquakes.



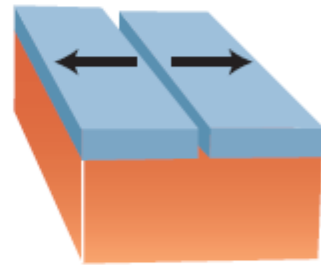
In Activity 44, "Mapping Plates," you recorded the overall movement of several large plates. Each plate may have different types of boundaries along different parts of its edge. A transform boundary is located between a part of the Pacific plate and a part of the North American plate, along the western edge of California. This is an area known for

Activity 45 • Understanding Plate Boundaries

its many earthquakes, as you can see in Figure 1, “Map of Recent Earthquakes and Volcanoes on Earth.” On its eastern edge, the North American Plate has a divergent boundary.

Spreading Plates

The place where plates are spreading apart is called a **divergent** (dy-VER-junt) boundary. Volcanoes as well as earthquakes are common along divergent boundaries. As the plates pull apart, the lithosphere thins and molten magma from the earth’s mantle erupts onto the surface, forming new lithosphere (See Figure 2, below). Over time, the lava from these volcanoes can build up and form volcanic mountains. You read about such mountains in Activity 38, “Beneath the Earth’s Surface.”



Sometimes, divergent boundaries are located under the ocean, and large underwater volcanic mountains can form. The plate boundaries seen along the middle of the Atlantic Ocean are an example of an underwater divergent boundary.

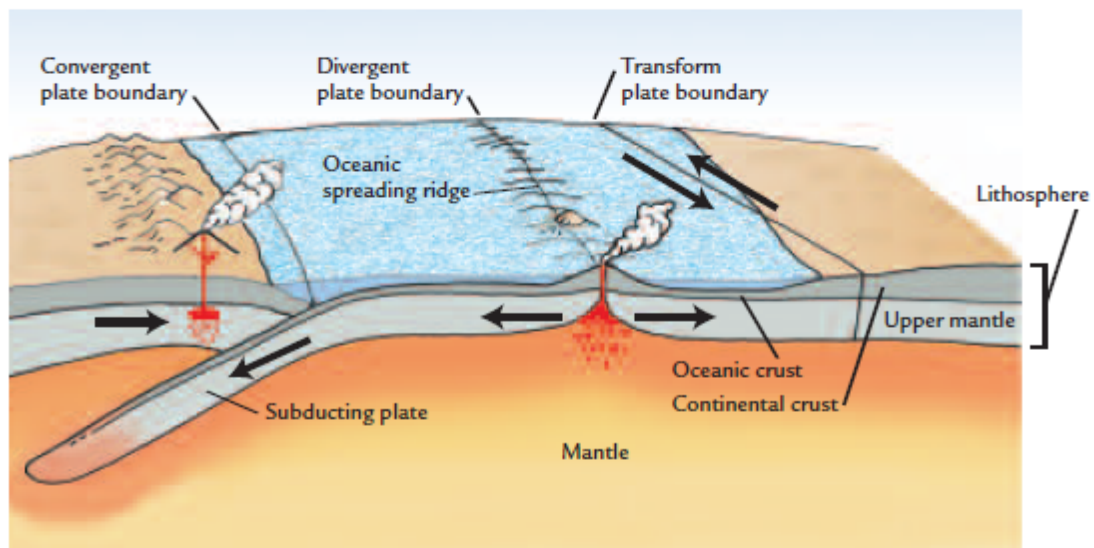


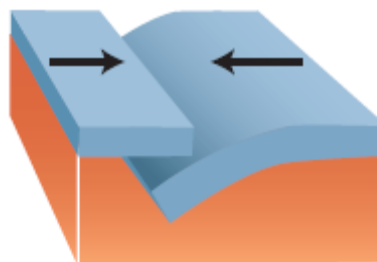
Figure 2: Types of Plate Boundaries

Understanding Plate Boundaries • Activity 45

Colliding Plates

Colliding plates create **convergent** (kun-VER-junt) boundaries. What happens along a convergent boundary depends on the type of lithosphere at the edge of each of the colliding plates. The earth's lithosphere—which includes the crust and solid upper mantle—varies over the surface of the earth. This is partly due to differences in the thickness of the earth's crust. The crust that makes up the oceans is generally thinner than the crust that makes up the continents. Oceanic crust is usually about 10 kilometers (km) thick, while continental crust ranges from 20 to 80 km thick. For this reason, the lithosphere is about 100–150 km thick under the ocean, and up to 300 km thick at some continents. Despite being thinner, oceanic lithosphere is denser than continental lithosphere because its crust is made up of denser rocks, such as basalt.

When continental and oceanic lithosphere collide, the less dense continental lithosphere usually rides up over the oceanic lithosphere, which goes down into the mantle and is destroyed. (See Figure 2.) The process of one plate moving below another plate is known as **subduction** (sub-DUK-shun). Both earthquakes and volcanoes are common along subduction zones. The volcanic mountains that you plotted along the western coast of South America in Activity 44 are a result of the oceanic lithosphere of the Pacific plate being subducted below the continental lithosphere of the South American plate. Subduction also occurs when two sections of oceanic lithosphere collide.



When two sections of continental lithosphere collide, the lithosphere tends to crumple and be pushed upward, forming mountains as well as causing earthquakes. The Himalayan mountains found along the northern border of India were formed when the Indian plate collided with the Eurasian plate. Several of the world's highest mountains, including Mount Everest, are part of the Himalayas and were formed from this collision.

Activity 45 • Understanding Plate Boundaries

Hot Spots

Most earthquakes and volcanoes occur along plate boundaries, but there are some exceptions. For example, the Hawaiian Islands are located in the middle of the Pacific plate. Yet each Hawaiian island was formed by a volcano, as lava from ongoing eruptions built up into an island.

A **hot spot** is a fixed area of the mantle that is so hot that magma rises through the lithosphere above it. As plates move, the location of the hot spot remains the same. In time, the movement of the plate can result in a chain of volcanic mountains or islands, like the Hawaiian Islands. (See Figure 3 below.) Scientists use this information to help determine the direction of plate movement.

Today, only the island of Hawaii (also called the “Big Island”) has an active volcano. At its southeastern corner, the next Hawaiian island, called Loihi, is already forming. It is still completely covered with seawater, but its top is almost 2 km high above the ocean floor. Scientists predict that it will build up enough to rise above the ocean’s surface in about one million years.

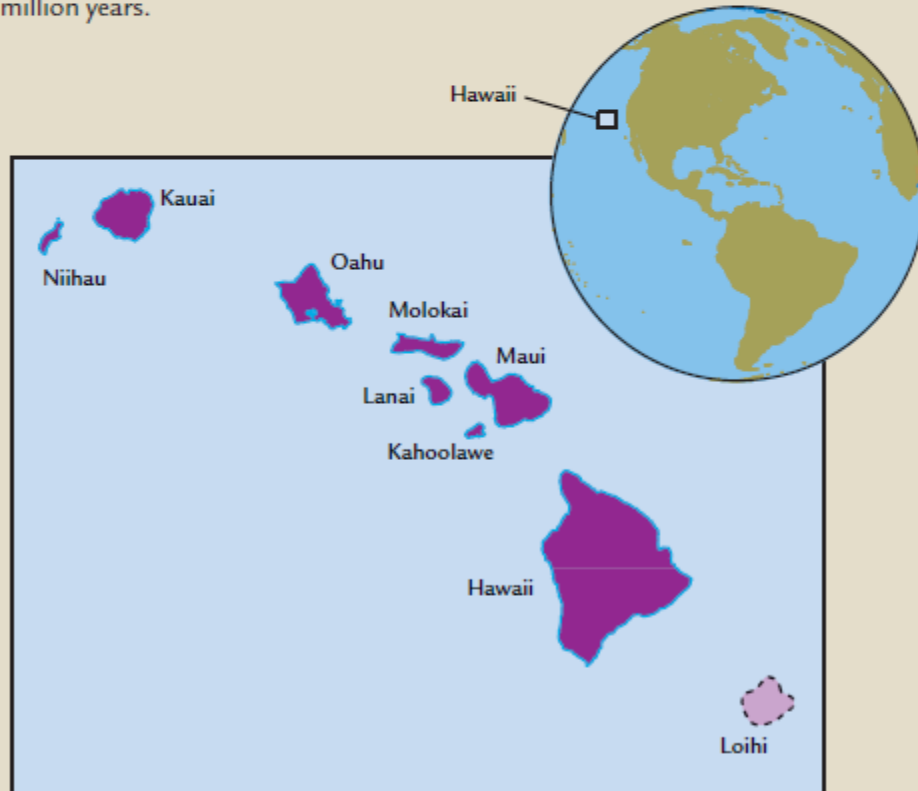


Figure 3: Map of the Hawaiian Islands

APPENDIX H

MODIFIED READING
(Modified from SEPUP, 2006, p. D-42 – D-46)

45 Understanding Plate Boundaries



The map below shows the locations of earthquakes and volcanoes on the earth's surface. Today, many of the world's most active volcanoes are located around the edges of the Pacific Ocean, and are often referred to as the "Ring of Fire." You may notice that both volcanoes and earthquakes tend to be concentrated in particular areas. The theory of plate tectonics helps explain this pattern.

CHALLENGE



How does the theory of plate tectonics help to explain the locations of earthquakes, volcanoes, and mountain ranges?

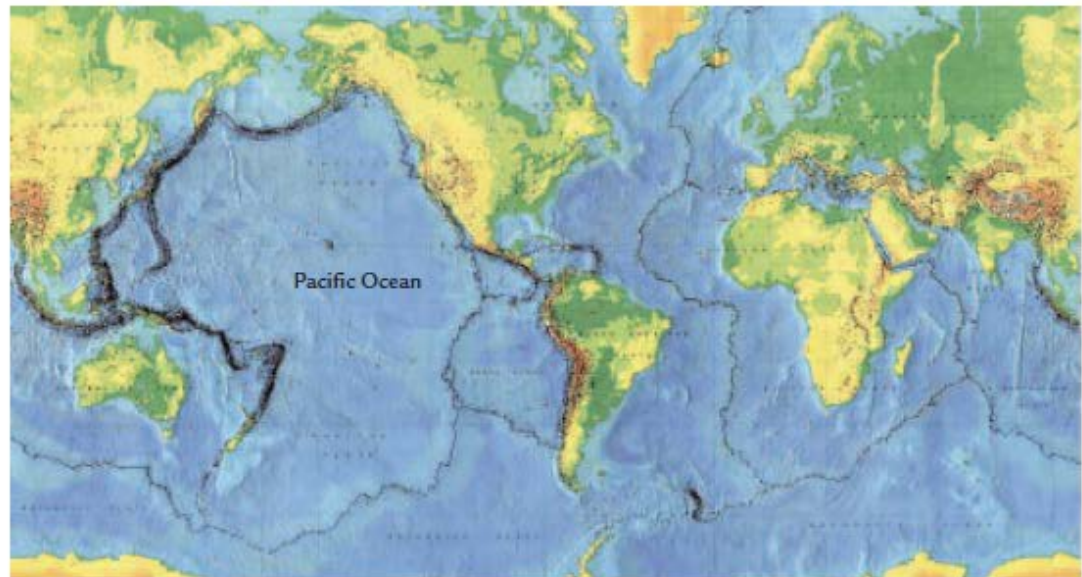


Figure 1: Map of Recent Earthquakes and Volcanoes on Earth
Black dots mark the locations of individual earthquakes and volcanoes.

INTRODUCTION

Plate tectonics is the theory that the earth's **lithosphere** is broken into pieces, called **plates**, which are always moving. Two plates can move toward each other, away from each other, or they can slide past each other. Over **geological time**, this movement can cause the formation of mountains, earthquakes, and volcanoes. In the next few sections, you will read about the different ways that plates move, called plate motion.

Lithosphere: all of the crust and the very top of the mantle

Plates: large pieces of earth's lithosphere

Geological time: thousands, millions or billions of years

SLIDING PLATES

In some places, two plates that are moving in opposite directions slide past each other. If one plate is moving north, for example, and the plate next to it is moving south, the two plates will slide past each other. The scientific term for this type of **plate boundary** is a **transform boundary**.

Plate boundary: the border between two plates or the place where two plates meet.

Transform boundary: a place where two plates are sliding past each other

Earthquakes, which are a type of geologic process, often occur on or near transform boundaries. At this type of plate boundary, the lithosphere is neither created nor destroyed. When two plates slide past each other, large pieces of rock along the boundary sometimes crack or move. This causes vibrations (shaking), which we call earthquakes.

As you can see in this picture, there is a transform boundary between the North American plate and the Pacific plate. This transform boundary is right next to the west coast of California, which is why California has so many earthquakes.



****Fill in the boxes about "sliding" plate motion on your worksheet.**

SPREADING PLATES

In some places two plates move away from each other, or spread apart.

The scientific term for this type of boundary is **divergent boundary**.

The geological processes that occur at this type of plate boundary are

earthquakes and the formation of volcanoes. At this type of plate

boundary, magma erupts through the space in between the plates and

hardens into rock. The rock becomes part of the lithosphere. This means that new lithosphere is



formed at a **divergent boundary**. Over time, the lava that erupts

can pile up and form a **volcanic mountain**. As you can see in the

picture, there is a divergent boundary between the African plate

and the South American plate. There is a long chain of

underwater volcanoes on this plate boundary called the Mid-

Atlantic Ridge.

Divergent boundary: a plate boundary where two plates are spreading apart or moving away from each other.

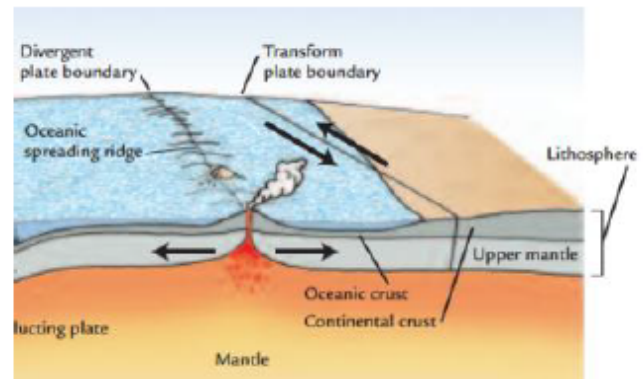
Volcanic mountain: a mountain that is a volcano

This picture shows a divergent plate

boundary and a transform plate boundary.

Underwater volcanoes are forming along

the divergent boundary.



**** Fill in the boxes about "spreading" plates on your worksheet.**

COLLIDING PLATES

In some places, two plates move toward each other, or collide. The scientific term for this type of boundary is **convergent**. The geologic processes that can occur at this type of boundary are: earthquakes, volcano formation, and mountain formation.

Convergent boundary: a plate boundary where two plates move toward each other or collide.

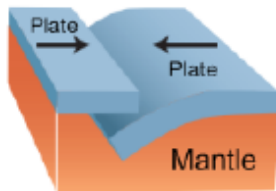
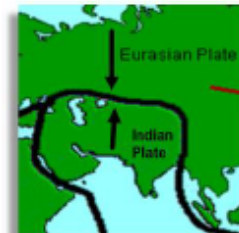
Subduction: the process of one plate moving below another plate.

If a **convergent boundary** is underwater, one plate gets pushed under the other plate.

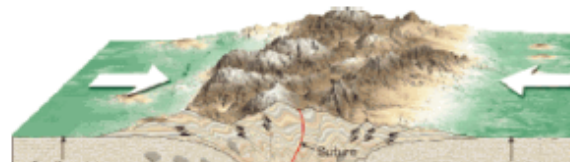


The piece of lithosphere that gets pushed into the mantle will melt into magma and be destroyed. The process of one plate moving below another plate is known as **subduction**. Subduction causes earthquakes and volcanoes to occur at convergent plate boundaries. There is a convergent plate boundary in between the South American plate and the

Nazca plate. As a result, there are many volcanoes and earthquakes along the west coast of South America. Subduction happens when a convergent plate boundary is under water. However, if a convergent plate boundary is on land, the lithosphere crumples and gets pushed upward instead. This forms mountains and causes earthquakes to happen. The Himalayan Mountains formed when the Indian plate collided, or moved toward, the Eurasian plate.



This picture shows subduction.



This picture shows mountain formation.

Activity 45 • Understanding Plate Boundaries

Hot Spots

Most earthquakes and volcanoes occur along plate boundaries, but there are some exceptions. For example, the Hawaiian Islands are located in the middle of the Pacific plate. Yet each Hawaiian island was formed by a volcano, as lava from ongoing eruptions built up into an island.

A **hot spot** is a fixed area of the mantle that is so hot that magma rises through the lithosphere above it. As plates move, the location of the hot spot remains the same. In time, the movement of the plate can result in a chain of volcanic mountains or islands, like the Hawaiian Islands. (See Figure 3 below.) Scientists use this information to help determine the direction of plate movement.

Today, only the island of Hawaii (also called the “Big Island”) has an active volcano. At its southeastern corner, the next Hawaiian island, called Loihi, is already forming. It is still completely covered with seawater, but its top is almost 2 km high above the ocean floor. Scientists predict that it will build up enough to rise above the ocean’s surface in about one million years.

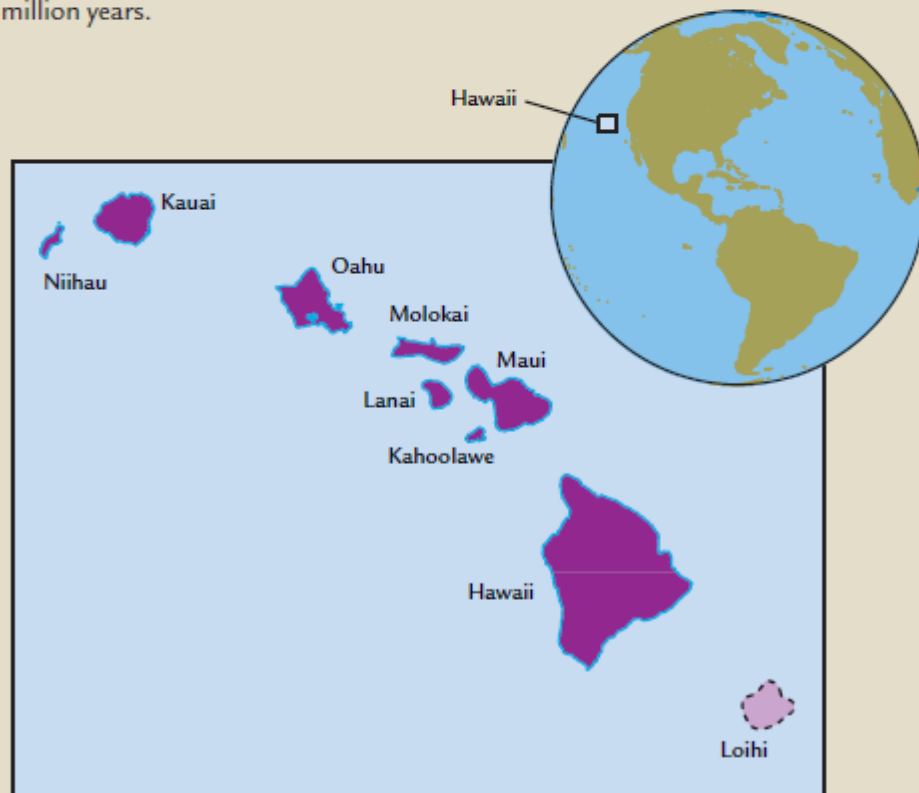


Figure 3: Map of the Hawaiian Islands

APPENDIX I

DIRECTED READING TABLE

(Taken directly from SEPUP Teacher's Guide, 2006, p. D-101)

Name _____

Date _____

Directed Reading Table: Understanding Plate Boundaries

Type of Plate Motion	Sliding	Spreading	Colliding
Scientific Term for Boundary Type			
At this type of plate boundary, which of the following geological processes are likely to occur?			
• earthquakes • volcanoes			
At this type of plate boundary, what happens to the lithosphere?			
It is: • formed • destroyed • neither			
Example of this type of plate boundary			

APPENDIX J

ATTITUDE SURVEY

Name: _____ Class: _____ Date: _____ Student #: _____

Read each statement and circle the answer that is true for you. Please be honest. There are no wrong answers! Your participation or non-participation will not affect your grade or class standing. Participation is voluntary, and you can choose to not answer any question that you do not want to answer, and you can stop at any time.

Thank you for taking the time to complete this survey.

1) I look forward to coming to science class.

usually

sometimes

rarely

never

Why? _____

2) I feel bored during science class.

usually

sometimes

rarely

never

Why? _____

3) Science class is fun.

usually

sometimes

rarely

never

4) I feel confused in science class.

usually

sometimes

rarely

never

Why? _____

5) Science class is too easy for me.

usually

sometimes

rarely

never

6) Science class is too hard for me.

usually

sometimes

rarely

never

7) I learn something new in science class.

usually

sometimes

rarely

never

8) I like science class.

usually

sometimes

rarely

never

Why? _____

9) Check off the statement that is *usually* true for you.

___ science class is **very** easy for me

___ science class is easy for me

___ science class is just right for me

___ science class is hard for me

___ science class is **very** hard for me

What makes science class easy, hard, or just right for you? _____

10) Use this space to share any other comments that you have about science class.

APPENDIX K

ENGAGEMENT SURVEY
(Modified from Wellborn, 1991)

How I Feel About School

Read each statement and circle the answer that is true for you. Please be honest. There are no wrong answers! Your participation or non-participation will not affect your grade or class standing. Participation is voluntary, and you can choose to not answer any question that you do not want to answer, and you can stop at any time.

Thank you for taking the time to complete this survey.

1. I try hard to do well in school.

- A) Not at all true B) Not very true C) Sort of true D) Very true

2. I enjoy learning new things in class.

- A) Not at all true B) Not very true C) Sort of true D) Very true

3. When we work on something in class, I feel discouraged.

- A) Not at all true B) Not very true C) Sort of true D) Very true

4. In class, I do just enough to get by.

- A) Not at all true B) Not very true C) Sort of true D) Very true

5. Class is fun.

- A) Not at all true B) Not very true C) Sort of true D) Very true

6. In class, I work as hard as I can.

- A) Not at all true B) Not very true C) Sort of true D) Very true

7. When I'm in class, I feel bad.

- A) Not at all true B) Not very true C) Sort of true D) Very true

8. When I'm in class, I listen very carefully.

- A) Not at all true B) Not very true C) Sort of true D) Very true

9. When I'm in class, I feel worried.

- A) Not at all true B) Not very true C) Sort of true D) Very true

10. When we work on something in class, I get involved.

- A) Not at all true B) Not very true C) Sort of true D) Very true

11..When I'm in class, I think about other things.

- A) Not at all true B) Not very true C) Sort of true D) Very true

12. When we work on something in class, I feel interested.

- A) Not at all true B) Not very true C) Sort of true D) Very true

13. Class is not all that fun for me.

- A) Not at all true B) Not very true C) Sort of true D) Very true

14. When I'm in class, I just act like I'm working.

- A) Not at all true B) Not very true C) Sort of true D) Very true

15. When I'm in class, I feel good.

- A) Not at all true B) Not very true C) Sort of true D) Very true

16. When I'm in class, my mind wanders.

- A) Not at all true B) Not very true C) Sort of true D) Very true

17. When I'm in class, I participate in class discussions.

- A) Not at all true B) Not very true C) Sort of true D) Very true

18. When we work on something in class, I feel bored.

- A) Not at all true B) Not very true C) Sort of true D) Very true

19. I don't try very hard at school.

- A) Not at all true B) Not very true C) Sort of true D) Very true

20. I pay attention in class.

- A) Not at all true B) Not very true C) Sort of true D) Very true

APPENDIX L

ROCKS AND MINERALS UNIT TEST

Name: _____ Class: _____ Date: _____

Rock and Mineral Test

Multiple choice: Circle the best answer.

1. Which of the following statements is TRUE?

- a) All minerals are made of rocks.
- b) All rocks are made of minerals.
- c) Rocks and minerals are the same.
- d) All of the above.

2. An example of a property of a mineral is _____.

- a) how common it is
- b) where it is found
- c) how it reacts with acid
- d) how much it costs

3. Which one of the following words tells you something about how a rock was formed?

- a) igneous
- b) granite
- c) mineral
- d) transparent

4. Which type of rock forms from the cooling of magma?

- a) igneous
- b) metamorphic
- c) sedimentary
- d) mineral

5. Which type of rock forms from the layering of sediments?

- a) igneous
- b) metamorphic
- c) sedimentary
- d) mineral

6. Which type of rock forms from heat and pressure deep underground?

- a) igneous
- b) metamorphic
- c) sedimentary
- d) mineral

7. Which type of rock is most likely to contain fossils?

- a) igneous
- b) metamorphic
- c) sedimentary
- d) all of the above

TRUE or FALSE:

8. Rocks can melt. _____
9. A translucent mineral is completely see-through. _____
10. A mineral can have an opaque luster. _____
11. A diamond is a 10 on Moh's Hardness Scale. _____
12. The size of a mineral sample can help you identify it. _____
13. Sediments are tiny pieces of rocks and shells. _____

Use the table below to answer Questions 14-16.

	Galena	Hematite	Magnetite
Hardness	2.5	6.5	6
Color	silvery gray	red to black	black
Is it magnetic?	not magnetic	not magnetic	magnetic

14. Based on the table above, which mineral is the hardest?
- a) galena b) hematite c) magnetite d) they are all the same.
15. Which of these minerals **cannot** be scratched by magnetite?
- a) galena b) hematite
- c) magnetite d) magnetite can scratch all of them
16. Your teacher gives you a mineral that is black. How can you figure out if the mineral is galena, hematite or magnetite. (Answer in a full sentence.)

17. Place a check mark in the correct box.

	Igneous	Sedimentary	Metamorphic
<i>Example: crumbly</i>		✓	
Glassy surface			
Large crystals that fit together like puzzle pieces			
Can see pieces of sand or pebbles			
Very small crystals			
Bands (ribbon-like layers) that look like they have been pressed together.			

18. Your teacher gives you a mineral, but she does not tell you what it is. List three properties that might help you identify the mineral. _____

19. List one igneous rock: _____

20. List one sedimentary rock: _____

21. List one metamorphic rock: _____

Answer in full sentences:

22. Is water a natural resource? Explain. _____

23. What do all minerals have in common? _____

24. Look at the mineral sample provided by your teacher and answer the following questions:

- Is the mineral harder or softer than copper? _____
- Is the mineral harder or softer than glass? _____
- What is the transparency of the mineral? _____
- Make one other observation about your mineral: _____

APPENDIX M

INSIDE EARTH UNIT TEST

Name: _____ Class: _____ Date: _____

UNIT D: PLATE TECTONICS TEST

Multiple choice: Circle the best answer.

1. The distance from the earth's surface to the center of the earth is _____.
a. 64 km b. 640 km c. 6,400 km d. 64,000 km
2. Which layer of earth is the hottest?
a. the mantle b. the inner core c. the crust d. the outer core
3. Which layer of earth is mostly made of magma?
a. the inner core b. the crust c. the outer core d. the mantle
4. Continental drift is the idea that _____.
a. the continents are the only solid surface on the earth
b. objects that fall into the ocean drift between the continents
c. ocean waves push the continents over the surface of the earth
d. the continents were once joined together in a single large piece of land
5. Which of the following is most likely to occur at a transform boundary?
a. earthquakes b. volcanoes c. mountain formation d. All of the above.
6. Plate tectonics refers to the theory that _____.
a. the continents float on the oceans like plates
b. each of the continents on the earth is also called a plate
c. the surface of the earth is made of large plates that cannot move
d. the surface of the earth is made up of large plates that move over time

7. Which one of the following statements is TRUE?
- a. The earth's crust moves around but is never destroyed.
 - b. New crust is always forming on the top of large mountains.
 - c. Old crust falls into the oceans and is destroyed over time.
 - d. Old crust is destroyed and new crust is formed over time.
8. The word "lithosphere" is used to refer to which layers of the earth?
- a. the crust only
 - b. the crust and the entire mantle
 - c. the crust and the upper mantle
 - d. the upper mantle only
9. Plate tectonics helps explain the formation of which of the following?
- a. mountains
 - b. trees
 - c. clouds
 - d. All of the above
10. Which of the following statements provides evidence for plate tectonics?
- a. The same kind of unusual fossils are found in South America and Africa.
 - b. The same kind of unusual rock layers are found in North America, Europe, and Africa.
 - c. The earth's continents are moving at a rate of centimeters per year.
 - d. All of the above.
11. Plate tectonics is the theory that sections of the earth's crust _____.
- a. were hot and they wrinkled as they cooled to form continents, mountains, and oceans
 - b. have moved toward and away from each other to form continents, mountains, and oceans
 - c. have collapsed, forming oceans between the continents
 - d. are floating in the oceans and are called continents
12. New lithosphere is mostly created at what type of plate boundary?
- a. convergent
 - b. divergent
 - c. transform
 - d. all of the above

13. What formed the Himalayan Mountains, which are along the northern border of India?
- a. the buildup of soil and rocks over millions of years
 - b. numerous eruptions of nearby volcanoes
 - c. the collision of two lithospheric plates
 - d. two lithospheric plates sliding past each other
14. What happens at a divergent boundary?
- a. two plates slide past each other
 - b. two plates move toward each other
 - c. two plates move away from each other
 - d. none of the above
15. What is glossopteris?
- a. an ancient plant that used to grow in warm places
 - b. a small land mammal that used to live in Australia
 - c. a mountain range that is in South Africa
 - d. the name of a glacier that existed during the time of Pangaea
16. How long ago did Pangaea exist?
- a. three thousand years ago
 - b. thirty million years ago
 - c. three million years ago
 - d. three hundred million years ago
17. Which if the following pieces of evidence was NOT used by Wegener to support the idea of continental drift?
- a. Coal was found in warm areas near the equator
 - b. Glacier marks were found in South Africa
 - c. Fossils of Mesosaurus were found in Brazil and South Africa
 - d. Fossils of Glossopteris were found in cold places
18. Why are there so many earthquakes in California?
- a. The ground in California contains a lot of sand and is very unstable
 - b. Large ocean currents sometimes collide with the coast of California
 - c. California is located in an area where two plates slide past each other
 - d. There are a lot of volcanoes in California which cause earthquakes

19. The earth's lithosphere can be destroyed at which type of plate boundary?
- a divergent boundary
 - a transform boundary
 - a convergent boundary
 - all of the above
20. Subduction can occur _____.
- when two plates collide
 - when two plates slide past each other
 - when two plates spread apart
 - all of the above are correct

True or False:

21. Wegener believed that the earth's lithosphere was divided into pieces called plates. _____
22. The continents (such as North America and Africa) float on water. _____
23. At a convergent boundary, two plates move toward each other. _____
24. The plates are the same shape as the continents. _____
25. The continents move about 3 feet every year. _____
26. Some plates include the lithosphere that is under the oceans. _____
27. Earthquakes and volcanoes occur along plate boundaries. _____

Identify the type of plate boundary being shown in each picture. Use the scientific terms.

28.



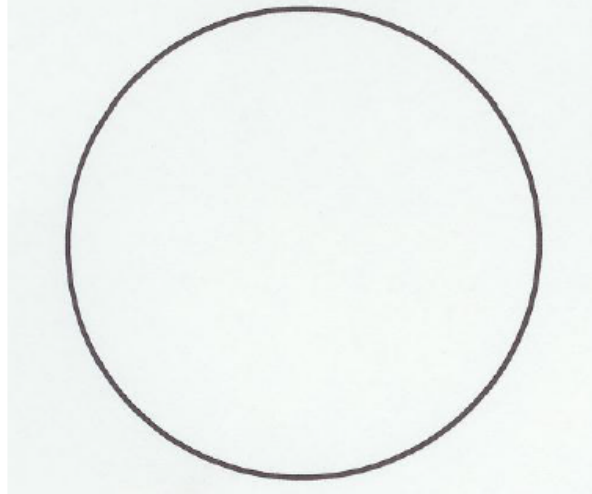
29.



30.



31. Use the circle below to draw a diagram of the earth's interior by:
- Sketching the approximate size of each layer
 - Labeling each layer with its name



32. In your own words, explain:
- the theory of plate tectonics
 - how earthquakes, volcanoes, and mountain formation are related to plate tectonics.

Be as specific as you can.

APPENDIX N

INTERVIEW QUESTIONS

Interview Questions

1. What classes do you enjoy this year? Why do you enjoy them?
2. Do you feel challenged in any of your classes this year?
 - a. Which ones?
 - b. What makes them challenging?
 - c. Does that make you like the class less? More?
 - d. Do you feel like you have to work hard during those classes or only at home?
3. Do you think that science class is easy, hard, or just right this year?
 - a. What makes it easy or hard?
4. How would you feel if your teacher divided the class into groups and gave each group different work to complete?
5. What can I do to make science class more interesting and enjoyable for you?

APPENDIX O

IRB EXEMPTION LETTER



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For the Protection of Human Subjects
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MEMORANDUM

TO: Batya Kinsberg

FROM: Mark Quinn, Ph.D. Chair *Mark Quinn ex'*
 Institutional Review Board for the Protection of Human Subjects

DATE: December 6, 2011

SUBJECT: *The Effects of Differentiating Instruction in a Sixth Grade Science Classroom* [BK120611-EX]

The above research, described in your submission of December 6, 2011, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal Regulations, Part 46, section 101. The specific paragraph which applies to your research is:

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

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