THE EFFECTS OF THE 5E LEARNING MODEL IN THE MIDDLE SCHOOL CLASSROOM

by

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ABSTRACT

Seventh graders continually need to be engaged and motivated to work in class. The main research question was "what are the effects of the 5E Learning Model on academic achievement and attitude in middle school classroom?" Students were split into four classes which engaged in traditional learning and 5E Learning Models. Pre- and post-treatment assessments, surveys, interviews and teacher observations were used as data collection instruments. Data were processed using both quantitative and qualitative analysis strategies. The results suggested that students' attitudes of science improved with the 5E Learning Model through student short answer responses and small group interviews. There was no conclusive quantitative data relating to the 5E Learning Model and academic achievement. Through qualitative responses, students' attitude and engagement towards science improved with the 5E Learning Model.

INTRODUCTION AND BACKGROUND

Context of the Study

The study took place in Charlotte, North Carolina. There are about 260 independent schools operating in North Carolina, 33 of which reside in Charlotte's county (NCDOA, 2021). Charlotte has a population of about 900,000 residents and growing. According to the Census Bureau the population is about 41% white, 35% African American, 14% Latinx, 6.5% Asian, 3% multiracial, and 0.4% Native American. The high school graduation rate is about 89% and 44% for a bachelor's degree or higher (USCB, 2019). The median home value is $350,000. Charlotte is one of the top 5 fastest growing cities in the United States.

I taught seventh grade science at Providence Day School, an independent school in Charlotte, North Carolina in the 2021- 2022 academic year. Providence Day School (PDS) is a Transitional Kindergarten-12 school operating a Lower School, Middle School, and Upper School. The whole student population was approximately 60% European American, 9.8% Asian American, 8.5% multicultural, 7.1% African American, 1.1% Middle Eastern, 0.9% Native American, 0.6% international, 0.2% Pacific Islander, and about 8.8% of the student population did not wish to answer. Tuition for 6^{th}-12^{th} graders was ~$30,000 a year in 2021. There was no free or reduced lunch program, but there was need-based tuition assistance. Most middle school students continue to the Providence Day High School. 100% of PDS high school students attend four-year colleges and universities. The make-up of the school does not represent that of the city of Charlotte. In the Middle School there are approximately 45 faculty and 455 students. There were two science teachers per middle school grade. Each teacher taught 4 middle school classes. There were 159 students in the 7^{th} grade. I taught 79 students over four classes in the first

semester of the 2021-2022 school year. There were 80 students in the other four seventh grade classes.

I had not had formal education experience before my first teaching assignment. In my first three years of teaching, I tried to do my best to engage students, increase student confidence, differentiate lesson plans, and work on classroom management. In my own personal experience in public school, the teaching styles that I experienced and the styles that the students expected did not align.

When I started teaching at a private school with an inquiry-based curriculum, both my new students and I had a lot to learn. I started by primarily teaching from notes and lecturing at the whiteboard. Students took more notes than in any other class. I gave pop quizzes as I was given throughout my learning experience. Labs always came after lecture and notes. There was usually no time built into class for reflection. The students were used to different and varied note taking. Other science teachers suggested mini-labs to engage students and get them excited about the content we were able to learn. The students liked to review using online review games that I had never used. I informally learned all I could to adapt to a new style of teaching and learning that I had not experienced.

After my second year of teaching, I started the MSSE program at Montana State University to help me dive deeper into science education pedagogy. I first learned about constructivism, phenomena-based learning, and the 5E Learning Model (5E Learning Cycle/5E's) the summer of 2020. I had already created a new curriculum without the 5E’s, but I was very engaged by the content and examples that I encountered during my summer classes. In 2021, I started teaching at a new school, Providence Day School. It was both exciting and

intimidating to start at a new school and adapt and reformat my teaching style, again. Fortunately, the new textbook that we use at Providence Day School is modeled with the learning cycle in mind; however most of the methods taught by my co-teacher were more traditional teaching methods. In the first few units I used and modeled my classes after my co-teacher's to help me get my feet under me. After I got to know the school and students better, I started working on 5E lesson plans.

I found in my teaching that student-centered and inquiry-based learning has led to more engagement and better attitude in classes. I wanted to explore how it can influence students academically. I am continuing to learn how to organize content, create units, and write curriculum more efficiently. A constructivist learning cycle model would be beneficial for my planning and student engagement. Since I have also not explicitly used the 5E Learning Model, I would like to see the value in the different stages of the model.

The goal of this Action Research project is to compare the 5E and traditional learning models and how they influence students' attitude towards science. My focus question centers on the effects of the 5E Learning Models on academic achievement and attitude in the middle school classroom, particularly my 7th grade science classroom. A lot of work has been done to measure traditional teaching methods to the 5E or other similar learning cycles. I plan to do the same in my classroom and capture both the student and teacher perspectives. Other colleagues have also wondered which E's they focus on in class and how it influences the students in their classrooms. It could speak to how teachers will think about how they present their curricula going forward at Providence Day School and other schools across the nation.

Focus Question

My focus question was, What is the effect of the 5E Learning Model on academic achievement and attitude in the middle school classroom?

My sub questions include the following:

1. How will the 5E model influence academic achievement?
2. How do 5E lessons impact attitude and engagement?
3. Which E's do students feel are most impactful?

CONCEPTUAL FRAMEWORK

Before the MSSE program, I did not practice inquiry-based teaching strategies. After learning more about the Next Generation Science Standards (NGSS) and the benefits of inquiry-based learning it was something that I strived to bring into my classroom. This section discusses the benefits of inquiry-based learning in academic achievement as well as student engagement. It looks in depth at the 5E Learning Model (5E Learning Cycle) which is a teaching tool that uses inquiry-based learning. Other extensions of the 5E Learning Model (5E's) are also discussed.

Inquiry

Is it possible to both keep students engaged and achieving at a higher level? Traditional teaching methods do not typically engage students in the classroom, especially as technology fights for their attention (Subramanian, 2018). There can be more passive learning in the traditional classroom and inquiry-based learning is an alternative approach. Other terms that reflect the same ideals as inquiry-based learning also include mastery learning or constructivist teaching.

There has also been a shift in bringing inquiry-based learning into more classrooms through the adoption of NGSS. These standards were based on a National Research Council (NRC) report on a framework for K-12 science education introducing practice, crosscutting concepts, and core ideas that students should engaged by the end of secondary school (NRC, 2012). NGSS was introduced in 2013 and inquiry plays a large role in its' practices (NGSS Lead States, 2013).

More and more studies looked at inquiry-based learning and it's benefits helping the NGSS and standards based on the same framework are being used in almost all of the US. According to Pedaste et al. (2015) inquiry-based learning supports problem solving and using more than one skill to be able to solve that problem, giving students an opportunity to have a more authentic process of discovery. Most inquiry-based learning cycles include a linear sequence of stages, but inquiry-based learning is not linear. The stages in various learning models are flexible.

How Inquiry Learning Influences Academic Achievement

Why have educators moved towards inquiry-based models of teaching? Trautmann et al. (2004) found that inquiry-based learning can lead to increased motivation, interest in science, higher order thinking, skills for independent work, design skills, and a greater ability to interpret results. These benefits were reported by both teachers and students. Although there are many benefits, inquiry-based learning still faces many challenges. Teachers who were not taught this way are more hesitant to teach this way. Teachers may also feel pressure to teach facts due to standard testing. It also can feel like teacher control is taken away when inquiry-based learning takes place in the classroom (Trautmann et al., 2004). Although it might be a hard transition for teachers, various studies show the benefits of inquiry-based learning on academic achievement. Lai (2018), Onsee and Nuangchalerm (2019), Yuliati et al. (2018), and various others have shown the impact of inquiry-based learning on students at various levels in their education and how it helped students improve their skills in science, technology, engineering, and math.

How Inquiry Learning Influences Student Engagement

Can inquiry-based learning improve student engagement? Sinatra et al. (2015) remind us that is important to define engagement as it can be used at different levels and contexts. I focused on the behavioral and cognitive student engagement. Parsons and Taylor (2011) studied research literature on student engagement from about 2000-2010. The authors came away with recommendations that include the need for interaction, exploration, relevancy, and technology. The exploration recommendation heavily learns into the importance of inquiry-based and problem-based classroom methods to increase student engagement. Parsons and Taylor (2011) also came to find that a move towards constructivist pedagogy can lead to greater student engagement. Buchanan et al. (2016) also found that inquiry based learning led to overwhelming positive results on student engagement as well as academic achievement. However, most of the literature that they reviewed were high school and college level work. Students are engaged because the material can cover topics they are interested in, the choice in work, and autonomy. Buchanan et al. (2016) point out that there is still more research to be performed on younger students and with the student perspective in mind. Student interviews and open responses in this study may help to better understand how the 5E Learning Model can influence student engagement from the student perspective.

How Inquiry Learning Influences Student Attitudes

Many learning cycles allow students the time and space to engage and learn. The 5E Learning Model allows students to engage in science learning. Learning cycles and instructional models have grained traction in science education over the course of the 18th century. As

technology has flourished and teachers continue to improve for their students, the 5E Learning Cycle has come to the forefront of the instructional models. There is a wide range of evidence that supports the effectiveness of learning cycles (Balci et al., 2006). Parsons and Taylor (2011) also discuss how engagement and attitude can go hand in hand. They discuss how misconceptions, trust in science, moral or political content can influence attitude. Student attitude change through engagement or vise versa. My goal is to overcome misconceptions and foster positive student attitude and engagement through the material that we learn.

5E Learning Model/Cycle

The 5E Learning Cycle has evolved starting in 1901 from the Herbart Instructional Model, Dewey Instructional Model (1910 & on), Heiss, Obourn, and Hoffman Learning Cycle, Karplus and Their Learning Cycle, Atkin-Karplus Learning Cycle (1950), and finally the Biological Sciences Curriculum Study (BSCS) 5E Instructional Model in the mid-1980's (Bybee et al., 2006). The 5E Learning Cycle is primarily used in elementary to high school education although the Instructional Model can be found even in post-graduate work. It has also expanded to other subjects outside of science (Bybee, 2014).

The stages of the 5E Learning Cycle used in this study include Engage, Explore, Explain, Elaborate, and Evaluate . A phenomenon is typically shared in the Engage stage of the cycle. This elicits interest in the unit and activates the student's prior knowledge and experiences as they try to construct the reasoning behind the phenomena. Examples of engaging tasks include asking a question, showing a discrepant event (live or by video), or acting out a situation (Bybee et al., 2006).

The next stage in the 5E cycle is Explore. Typically, there is a misconception that may be addressed through the phenomenon and the Explore activity can guide students toward conceptual change. This stage includes a hands-on activity to help the students begin to grasp concepts, processes, and/or skills. This stage is where a lot of the inquiry-based learning happens. Example include worksheets or labs that include problem solving, research activities, and activities that include visual, auditory, and/or kinesthetic components.

The third stage is Explain. At this state the instructor and students work together to create an explanation of the phenomena. Vocabulary terms and concepts are shared at this stage to bring common language and order from the Explore stage. Students should be encouraged to explain concepts and definitions in their own words using their new learned vocabulary. The goal is for connections to be made between the students' prior knowledge, the previous class activities, and the definitions from class.

Elaborate is the next stage and this is when the student continues to share their understanding of the phenomenon through new experiences or activities. At this stage students may still carry misconceptions from earlier stages. This gives students time and space to learn and expand the students' ideas of the concepts from the previous examples. This stage of the learning cycle can include role playing, different methods of applying their knowledge, and creating conclusions or reports. It's valuable at this stage to extend the students' knowledge beyond the classroom and to also think of other possible connections outside of the classroom to their daily lives to increase student engagement.

The last stage is Evaluate. This is when the instructor assesses the students' understanding of the phenomenon. The students can use the skills they learned and receive

feedback from their instructors. Examples of evaluate tasks include self and peer assessment, lab practicals, a learning journal, mind maps, and target setting.

The 5E Learning Cycle developed by BSCS views learning as both dynamic and interactive. There is a general progression to the stages, but they are not set in stone. This allows time and stages for students to challenge their current conceptions and allow for reconstruction to take place (Figure 1) (Bybee et al., 2006).

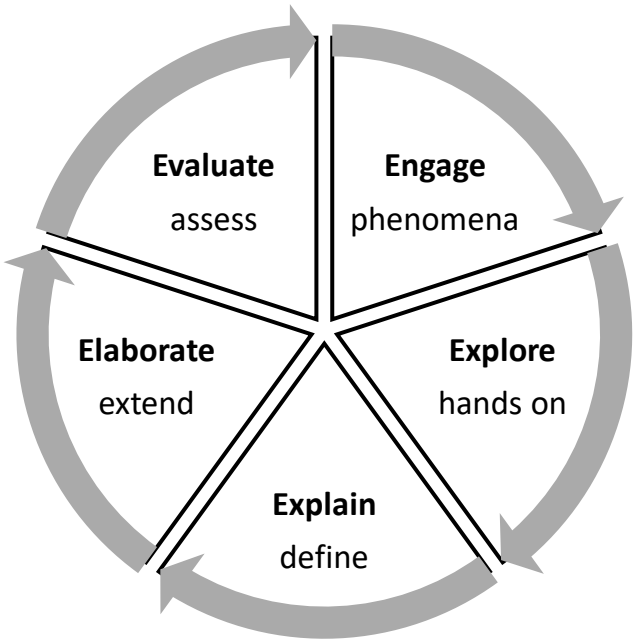

Figure 1. The 5E learning model. The Engage phase usually introduces a phenomenon, the Explore phase is typically hands on, the Explain phase is when terms and ideas are defined, the Elaborate phase is when knowledge is extended, and the Evaluate phase includes an assessment of the students' knowledge.

Expanded 5E Learning Models/Cycles

Although the 5E Learning Cycle was developed in the 1980's the work did not stop there. The model was used, analyzed, studied, and reported on. Other stages were also added and there

are a multitude of other “E” Learning Cycles. There are various versions of the 5E Instructional Model.

The 6E Instructional Model in this study is found in Duran et al. (2011). The stages of this 6E Learning Cycle include Engage, Explore, Explain, Express, Elaborate, and Evaluate. The Express stage comes after the Explain stage and before the Elaborate stage from the BSCS 5E Instructional Model. This new stage is added to help students at different levels of understanding differentiate the Elaborate stage and help the students reach their learning goal. Duran et al. used a formative assessment probe for this differentiation stage. This allows the instructor to see if misconceptions from the Explore and Explain stages have been addressed.

These formative assessment probes can have varying levels of check-in. Keeley (2019) explored an example that set up students into novice, partial, and complete understanding groups. The added stage can be a help to both students and instructors to catch misconceptions before the Evaluate stage.

The 7E Learning Model was developed by Eisenkraft. The stages of the 7E Learning Cycle used in this study include: Elicit, Engage, Explore, Explain, Elaborate, Evaluate, and Extend (Balta & Sarac, 2016). The Elicit stage (which will also be found in the 9E Instructional Model) allows for students to share prior understandings before engaging in phenomena. This stage can help teachers have a better idea of how to capture students’ attention moving forward in the 7E Learning Cycle. The second additional stage is Extend. The 7E model does not include the Express stage as described in Duran et al. (2011). The Extend stage students continue to apply the principals that they learned to new content. This could be a time to address any

lingering misconceptions from the Evaluate stage. This can help students extend to applications they may be interested in or related to everyday life (Balta & Sarac, 2016).

The 9E Learning Cycle was developed by Kavur and Gakar in 2014. The stages of the 9E Learning Cycle used in this study include Elicit, Engage, Explore, Explain, Echo, Elaborate, Evaluate, Emend and E-search (Nicol et al., 2020). The Echo, Emend, and E-search stages have not yet been used in the other instructional models. The Elicit stage is the same as mentioned in the 7E Instructional Model. E-search is presented at the center of this learning model encouraging electronic searching at each of the eight other stage s of the model. The Echo stage promotes further practice by learners in addition to the Elaborate stage. This allows for more applications for students after the Explain stage. The Emend stage is similar to the Extend stage in the 7E. It gives the instructor a chance to go back and correct any last misconceptions that students may have after the Evaluate stage.

The Learning Cycles are effective at engaging students (Çakır, 2017). 5E, 6E (Figure 2), 7E, or 9E learning cycles are generally found to improve engagement, confidence, and academic achievement. There is overlap and similarities between the 5E, 6E, 7E and 9E Learning Models. Studies such as Nicol et al. (2020) explored the effectiveness of 3E, 5E, 7E, and 9E Learning Cycles.

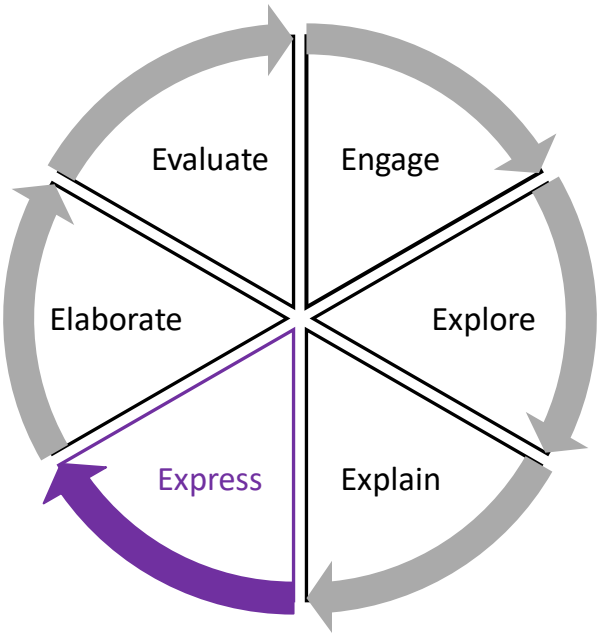

Figure 2. The 6E learning model. The Express stage is added between the Explain and Elaborate stages.

Strategies for Teaching Using the 5E Instructional Models

One major benefit and challenge of the 5E Learning Model is that there is a lot of flexibility between the five E's listed: Engage, Explore, Explain, Extend, and Evaluate. There are a multitude of already prepared 5E instructional tools and lessons online that are available both free and paid for teachers. It is always fun to be able to create one's own lessons and curricula as well. There are also multiple points to be able to add formative or summative assessments between stages or to repeat stages where students struggle. One issue with this in doing two 5E units is the difficulty in assessing how students feel about 5E in general or the specific labs, assignments and projects that I choose in my 5E unit. I chose tasks that most interested me, and I thought would be engaging for the students at the various stages of the cycles. I also tried to stay away from doing the same types of activities between the different stages so the students could

more easily evaluate which stage of the 5E Learning Model they enjoyed and connected with the most.

Examples of Engage tasks include asking a question, showing a discrepant event (live or by video), or acting out a situation (Bybee et al., 2006). Examples of Explore activities include worksheets or labs that include problem solving, research activities, and activities that include visual, auditory, and/or kinesthetic components. My students prefer manipulating and exploring kinesthetically, but can become frustrated at this stage because there is usually no formal teaching until the Explain stage. Some students prefer to be able to know or find an answer rather to explore and ask questions. Vocabulary terms and concepts are shared at the Explain stage to bring common language from the Explore stage. Students should be encouraged to explain concepts and definitions in their own words using their new learned vocabulary. The goal is for connections to be made between the students' prior knowledge, the previous class activities, and the definitions from class. The Elaborate stage of the learning cycle can include role playing, different methods of applying their knowledge, and creating conclusions or reports. It's valuable at this stage to extend the students' knowledge and connect content to their daily lives to increase student engagement. The final stage is Evaluate where students can use the skills they learned and receive feedback from their instructors. Examples of evaluate tasks include teacher, self, and peer assessment, lab practicals, a learning journal, mind maps, and target setting.

Teachers can use so many different tools and activities to utilize the 5E Learning Model. This creates a lot of variation in methodology and measuring success. In my study, the two 5E lessons are both taught in the earth science unit to decrease some of the variability in results. The

methodology section will dive more into how I conducted the study and how success can be determined.

Educator Impact

Learning Cycles can improve and change teacher's belief systems (Glasson, 1993). It is important to teach students using the method, but also can be very valuable to help teachers learn about and experience a Learning Cycle for themselves. Kazempour et al. (2020) explored the effects of immersive teaching the 5E learning Cycle for pre-service teachers. This helps to address misconceptions that teachers may have about the process and stages of the learning cycle. The stages can easily blend into one another and overlap. Learning cycles including the 5E Instructional Model can also improve instruction design process of novice teachers throughout their careers (Hu et al., 2017).

The evidence points to 5E-based learning cycles improving student engagement, attitude, and sometimes academic achievement. I have decided to focus on the 5E Learning Model. The students will share which stage: Engage, Explore, Explain, Elaborate, or Evaluate was most interesting to them. In addition to tracking the impact of the 5E Learning Cycle on my 7th grade students, I am also curious to see its impacts on me for planning, formative assessments, grading, and my overall workflow.

METHODOLOGY

The study's goal is to see the effects of the 5E and 6E learning models on academic achievement and attitude in the 7th grade science classroom. Secondary questions include: 1. How will the 5E model influence academic achievement? 2. How do 5E lessons impact attitude and engagement?, and 3. Which E's do students feel are most impactful?

The capstone project was conducted at Providence Day School. The research methodology received an exemption from Montana State University's Institutional Review Board and compliance for working with human subjects (Appendix A). Two units in earth science were implemented with the 5E Learning Cycle. Originally two units in nature of light were with the 6E Learning Cycle. However, due to my family's out of state move, I was not able to do any 6E testing on my classes.

Demographics and Treatment

The purpose of this study was to determine the effects of the 5E learning cycle on engagement, confidence, and academic achievement in a seventh grade science class. At Providence Day School tuition for 6^{th}-12^{th} graders in 2021 was ~$30,000 a year. There was no free or reduced lunch program, but there was need-based tuition assistance. Most students go from the middle school to the Providence Day High School. 100% of PDS high school students attend four-year colleges and universities.

Students from four seventh grade science classes out of eight seventh grade science classes participated in the study. The other four seventh grade classes received traditional teaching from my co-teacher. The study covered two science units. The first class had 20

students, second class had 20 students, the third class had 19 students, and the fourth class had 20 students. Each class had the opportunity to learn through the 5E Learning Cycle. The stages of the 5E Learning Cycle used in this study include Engage, Explore, Explain, Elaborate, and Evaluate (Bybee et al., 2006). Each class did the two units in the same order.

Two units were created with the 5E Learning Cycle and two units were originally created with the 6E Learning Cycle. The initial goal was to compare the two different Learning Models and see if there was a difference in student academic achievement and attitude. Unfortunately, I had to move half-way through the school year and was not able to run the units with 6E Learning Cycle/Model. Students in each of the four classes were able to experience the 5E Learning Cycle through the same material.

Data Collection and Analysis Strategies

The Data Triangulation Matrix (Table 1) includes a summary of the research questions and data sources.

Table 1. Data Triangulation Matrix.

Focus Questions	**Data Source 1**	**Data Source 2**	**Data Source 3**
How will the 5E model influence academic achievement?	Pre-and Post-Treatment Assessment	Unit Grades	Teacher Observations
How do 5E lessons impact attitude and engagement?	Pre- and Post-Treatment Surveys	Student Interviews	Teacher Observations
Which E's do students feel are most impactful?	Pre- and Post-Treatment Surveys	Student Interviews	Teacher Observations

Prior to any of the four treatments, all students were administered a Likert survey (Appendix B), regarding student attitude and engagement, and a pre-assessment. These were the same across all four classes. The surveys were sent via Google Forms, so I could easily aggregate and analyze the responses. The attitude surveys asked about student's confidence, excitement, and comments. The surveys asked about the students' perceptions of the different E stages and which stages they thought would be most valuable to them. The original idea was to use normalized gains to see each students' perceptions along the way; however due to COVID, various absences, and student make-ups after I had left the school, I analyzed the data using basic statistical methods and created box and whisker plots for each class.

Some students in each class were also be interviewed to get a better picture of the survey, attitude, and assessment results. This was done randomly after each unit. Three to six students were randomly chosen for the group interviews. All the interviews were collated for a qualitative overview of the results. The interview questions (Appendix C) look at student preferences, how science compares to other classes, how students prioritize work, confidence, how and what motivates them, and how students have and are engaging in science. Patterns were recorded for the attitude scales, surveys, and interviews through basic statistical averaging methods. Throughout the classes and process, teacher notes were taken to also assess engagement across the units and through each stage of the 'E' learning stages. The results of the pre-assessment and post-assessment were analyzed using bar graphs. Mode and percentiles of improvement were also used for analysis. Each pre-and post-treatment survey was stored and organized in Google Sheets. Each of the four classes had their own tab in a Google Sheet for each pre-and post-test. I

found the averages, modes, and percentiles for each class. I compared the data from the different classes.

In all the treatments, a test was administered to all students before and after each unit to measure how the students comprehended the material. The exam consisted of overarching big picture questions to show that the students have grasped the main content. The results were analyzed using various basic statistical methods, mean, median, mode, and box and whisker plots.

Once each unit was completed, all students would complete a survey (Appendix D), attitude scale, and post assessment. I also made observations after each class for the two units and made sure to reflect on the unit as a w hole for each class. Some students in each class would also be interviewed to get a better picture of the survey, attitude, and assessment results. Patterns were recorded for the attitude scales, surveys, and interviews. Notes were taken from the interviews. Common phrases and responses were extracted. The results of the study were shared with the Middle School Science Department, the Science Department Head, Doug Burgess, and the Head of Middle School at Providence Day School, Lee Tappy. The thesis can also be found in Montana State University's database. The study is shared electronically and may be presented at educational conferences in the future.

DATA AND ANALYSIS

Table 1 includes a summary of the research questions and data sources used for this study. Before each unit a pre-treatment assessment (Appendix C & Appendix D) and pre-treatment survey with both Likert and short answer questions (Appendix B) were administered. An earthquake unit and a volcano unit were taught with the 5E Learning Method. At the end of each unit a post-treatment assessment which was the same as the pre-treatment assessment was administered (Appendix C & D), a post-treatment survey with both Likert and short answer questions (Appendix B), a post-treatment Likert survey about preferences for the 5E's (Appendix E), and random small group interview questions (Appendix F) were given.

Results

Prior to any of the four treatments, all students were administered a Likert survey (Appendix B), regarding student attitude and engagement, and a pre-assessment (Appendix C and Appendix D). These were the same across all four classes. The earthquake pre- and post-treatment assessment can be found in Appendix C. The assessments were exactly the same, just given at different times. Figure 3 shows the results of the pre-treatment assessment (N=74) and post-treatment assessment (N=63). The results show that the students did learn after this unit.

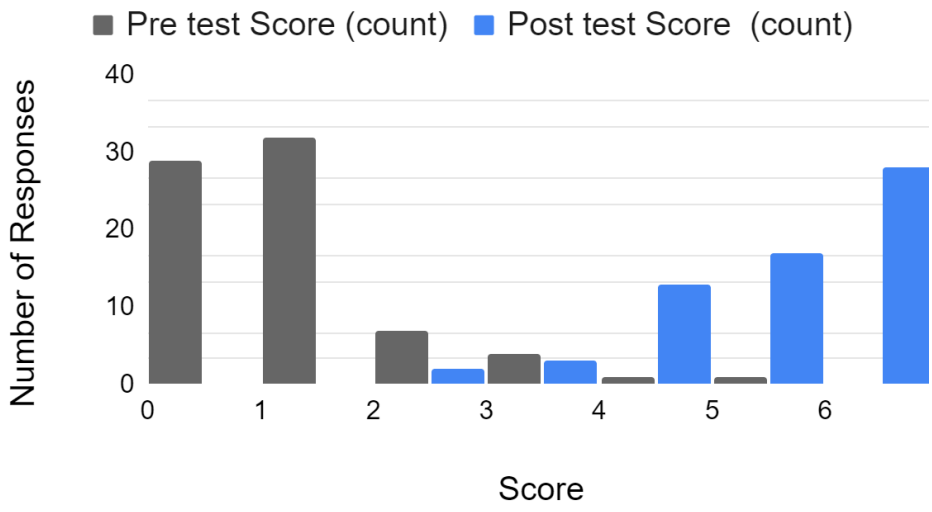

Figure 3. Earthquake unit assessment results. Earthquake 5E unit pre-unit (gray) and post-unit (blue) test results. The students answered six questions before and after learning unit content.

The volcano pre- and post-treatment assessment can be found in Appendix D. Figure 4 shows the results of the pre-treatment assessment (*N*=70) and post-treatment assessment (*N*=73). The assessments were exactly the same, just given at different times. The surveys were sent via Google Forms, so I could easily aggregate and analyze the responses.

The results from Figure 4 show that the students did learn after each unit. The data was aggregated to support how the 5E model may influence academic achievement. Looking through the results, I'm not sure if I can conclusively say that the students better learned the data because of the 5E Learning Model, but I am happy to say that most of the students picked up the big picture topics and ideas that we covered in each unit. Because I was initially going to compare 5E to 6E learning, the data might have found one led to better retaining of the content. However, the other four 7th grade science classes that underwent traditional teaching also picked up the major concepts from their test results and my observations of their classes. The students took in big picture ideas, but not necessarily because of the 5E Learning Model.

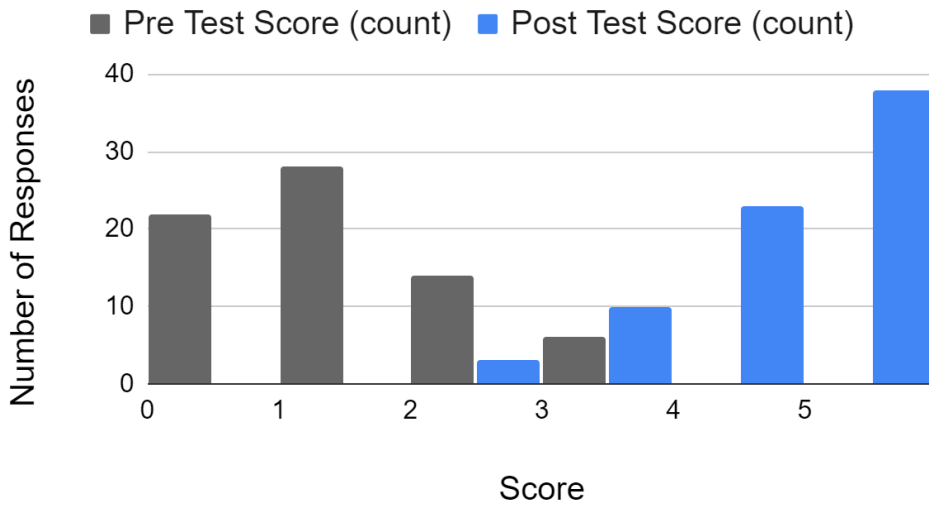

Figure 4. Volcano unit assessment results. Volcano 5E unit pre-unit (gray) and post-unit (blue) test results. The students answered five questions before and after learning unit content.

To assess academic achievement I also reviewed student scores over the first five units of the school year (the first half of the year that I taught at Providence Day School). The first three units were taught with traditional teaching methods following the material provided by my co-teacher. The last two units were the 5E units that I created from my co-teacher's notes. I was able to get the student averages for the first half of the year and the second half of the year as well. I did teach a small part of second semester, but another teacher took over after I moved back to Massachusetts. I used box and whisker plots to show unit test data and semester averages for each of my four classes as seen in Figure 5. All four classes did the best on their last assessment, the second 5E unit on volcanoes, and the worst on their fourth assessment, the first 5E unit on earthquakes. Each class also varied in their overall performance for each test. Period 2 was my most challenging class behaviorally. They were my lowest performing class. Their average for the first 5E test was 80% and 92.6% for the second 5E test. The test ranges varied for most of my four classes. Period 6 was the only class that I saw every day of our 6 day rotation. This gave

them a bit of an edge with respect to time on material and repetition, but it was also right after lunch and recess which led to some challenges staying focused. Their average for the first 5E test was 87% and 98.7% for the second 5E test. The other three classes had one drop period. Periods 7 and 8 were most similar in performance and trends, although Period 7 was my highest performing class of the four classes. Period 7's averages were 88.8% for the first 5E test and 98.2% for the second 5E test. Period 8's averages were 83.4% for the first 5E test and 96.6% for the second 5E test.

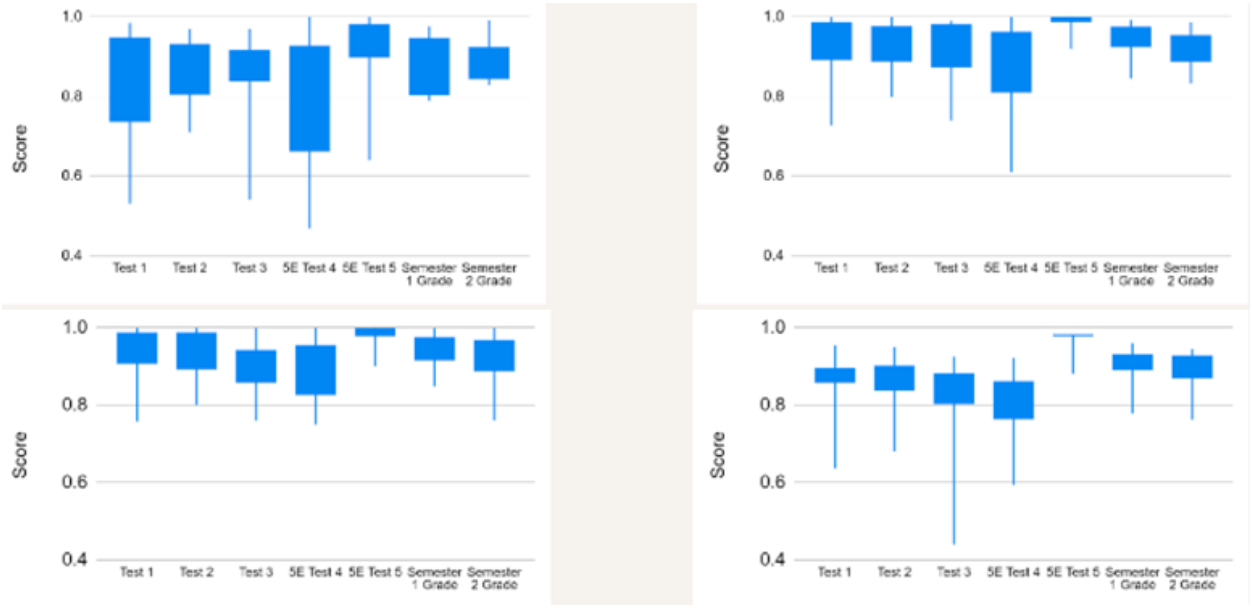

Figure 5. Semester one test scores and averages. Period 2 (top left), Period 6 (top right), Period 7 (bottom left), and Period 8 (bottom right) each had five unit exams in the first semester. Each student's grades at the end of the semester were also averaged. The first three tests were given after traditional teaching. The fourth and fifth tests were given after 5E Learning Model units. The second semester grades consisted of traditional teaching and labs by a new teacher.

The students may have needed more lead-up time to be introduced to the new 5E learning Model because the 5E earthquake unit was one of the worst test of the semester (both largest

range and lowest average). There was some harder content in the last three units (the first two units were easier as we were returning from hybrid learning to full-time learning and no longer allowed online schooling) which may have contributed to the trends seen. There is no conclusive data with respect to the 5E Learning Model with respect to test scores.

Student grades mostly stayed consistent with how they were doing from the beginning of the year. As we got closer to winter break the students were definitely a little more distracted in class, too, which may have led to the variation. Students were also studying for semester 1 finals as they took the last test, so they may have done better since it there was a lot of review taking place the last few weeks of school before winter break.

Another trend seen in the data was that the range of grades was generally smaller in the first semester when I taught. This may have been due to the 5E Learning Model or just because the students had an easier first two units compared to second semester. The average grades in first semester were also higher than that of second semester. All in all, there was no conclusive evidence from this study that the 5E Learning Model improved academic achievement. More testing and possibly more explanation and practice would be needed to draw more conclusive data.

The pre- and post-treatment surveys asked about student's confidence, excitement, and comments to see how the 5E learning Model impacted student attitude and engagement in science class. Some students in each class were also be interviewed to get a better picture of the survey, attitude, and assessment results. All the interviews were collated for a qualitative overview of the results. Throughout the classes and process, teacher notes were taken to also assess engagement across the units and through each stage of the 'E' learning stages. Mode and

percentiles of improvement were also used for analysis. Each pre-and post-treatment survey was stored in Google sheets. After performing basic statistical analysis around normalized gains, mean, median, and mode. I found that the Likert Survey did not provide much valuable content from the students (and normalized gains brought my responses to 40-50 student from 60+ because some students look the pre-treatment survey and some only the post-treatment). I compared the data from the different classes. I also combined all of the class data. As mentioned earlier I also had a hard time keeping track of students and surveys as they were not mandatory and there was a lot of interruption due to COVID. The qualitative observations, short answers, and led to more valuable information and conversations around attitude and engagement.

One takeaway from the qualitative data was that students underwent survey fatigue in my class and I believe that most of them just did the best they could to fill out the surveys as quickly as they could since there were so many before and after each unit. The time after the first unit and before the second unit I heard the most moans and groans regarding the surveys.

Through the short answer questions in the surveys and student interviews I could draw 4 conclusions on student interest in science, unit motivation, unit engagement, and unit interest. First, students showed more interest and participation in science class during our 5E lesson plans. There may have been a little more frustration in the Explore phase, but it made the students more curious. One student said, "The way you teach makes the unit interesting and makes me more motivated." Another student said, "I was motivated but it was hard because I also had other Exams to study for so it was hard to balance things." Both these students showed increased interest and also reminded me how other classes and the many activities outside of my classroom could have also affected the grades, attitude, and interest in my science classroom.

Next, most student enjoyed the actual topics and variation of activities compared to the first three units. One student said, “I was very motivated because it was a fun unit.” Another student said “I pay attention more when I like [the content] more.” Some students did not engage as much with the units: “I wasn’t interested in volcanoes that much because volcanoes don’t happen near here.” However, in a high-achieving private school, one cannot forget the importance of grades. One student said, “I’d like to know more about earthquakes and I want to get good grades so that is making me motivated.” Many students wrote similar responses to this student: “Grades motivate me 1000%.” Grades were consistently the highest Likert score and short answer motivator for students throughout all surveys.

Lastly, I observed that overall with the 5E units students were less distracted and tired in class. Even if they did not always find interest in the content, the classes were engaged. Something that could easily flip that was time of day or the last class on a Friday afternoon. The students are still kids! One last note that I wanted to include was from a student that may have had survey fatigue, but still liked the check-in after each unit. The student said "...but I appreciate how you took our suggestions for class.” I think an important part of the study and 5E content for me was seeing what worked and how the students were taking the new learning model format. They could see that I was trying to improve their experience and wanting to know their opinion. Many students appreciated having a voice in the class.

The results of the Likert survey (Appendix E) showed that the students did not understand exactly what all of the E's were about. It was partly my fault. While students were taking some of the surveys, I would hear whispering and some would ask me what Engage, Explore, or any of the other E's meant and when we did them. Through my own observations I

think that the students got the most from the engage and explore stages. I had all of their undivided attention for at least five minutes or more when we were doing lab activities, watching videos, or watching demos. It was a large contrast to the way the other teacher introduced topics and ideas before lab activities. Some students that I didn't teach shared with me that science class felt dry or boring and quiet in their classes.

Although the quantitative data did not support some of my claims, through the qualitative short answer questions and interviews with students I found that the 5E Learning Model improved overall student attitude and engagement in science. There was no conclusive evidence for the 5E learning Model and academic achievement through this study.

CLAIM EVIDENCE AND REASONING

Claims From the Study

The study demonstrated that student attitude and engagement towards science was impacted positively using the 5E Learning Model over traditional teaching. There was no conclusive evidence on the influence of 5E Learning Model on academic achievement. The inquiry-based 5E Learning Model was different than what students were used to, but kept them attentive in class. Through class observations I noticed that behavioral problems went down in all classes throughout the study. This showed that the students were more engaged in class activities. Students were able to address some misconceptions on their own and reflect on their interests, motivations, and learning styles in class especially during the Engage and Explore stages of the learning model. I could see more student interaction through class and group participation from students that did not participate at the beginning of the year. Student attitude and engagement in science increased during the 5E Learning Model units as described in short answer survey questions and in student interviews post-treatment. Students especially enjoyed the variation in activities, less note-taking, and less lecture. Many shared they science was more fun. It improved both their attitudes and mine. Starting new units or ideas with inquiry brought curiosity and wonder back to the middle schoolers. It gave students the space to think on their own, address misconceptions, learn new content, relate the content to something they were familiar with, and then be assessed on the content. Students overall improved their attitudes and engagement in their 7th grade science classes when using the 5E Learning Model.

Value of the Study and Consideration for Future Research

The goal of this Action Research project was to compare the 5E and traditional learning models and how they influence students' attitude towards science. My focus question centers on the effects of the 5E Learning Models on academic achievement and attitude in the middle school classroom, particularly my 7th grade science classroom. I found that it did influence student attitude and engagement in the four classes that I taught. In middle school, I think it's important to keep doors open to make sure students feel inclined to develop their curiosity towards science and the world around them. Keeping their attitudes neutral to positive is important to keep them engaged in science through their high school experiences as well.

Although there was no conclusive evidence with respect to the 5E Learning Model and academic achievement, I believe part of that was the way I needed to rush through my Action Research project. If I had more time and was able to stick to my original Action Research plan, students would have had a better grasp of the 5E Learning Model before being immersed in it. They would have also had the opportunity to try a 6E Learning model.

In the future, I would like to spend more time explaining to students the 5E Learning Model and be more explicit for each section. I would also do more units with the 5E Learning Model. I would try to decrease the amount of variability in my 5E lessons by sticking to similar tasks for each "E" instead of doing what I thought provided the most interesting content for the students to better standardize student results. In the future I would also whittle down the number of survey and Likert questions in pre- and post-treatment surveys. It was overwhelming for me to parse through and also for the students to fill-out. I would keep it to no more than ten questions

at once. I learned a lot from this formal approach to action research and see myself doing a lot more of it in my classroom.

Impact of Action Research on the Author

The whole MSSE experience has been such a blessing for me. I have learned so much and my confidence as an educator and a learner has increased substantially. I really had no idea what I was doing in a classroom my first year teaching. Now that I know more about inquiry-based learning, both the students and I are more engaged in the content that we need to cover. I will continue to implement the 5E Learning Model and other inquiry-based models in my classroom.

I think for me to not see the expected trends in student achievement was also important for me as a teacher and a learner. My procedure and ideas didn't work out as planned, but I am ready to try, try again. There were some trends seen, but further testing and comparison is needed. There were some personal circumstances that may have influenced these results as well. Either way it makes me more motivated to rethink procedures and try again to see if there can be an impact.

Through this action research project I learned a lot about my students. I was able to see how their attitudes changed, to get feedback on my lessons frequently, and to have conversations with them about their learning. It made them realize that I wanted to hear their voices and would actually take their suggestions in the classroom. It built more students trust and strengthened relationships, which was a result that I did not expect. I plan to continue this in the future so that students feel that my classroom is a safe space that is focused to help their learning.

I learned that interest in the subject matter influenced student attitude and engagement. I also learned that for some even if the interest wasn't there, grades will always be a big motivator, especially since I am in the private school space. It was disheartening to see how strongly students agreed on this point. In the future I would also like to look into how we can get students to focus on learning and understanding more than grades. I also learned that there are some days you cannot control student engagement- especially the last class of the day on Friday or before a break. Time of day can be a big factor in student engagement and content retention.

For myself, I gained a lot knowledge and organizational tools with the help of the 5E Learning Model. It was hard to learn a new curriculum that I was teaching at the same time as adapting a new learning method to teach it. However, as I did more planning, the 5E Learning Model helped me organize my lessons and content in a way that was more efficient and a better workflow for me personally. It also helped with backwards planning, I've always had a hard time with that scrambling to make a test and make sure I've taught all of the important big picture topics as we neared the end of a unit. I also had to take a breath a lot of the time and go with the flow. I had to give myself more grace than usual with COVID, COVID protocols, moving and leaving my school shortly after the first semester. It was hard to do all of the planning and research to end up only doing half of my intended action research project. Teachers make so many decisions about their classrooms in a day, but sometimes it felt unbearable how many times I needed to pivot. All in all, these experiences helped me feel and act like an educator ever when times got tough. My goals are to continue this work at my next school and to continue to grow and teach as a life-long learner.

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APPENDICES

APPENDIX A

INSTITUTIONAL REVIEW BOARD EXEMPTION APPROVAL

MONTANA STATE UNIVERSITY
Request for Designation of Research as Exempt
MSSE Research Projects Only
(6/16/14)

THIS AREA IS FOR INSTITUTIONAL REVIEW BOARD USE ONLY. DO NOT WRITE IN THIS AREA.
Confirmation Date: 12/21/21 Mark J. Quinn
Application Number:

DATE of SUBMISSION: November 29, 2021

-Okay as exempt
-MSSE Classroom assessment
-Little/no risk
-Head of School approved
-No concerns
MQ 12/21/21

Address each section – do not leave any section blank.

I. INVESTIGATOR:

Name: **Katy Zavesky**
Home or School Mailing Address: **7727 Calhoun St. Apt. 3108, Charlotte, North Carolina, 28216**
Telephone Number: **973-489-4140**
E-Mail Address: **zavesky.katy@gmail.com**
DATE TRAINING COMPLETED: **18-Feb-2021** *(Required training: CITI training; see website for link)*

Investigator Signature **Katy Zavesky**

Name of Project Advisor: **Marcie Reuer**
E-Mail Address of Project Advisor: **marcie.reuer@ecat1.montana.edu**

II. TITLE OF RESEARCH PROJECT: **5E and 6E Instruction in the Middle School Classroom**

III. BRIEF DESCRIPTION OF RESEARCH METHODS (If using a survey/questionnaire, provide a copy).
I will be incorporating pre and post-unit surveys, pre and post unit knowledge checks, and post unit interviews into the curriculum. These surveys will gauge student engagement, motivation, and preference for the 5E and 6E instructional model.

IV. RISKS AND INCONVENIENCES TO SUBJECTS **(do not answer 'None'): Surveys and interviews, as will be used in this project, carry no risk to students. The students may feel more challenged by the tasks and activities, but the activities fall under normal classroom experiences. There will be additional class time spent on surveys and interviews as well throughout the process of data collection.**

V. SUBJECTS:

A. Expected numbers of subjects: **79**

B. Will research involve minors (age <18 years)? **Yes**
(If 'Yes', please specify and justify.)
Research will involve 4 classes of 7th grade students between the ages of 12-14 that I will be instructing.

C. Will research involve prisoners? **No**

D. Will research involve any specific ethnic, racial, religious, etc. groups of people? (If 'Yes', please specify and justify.) **No**

VI. FOR RESEARCH INVOLVING SURVEYS OR QUESTIONNAIRES:
(Be sure to indicate on each instrument, survey or questionnaire that participation is voluntary.)

A. Is information being collected about:

Sexual behavior?	**No**
Criminal behavior?	**No**
Alcohol or substance abuse?	**No**
Matters affecting employment?	**No**
Matters relating to civil litigation?	**No**

B. Will the information obtained be completely anonymous, with no identifying information linked to the responding subjects? **No**

C. If identifying information will be linked to the responding subjects, how will the subjects be identified? (Please circle or bold your answers)

By name	**No**
By code	**Yes**
By other identifying information	**No**

D. Does this survey utilize a standardized and/or validated survey tool/questionnaire? **(If yes, see IRB website for <u>required wording</u> on surveys and questionnaires.)** **Yes**

VII. FOR RESEARCH BEING CONDUCTED IN A CLASSROOM SETTING INVOLVING NORMAL EDUCATIONAL PRACTICES:

A. This research project must be approved by your Principal or School Administrator, unless there are circumstances or policies that do not make this possible. **Provide a copy of the principal's signed approval.** If such approval is not possible, please explain.

B. **Participation of your students in research must be voluntary** and can never affect their rights. Please make this issue clear on all of your research surveys (use introductory text, see below) and/or interviews (use introductory verbal statement, see below). The following wording or something similar can be used for the introductory text or statement: **Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.**

C. Extra credit should not be used to encourage participation. If you absolutely need to use extra credit, then an alternative activity involving the same amount of time and effort must be provided for those who choose not to participate. This must be clearly described in your IRB application.

E. Depending on your school policies, **consent forms may or may not be required for your research.** Please indicate whether you will be using consent forms or not. If you are not using consent forms, please justify (e.g., school policy, etc.). **If you do use consent forms, you must include signature lines for parental consent AND student assent.** (Please use accepted format from our website and provide a stand-alone copy. Do not include form here.)

Since participation is voluntary and grades will not be affected, my school administrators have approved my research and do not require consent forms.

APPENDIX B

PRE- AND POST-TREATMENT SURVEY

Science 7 Pre and Post Unit Survey

Please answer the questions below. Participation in this survey is voluntary and participation or non-participation will not affect your grades or standing in class in any way.

Section 1 is adapted from the Science Motivation Questionnaire II © 2011 Shawn M. Glynn. [Glynn, S. M., Brickman, P., Armstrong, N., & Taasoobshirazi, G. (2011). Science Motivation Questionnaire II: Validation with science majors and nonscience majors. Journal of Research in Science Teaching, 48, 1159-1176.]

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The science we learn(ed) in this unit is relevant to me	☐	☐	☐	☐	☐
Learning science is interesting to me	☐	☐	☐	☐	☐
Getting a good science grade is important to me	☐	☐	☐	☐	☐
I put enough effort into learning science	☐	☐	☐	☐	☐
I am confident I will do well on science tests	☐	☐	☐	☐	☐
Understanding science will benefit my career goals	☐	☐	☐	☐	☐
I believe I can master science knowledge and skills	☐	☐	☐	☐	☐
I prepare well for science tests and projects	☐	☐	☐	☐	☐
I will enjoy/enjoyed this science unit	☐	☐	☐	☐	☐

Please answer the questions below. Participation in this survey is voluntary and participation or non-participation will not affect your grades or standing in class in any way.

Reflection

How motivated are you/were you to do well for this unit? *

	1	2	3	4	5	
Not Interested At All	○	○	○	○	○	Extremely Interested

Why was that your level of motivation? What would make you more motivated in class? *

Your answer

How interested are you/were you in the content of this unit? *

	1	2	3	4	5	
Not Interested At All	○	○	○	○	○	Extremely Interested

Why is/was that your level of interest? What would've made you more interested? *

Your answer

Why will you or will you not change any of your note-taking or study habits as we move into our next unit? *

Your answer

Do you have any suggestions for Mrs. Z? *

Your answer

APPENDIX C

PRE- AND POST-UNIT EARTHQUAKE ASSESSMENT

Where do earthquakes happen and why? *

Your answer

What are two or more things you should do if an earthquake is happening? *

Your answer

What are the three types of plate boundaries? *

Your answer

How do we know about the earth's core and layers? *

Your answer

What are the 3 main layers of the earth? *

Your answer

How do we measure earthquakes? *

Your answer

APPENDIX D

PRE- AND POST-UNIT EARTHQUAKE ASSESSMENT

How can you be prepared for a volcano? *

Your answer

Why can earthquakes and volcanoes be found in the same areas? *

Your answer

Is magma found above or below ground? What about lava? *

Your answer

What are the parts of a volcano that you know? *

Your answer

What are the different types of volcanoes? *

Your answer

APPENDIX E

5E AND 6E PREFERENCE SURVEY

Science 7 Pre and Post Unit Survey

Please answer the questions below. Participation in this survey is voluntary and participation or non-participation will not affect your grades or standing in class in any way.

Section 1 is adapted from the Science Motivation Questionnaire II © 2011 Shawn M. Glynn. [Glynn, S. M., Brickman, P., Armstrong, N., & Taasoobshirazi, G. (2011). Science Motivation Questionnaire II: Validation with science majors and nonscience majors. Journal of Research in Science Teaching, 48, 1159-1176.]

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The science we learn(ed) in this unit is relevant to me	☐	☐	☐	☐	☐
Learning science is interesting to me	☐	☐	☐	☐	☐
Getting a good science grade is important to me	☐	☐	☐	☐	☐
I put enough effort into learning science	☐	☐	☐	☐	☐
I am confident I will do well on science tests	☐	☐	☐	☐	☐
Understanding science will benefit my career goals	☐	☐	☐	☐	☐
I believe I can master science knowledge and skills	☐	☐	☐	☐	☐
I prepare well for science tests and projects	☐	☐	☐	☐	☐
I will enjoy/enjoyed this science unit	☐	☐	☐	☐	☐

APPENDIX F

INTERVIEW QUESTIONS

Interview Questions:

Please answer the questions below. Participation in this survey is voluntary and participation or non-participation will not affect your grades or standing in class in any way.

1. How did you feel about science in the beginning of the year and how do you feel about science now? [Or at the beginning of the unit vs now for post-test]

2. Which classes do you prioritize the most?

    Follow-ons: Where do you prioritize science and why do you think you prioritize it there?

3. How do you prioritize your science work (assignments, tests, projects)?

4. How confident do you feel in science?

    Probes: What helps you feel more confident? What can make you feel less confident?

5. Can you tell me about your level of motivation in science class?

    Probes: What does motivation mean to you? Do you want to change your level of motivation?

6. Can you tell me about your interest in science class?

    Probes: What about your interest in this unit? What would be more interesting to you?

---

7. What do you think about the new 5E/6E units?

8. Which "E" do you like the most?

    Follow-ons: Why do you think that is? Which "E" helps you understand the concepts the best? Which "E" keeps your interest the most?