

THE 5E INSTRUCTIONAL METHOD IN HIGH SCHOOL

by

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A thesis submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Science Education

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Bozeman, Montana

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DEDICATION

I dedicate this capstone paper to my family. Their encouragement and support has helped me to persevere. I dedicate it specifically to my children, Trenton and Keaton, who endured many hours of me working on or discussing my capstone work, and my niece, Madilyne Kane, who so graciously edited my paper.

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ABSTRACT

This research addressed the question of whether the 5E Instructional Method improves test scores in the science classroom. Students were given a pretest and a posttest for both a nontreatment and treatment unit. The results of those tests were compared. This research did not show a significant difference in tests scores between nontreatment and treatment units. The 5E Instructional Method was a beneficial teaching method because it increased student attitude and engagement, even though it was not found to increase test scores in this situation.

INTRODUCTION AND BACKGROUND

Context of the Study

Mosinee School District has one elementary school, one middle school, and one high school. It is located in central Wisconsin, a rural, small town area. Mosinee High School has about 600 students; with approximately 150 per grade. We are a small school setting with the opportunities that would be provided by a larger school, such as offering the same number of advanced placement and dual credit courses as larger schools in the area. Our population is approximately 94% Caucasian, with a 6% minority population, having only two English Language Learners in the high school. Most of the students come from middle class families, only 22% of our students are considered economically disadvantaged (wisedash.dpi.wi.gov, 2019).

The Earth and Space Science class that I teach has been 75% male students and 25% female students in previous years. These classes are a mix of sophomores, juniors, and seniors, the classes may also include students from other self-contained areas, such as cognitively disabled and severe emotional, behavioral disordered students. Many of these students dislike science classes or have struggled with their confidence regarding their ability to perform well in science related activities. The class normally has a higher than average learning disabled population. Historically this class has used mostly lectures and other traditional learning methods, but I began to wonder if the students in my class might benefit from other techniques that allowed for more student engagement. Those thoughts lead me to the development of my research question.

The Study Focus Question

The focus question for this study was, What effect does the 5E Instructional Method have in the high school? Going through the Masters of Science in Science Education (MSSE) program I became familiar with the 5E Instructional Method, which includes five specific phases: engagement, exploration, explanation, elaboration, and evaluation. I was drawn to this model because it incorporates other learning techniques such as using phenomena during the engagement phase which could provide the hook to get students interested in learning about a new concept. This method also includes much more engagement of students in their own learning process, which should improve the students' success.

CONCEPTUAL FRAMEWORK

Background

Traditional teaching methods have a lot of sit and get; teachers tell students facts which they must memorize for a test. However, this is not how science is done outside of the classroom. Scientists are looking for answers to questions about the natural world through experimentation; not just memorizing facts. If teachers want to inspire students to be scientists, they need to allow them engage in scientific learning in the same manner that scientists do (Sen, 2016). One teaching strategy that allows students to develop ideas by engaging in science learning is the 5E Instructional Method.

The 5E Instructional Method

The 5E Instructional Method was developed by Biological Sciences Curriculum Study (BSCS) during a teacher retreat, in Colorado, in 1987. Many teachers think that the 5E Instructional Method is a new idea but earlier versions were labeled as constructivist which is an application of John Dewey's concept of a complete idea of thought (Bybee et al., 2006). Constructivist teaching strategies help students construct their knowledge through relevant experience (Cakir, 2017). The 5E Instructional Method has five specific phases which are engagement, exploration, explanation, elaboration, and evaluation (BSCS, para. 7).

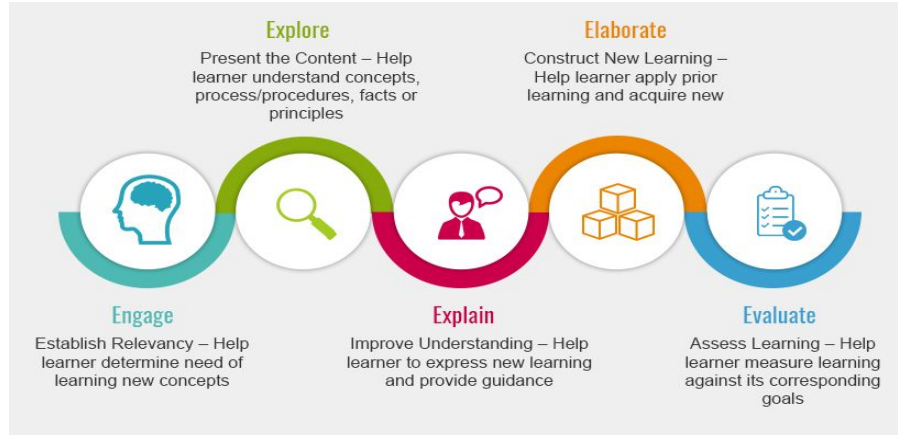


Figure 1. 5E instructional method flow diagram from <https://www.swiftelearningservices.com/5e-instructional-model-for-elearning-a-model-preferred-by-nasa/>

These steps illustrate what should happen during each stage and how to achieve the desired outcome. The engagement stage should allow students to recall prior knowledge they have on a topic and engage the student with an activity or phenomenon. During the exploration stage, students should be involved in activities that allow them to identify their misconceptions, develop skills and allow the ideas they had held about the topic to change. During the explanation phase, the teacher can present concepts or skills, and more importantly students can demonstrate the understanding they gained from the previous steps through discussion. Elaboration allows students to take their understanding a step further and extend what they already know and have learned by applying their knowledge, demonstrating understanding of their learning up to this point with new facts or skills.

Reasons to Use the 5E Instructional Method

Students in the classroom are often concerned with their test scores, they want to get a good grade. The 5E Instructional Method can help to improve test scores, and it does so by purposefully engaging students in the lesson. This is a student-centered method in which students can take what they already know and enhance those ideas, instead of feeling as though they are starting from

scratch and becoming overwhelmed (Sickel, 2012). The 5E Instructional Method emphasizes students' understanding of concepts as opposed to students merely memorizing facts that they can now quickly and easily find on the internet (Lara-Alecio, 2018). Using student-centered activities allows for meaningful learning which leads to permanent learning, benefiting the students in their long term educational and career goals as opposed to the short-term goals of brief, rote memorization (Seker, 2017).

One of the issues that can often inhibit students from learning new material is conceptual errors from previous experiences. Students will hold tightly to these ill-informed ideas, refusing to grasp the new ideas (Seker, 2017). When using the 5E Instructional Method students are able to confront their misconceptions and develop new ideas through their own personal experiences and classroom guided activities. The use of student-centered activities that allow for personal engagement and individual discovery of information increases the motivation of students, along with building their problem solving skills and overall learning. As motivation increases students become more actively curious and their conceptual understanding increases, allowing them to make connections (Sen, 2016).

With standardized test scores being used to evaluate the merit of schools and school districts in many parts of the country, those who work in education always have to be concerned with the connection of methodologies and test scores. There is evidence to show that students who learn according to the 5E Instructional Method perform significantly better than groups taught using traditional instructional methods (Sen, 2016). Multiple studies have shown that students in classrooms with 5E Instructional Methods will outperform those students in control groups (Lara-Alecio, 2018). The 5E model not only increases standardized test scores, but also increases the students' ability to use science process skills and general knowledge of the concepts, and hones

laboratory skills. In all areas, students who are in effective inquiry based classes will outperform students who are in traditional classrooms. It is important to note that in an effective inquiry based classroom, teachers will improve their methods over time. When incorporating new methods for the first time, a teacher may notice only modest improvements but as their skills grow in implementing these methods, and so will the achievement of their students (Cherry, 2011). In a perfect scenario, teachers hoping to utilize the 5E Instructional Method would be supported with professional development instructing them on the implementation of the method and allowance of time to develop their new lessons and activities. In reality, teachers will need to incorporate these methods over time, changing a few lessons each year until many, if not all, of their plans and activities include a breadth of the engagement, exploration, explanation, elaboration, and evaluation strategies. Teachers will have to become more comfortable with new methods, while utilizing more open-ended questions and providing student feedback in a timely fashion (Sickel, 2012).

Studies have found that using the 5E Instructional Method has improved the attitudes of students toward science lessons, when compared with students in classrooms taught traditionally, and can even improve the attitude of students toward science in general (Sen, 2016). These improvements are minor compared to the much larger improvements in regards to the increase in feelings of motivation and achievement in students (Cakir, 2017).

High school prepares students to be college and career ready by the time they graduate and there are many skills they need to learn for both college and careers that are difficult to measure with standardized testing alone. Some of the skills that are important for success are logical thinking, problem solving, and developing the ability to formulate and ask pertinent questions. These skills can be developed in a classroom using student centered inquiry based methods such as the 5E Instructional Method (Sen, 2016). Another skill that can be developed using this method is the

ability of the students to internalize the new science concept and use this information to explain phenomenon (Sickel, 2012). It has also been observed that these methods are effective in developing scientific literacy and process skills (Cherry, 2011), which allows them to feel confident in approaching scientific concepts they might come across in their college classes, careers, in politics, or even in personal projects and hobbies. Through the 5E Instructional Method, students are able to take control of their own learning; they set goals and become aware of their progress toward those goals (Bybee et al., 2006).

Evaluating the research, traditional methods of teaching are not as successful in improving the motivation, achievement or attitudes of students as the 5E Instructional Method; therefore, it is worth the effort it takes to implement because of the ability of the model to cause such great improvements (Cherry, 2011). If a teacher were able to see the development of their students after engaging and learning through the 5E Instructional Method, they would want to adjust their current methods and step out of their comfort zone to make the changes necessary to make the 5E Instructional Method a part of their approach.

METHODOLOGY

Demographics

The study involved 10th, 11th, and 12th grade students in Earth and Space Science ($N=56$). The study focused on using the 5E Instructional Method compared to using a traditional nontreatment teaching method on student achievement and engagement. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for work with human subjects was maintained (Appendix A).

Treatment

The treatment used for this study was the 5E Instructional Method. During the first stage, Engagement, a short activity or phenomenon was used to help students connect new information to their prior knowledge. During the second step, Exploration, students performed activities to develop new knowledge and address their previous misconceptions. The Explanation step involved both a lecture and discussion through which information was explained to students and the students could explain what they knew. During the fourth stage, Elaboration, students extended their knowledge through further investigations. Finally, Evaluation allowed for assessment of students' progress toward the learning objectives of the unit. This method of instruction allowed for high levels of student engagement and understanding.

Data Collection and Analysis Strategies

The data collection instruments used were a Likert survey, interview questions, pre and post tests, and evaluation of work completed. Multiple data collection instruments were used in order to

analyze test scores and student engagement in the classroom. All of the test collection methods were important in developing an overall opinion of the 5E Instructional Method.

A Likert survey was conducted before the Plate Tectonics treatment unit and the Moon nontreatment unit were begun (Appendix B). The Likert Survey asked students to rate how much they agreed with a statement on a scale of one to five, one was strongly disagree and five was strongly agree. The Likert survey included statements about how much the students enjoyed science class, participated in class, asked questions, felt engaged, and felt they were given an opportunity to explore new ideas. This was done to assess how students felt about the level of engagement in the classroom and how they felt the instructional methods affected their performance on tests. The same Likert survey was conducted again upon completion of the treatment units to determine if the 5E Instructional Method changed their attitudes or opinions about science class or teaching methods.

After the treatment unit, random students were also interviewed regarding how they felt about the 5E Instructional Method (Appendix C). The interviews were done as personal conversations between the students and teacher. The students were asked questions about how they thought the method changed the way they learn, which method they thought was more engaging, and which method they preferred traditional lessons or 5E lessons. The answers to those questions were recorded by the teacher and later assessed for value. Students who were randomly selected were given the choice of participation and did not receive any extra credit for participating.

Pre and post tests covering the science content of the unit were used in both the Plate Tectonics treatment unit and the Moon nontreatment unit assessed during the research in order to be able to compare the amount of academic improvement students made (Appendix D). The pre and post tests for each unit contained the same questions in order to assess whether the students were better able to answer the questions after the unit. The pretest was completed before any lecturing or

activities were done. The post test was completed as a summative activity at the end of the unit. The results of these tests were analyzed to determine if the 5E Instructional Method had an affect on test scores in the science classroom.

An analysis was also done comparing classwork between the 5E Instructional Method and traditional teaching methods. The percent of work completed and turned in during each unit was compared. Then the score earned on the work was analyzed for improvement. Finally, a Teacher Journal was kept where I recorded observations as we went through the study. Data from the journal was used to support quantitative data sources.

Table 1. Data Triangulation Matrix

Focus Question	Data Source
<i>Primary Question:</i> 1. Student Understanding of Concepts	Pre-test and post-test data, Teacher Journal
2. Students' Attitudes Towards Science	Student Survey data pre and post units, interview questions, Teacher Journal
3. Students' Attitudes Towards 5E Instruction	Student Survey data pre and post units, interview questions, Teacher Journal

DATA AND ANALYSIS

Results

The test score results of the nontreatment and treatment units were nearly identical. The nontreatment unit had an average pretest score of 41.5% and an average posttest score of 86.9%. The treatment group had an average pretest score of 41.7% and an average posttest score of 86.5%. The increase in test scores from the pretest and the post test of the two units was nearly identical (Figure 2).

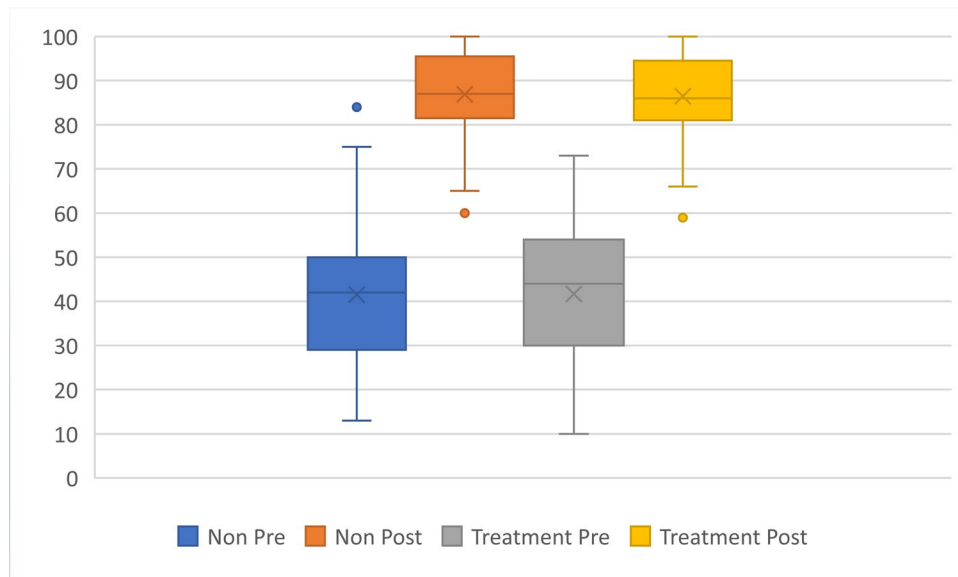


Figure 2. Pre and post test scores for the nontreatment and treatment units.

Although the test scores did not increase, there was a 4% increase in the students who agreed with the statement that there are sufficient engagement activities. There was also a 4% increase in the students who agreed with the statement that they ask questions in class (Figure 3 and Figure 4). Students also stated in personal interviews that they enjoyed having more activities. They also said that they preferred the 5E Instructional Method to traditional lecture because they enjoyed having more activities and working in small groups before large group discussion. One student mentioned

that it was “fun to not always do the same thing like take notes in class but be able to work with people.” It was noted in my teacher journal that participation in class discussion seemed to improve. I noted more students involved in discussions and depth of discussion seemed more robust than in years past.

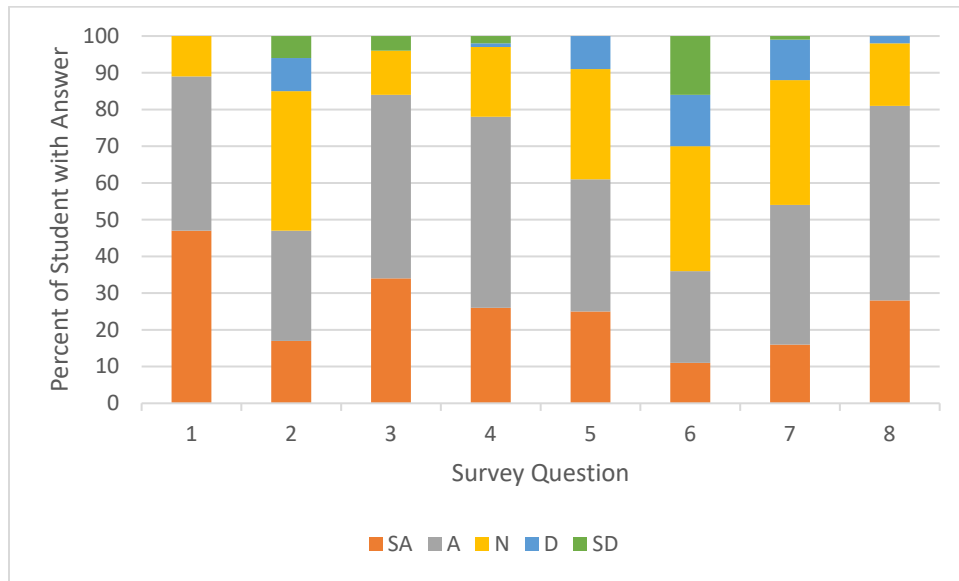


Figure 3: Moon unit Likert survey data, (N=56)

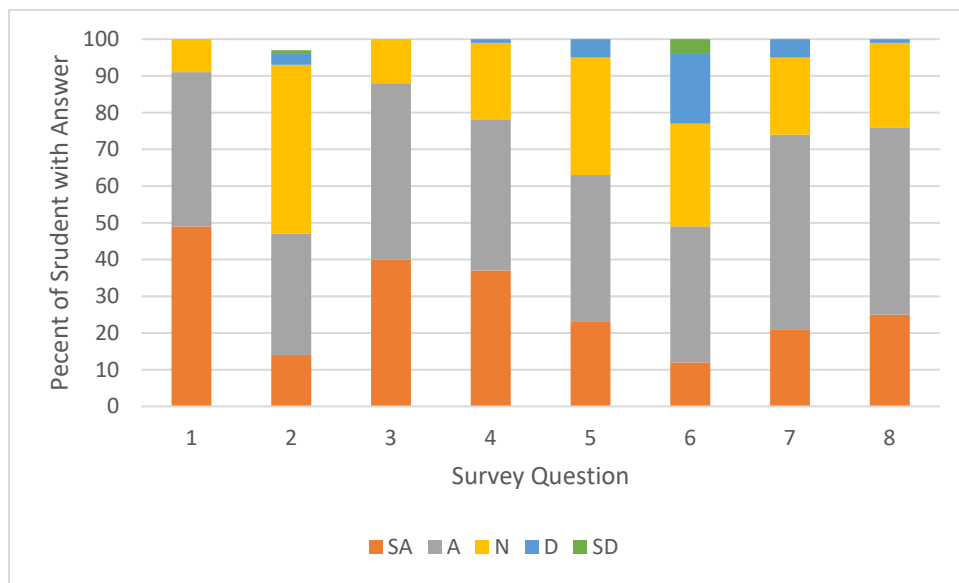


Figure 4: Plate tectonics unit Likert survey data, (N=56)

Based on my teacher reflections journal, I noticed that during the treatment unit, students would come into class excited to do activities. As students would walk into the room they would go to the lab section of the room to see if anything was set up for an activity. One of the 5E lessons included an explore phase in which students looked at seismic data. It was one of the first 5E lessons, so there was some guidance given concerning what students should be achieving. The lesson was about the structure of the Earth and the seismic data showed how the S and P waves travel through Earth's interior. There was both a diagram showing how the waves bend at each of the discontinuities and graphs showing how the velocity of the waves changed and the density of the Earth changed with depth. This lesson was intended to inspire students to think about how scientists know about the interior of the Earth and explore other sources of information about the interior of the Earth. As I walked around and talked to students, most of them said they don't question how scientists know the facts they know, they just trust that what the teacher is teaching them is correct. As students were given more opportunities to explore new ideas, they began to question more and more, they eventually were developing their own questions. For example, a student asked, "how did scientists know that tectonic plates moved in the past?" Another student asked, "how long have scientists been studying plate tectonics?" On the test, there was a question that asked about evidence it stated, "Name three pieces of evidence Wegener used to support his hypothesis of continental drift." This year, using the 5E Instructional Method, 90% of students could state the correct answer. In past years, that was one of the hardest questions on the test because, with less than half of the students answering correctly. In past years, it was just memorization of what the teacher said but this year when students wondered about the question and then looked for answers themselves they remembered the information better. While correcting tests in the past, I was always perplexed about why students did so poorly on that question and this year I was overjoyed with the amount of

students answering correctly. Students were also better able to answer questions about the structure of the Earth on formative assessments in the early stages of the unit, with all students scoring 75% or better, so I did not have to continue to reinforce the idea because they understood the concept after the first lesson. These examples of improvement in learning and understanding gave me observational data that inspired me to continue to use the 5E Instructional Method to plan my lessons and units. Additionally, my students were developing a sense of wonder about the natural world and how to ask their own questions about the natural world.

The biggest improvement between the 5E Instructional Method and traditional teaching method was amount of work completed and turned in and the quality of work turned in. During the traditional unit 63% of students completed their work and turned it in, but during the 5E unit 93% of the students completed their work and turned it in. When quality of work was compared, in the traditional unit 80% of students received a score of 75% or above, but when using the 5E Instructional Method all of the students scored a 75% or above. This is a significant improvement in both the amount of work turned in and the quality of the work.

CLAIM, EVIDENCE AND REASONING

Claims from the study

The goal of this research was to show the effect of the 5E Instructional Method in the high school science classroom, with the intention that the method could increase students' understanding of science concepts, measured by using test scores. Additionally, it was hoped to improve students' attitude and engagement in the classroom. The 5E Instructional Method did not cause a significant improvement in student test scores in this study but it did improve students' attitude and engagement.

Value of the Study and Consideration for Future Research

Test scores are not the only measure of the quality of education, so even though students did not have a significant increase in test scores the treatment did markedly improve the learning environment. During the treatment group, students were much more engaged and active participants in their own learning. They completed activities on their own or in small groups before discussion of the activities as a large group. Many students commented that they enjoyed having more hands on learning during the treatment unit rather than just taking notes. One student said, "I like it that we don't just sit and take notes, we actually have to do things." Hands on learning is very important in science because that is how science learning is done in the real world. Just like this capstone research, I could have just researched what someone else had already written about the 5E Instructional Method but, instead, by doing hands on implementation in my own classroom, I gained a deeper understanding of the process. The engagement of the students in the activities could account

for the increase in the amount of work completed and the quality of work. They cared more about their work because they were actually curious about the answers, instead of just trying to complete an assignment. The students also scored better on assignments because they were engaged and gaining a better understanding of the concepts.

Impact of Action Research on the Author

When the tests for the two units were compared, the nontreatment unit test was much shorter and more straightforward than the treatment test. The treatment unit test also included more short answer and essay questions than the nontreatment unit. More attention should have been given to making the tests similar in style and length. The nontreatment unit was done during an astronomy unit and the treatment unit was done during a geology unit. The results may have been different if both units would have covered more similar topics.

When my teaching methods were analyzed during this research, I was led to the conclusion that in my traditional teaching I incorporated parts of the 5E Instructional Method, but as one large group rather than small groups or individually. For example, some type of engagement at the beginning of a lesson to hook their interest was included in both the treatment and nontreatment units. The biggest difference in the treatment unit was that students had more activities to complete on their own or in small groups before large group discussions. I will definitely use the 5E instructional method again, as it shifts the learning from teacher-centered to student-centered. The results of my research could have shown more improvement in test scores if I would have been careful to not include any part of the 5E Instructional Method in my nontreatment group. Additionally, the research says that a teacher will improve their implementation as they continue to use the method. As I have more time to implement the 5E Instructional Method I will have better results. The results of this study could be improved upon with further investigation, such as

repeating the investigation but correcting the errors in testing that occurred in this research. Also, I think it would have been beneficial to record data on student participation, which was not done.

Although my research did not show an improvement in test scores, improving student's attitude about science classes will likely lead them to take more science classes. As students take more science classes, they gain understanding of more science concepts and that is the ultimate goal of science education. Another benefit of the 5E Instructional Method was that while students were working on inquiry projects or activities, I had the opportunity to walk around the classroom and have conversations with the students. This was beneficial in many ways, I could gauge students understanding and address any misconceptions they were having, all of the students responded when I talk to them individual or in small groups as opposed to as an entire class, and students gained a better understanding than they would have from lecture alone. Additionally, students developed their own sense of wonder. For example, to engage students at the beginning of the 5E lesson about earthquakes students were shown a collage of images of damage done by earthquakes and tsunamis. Students were so interested in the pictures that an intense discussion began about whether earthquakes and tsunamis could really do such things, such as bend railroad tracks or leave boats on top of buildings. The students wanted to know how the earthquakes occurred and what was causing the amount of damage to be so different. Their curiosity led them to pay attention during lessons which led to a better understanding.

The most significant improvement, from my research, was that the increased engagement lead to an increase in students completing work and turning in higher quality work. The 5E Instructional Method is designed for students to gain a better understanding and be more engaged in their work. The more engaged students were the more likely they were to put effort into their work.

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APPENDICES

APPENDIX A

MONTANA STATE UNIVERSITY INSTITUTIONAL REVIEW BOARD APPROVAL



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
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MEMORANDUM

TO: Natalie Wieloch and John Graves
FROM: Mark Quinn *Mark Quinn CJ*
 Chair, Institutional Review Board for the Protection of Human Subjects
DATE: November 12, 2019
RE: "The Effect of the 5E Instructional Method in the Science Classroom" [NW111219-EX]

The above research, described in your submission of November 10, 2019, 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; and (iii) the information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by section 16.111(a)(7).
- (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.

APPENDIX B

LIKERT SURVEY QUESTIONS

You are being asked to participate in a research on educational practices. This may help me obtain a better understanding of how the 5E instructional method affects the Earth and Space science classroom. Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in anyway.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree			
5	4	3	2	1			
1. I enjoy science class.			5	4	3	2	1
2. I engage in discussion in class.			5	4	3	2	1
3. I participate in activities in class.			5	4	3	2	1
4. This class captures my interest and holds my attention.			5	4	3	2	1
5. I like the number of activities that are done in class.			5	4	3	2	1
6. I ask questions in class.			5	4	3	2	1
7. There are sufficient engagement activities.			5	4	3	2	1
8. There are opportunities for me to explore ideas.			5	4	3	2	1

APPENDIX C

INTERVIEW QUESTIONS

Post Treatment Interview Questions

You are being asked to participate in a research on educational practices. This may help me obtain a better understanding of how the 5E instructional method affects the science classroom. Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in anyway.

1. How do you think the 5E instructional method changed the way you learned in this class? Explain.
2. Which method, traditional lecture or 5E, do you prefer? Why?
3. Which method do you feel was more engaging? Why?
4. Which method do you prefer? Why?
5. Do you have any other comments?

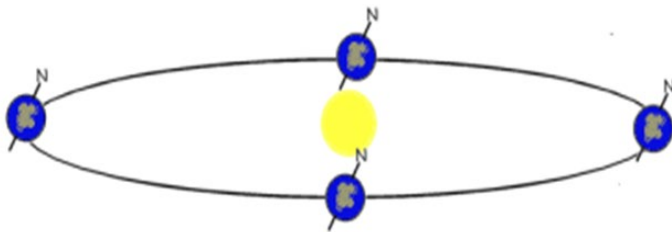
APPENDIX D

PRE AND POST TESTS

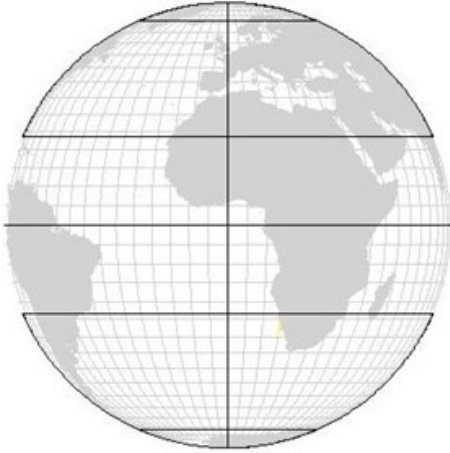
- ___ 11. What is a partial solar eclipse?
- | | |
|---|--|
| a. when the sun is only partial covered by the moon | c. when the moon is completely in earth's shadow |
| b. when the moon is farthest away and you can still see a ring of the sun | d. when the moon comes near earth's shadow. |
- ___ 12. Who has had men walk on the moon?
- | | |
|-----------|---------------------|
| a. US | c. China |
| b. Russia | d. All of the above |
- ___ 13. What is the most accepted explanation for the formation of the moon?
- the earth's gravity captured a large asteroid
 - earth "stole" the moon from venus
 - a mars sized planetoid collided with early earth
 - dust left over from the formation of earth stuck together
- ___ 14. Which of the following is NOT true about earth's moon compared to other moons?
- | | |
|---|---------------------------------------|
| a. it is large compared to the size of our planet | c. it is icy |
| b. it is rocky | d. it orbits far away from the planet |
- ___ 15. What is the name of the light colored, heavily crated, mountainous regions of the moon?
- | | |
|--------------------|-----------|
| a. maria | c. rilles |
| b. lunar highlands | d. yurals |
- ___ 16. What are the low lying, dark, smooth plains of the moon called?
- | | |
|--------------------|-----------|
| a. maria | c. rilles |
| b. lunar highlands | d. yurals |
- ___ 17. How much of the sun's light does the moon reflect?
- | | |
|--------|--------|
| a. 72% | c. 27% |
| b. 55% | d. 7% |
- ___ 18. The moon is tidally locked with earth, what does that mean?
- | | |
|--|--------------------------------------|
| a. it rotates on its axis at the same speed as the earth rotates on its axis | c. the same side always faces earth |
| b. it causes the volcanoes | d. the moon is always getting closer |

Short Answer

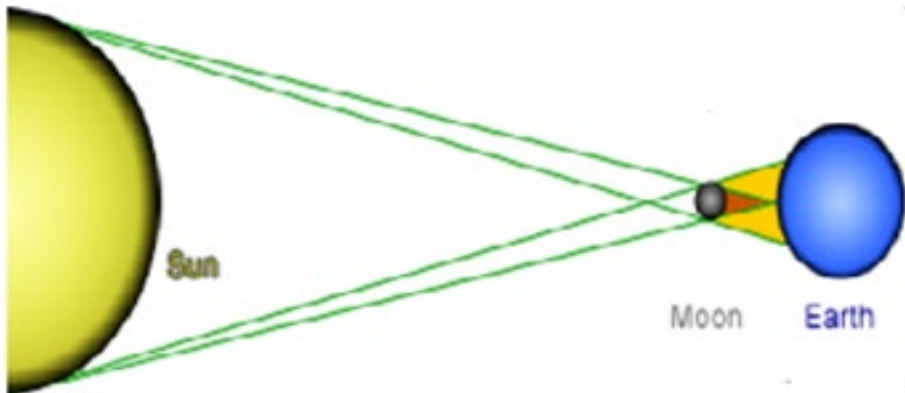
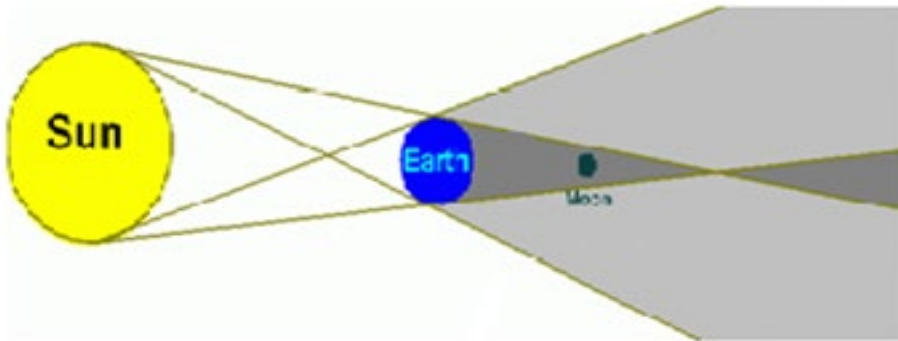
19. Label the summer and winter solstices, spring and fall equinoxes.



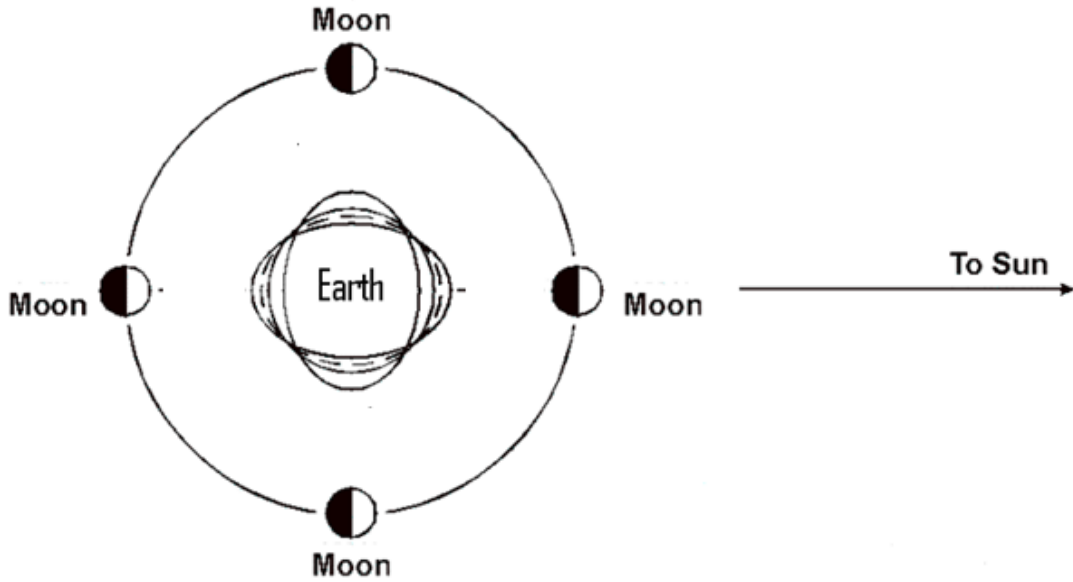
20. Label the Arctic Circle, Antarctic Circle, Tropic of Capricorn, Tropic of Cancer and Equator.



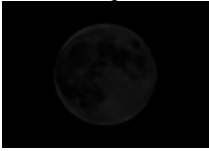
21. Label the diagrams as solar eclipse or lunar. Label the umbra and penumbra in each diagram.



22. Label each position of the moon as whether it would cause spring tide or neap tide. Circle the positions of the moon that would cause the highest high tides.



23. For each picture, NAME the phase of the moon









**Short Answer**

24. How does the speed of the moon's rotation compare to its revolution?

Earth Science: Plate Tectonics

Multiple Choice

Identify the choice that best completes the statement or answers the question.

- _____ 1. The existence of coal beds in Antarctica indicates that the continent once was _____.
 a. part of Africa
 b. closer to the equator
 c. cold and dry
 d. farther from the equator
- _____ 2. _____ is a fossil fern that helped support Wegener's hypothesis of continental drift.
 a. *Gondwanaland*
 b. *Kannemeyrid*
 c. *Mosasaurus*
 d. *Glossopteris*
- _____ 3. Earth's continents were last joined as a single landmass called _____.
 a. Gondwanaland
 b. Kannemeyrid
 c. Laurasia
 d. Pangaea
- _____ 4. The youngest part of the ocean floor is found _____.
 a. along deep sea trenches
 b. where ocean sediments are thickest
 c. near ocean ridges
 d. where Earth's magnetic field changes polarity
- _____ 5. At an oceanic-oceanic convergent boundary, _____.
 a. new crust is created
 b. old crust is recycled by subduction
 c. old crust is deformed or fractured
 d. plates slide past one another
- _____ 6. Convection currents transfer thermal energy _____.
 a. between continents
 b. from cooler regions to warmer regions
 c. from warmer regions to cooler regions
 d. as a result of buoyancy
- _____ 7. The downward part of a convection current causes a sinking force that _____.
 a. pulls tectonic plates toward one another
 b. moves plates apart from one another
 c. lifts and splits the lithosphere
 d. creates a divergent boundary
- _____ 8. Many early mapmakers thought Earth's continents had moved based on _____.
 a. plate boundary locations
 b. fossil evidence
 c. climatic data
 d. matching coastlines
- _____ 9. Continental drift was not widely accepted when it was first proposed because _____.
 a. Wegener couldn't explain why or how the continents moved
 b. continental landmasses were too big to move slowly over Earth's surface
 c. magnetic and sonar data proved that Wegener's hypothesis was incorrect
 d. mantle convection currents weren't in motion at that time
- _____ 10. Compared to ocean crust near deep-sea trenches, crust near ocean ridges is _____.
 a. younger
 b. older
 c. the same age
 d. magnetically reversed

- ___ 11. The magnetic pattern of ocean-floor rocks on one side of an ocean ridge is ____.
- a mirror image of that of the other side
 - younger than on the other side
 - much different from the magnetic pattern found in rocks on land
 - at right angles to the ocean ridge
- ___ 12. Isochron maps of the seafloor indicate that ocean crust is ____.
- oldest near ocean ridges
 - youngest at deep-sea trenches
 - youngest near ocean ridges
 - thinnest in subduction zones
- ___ 13. Each cycle of spreading and intrusion of magma during seafloor spreading results in ____.
- magnetic reversals
 - new ocean crust
 - subduction
 - plates colliding
- ___ 14. Features found at divergent boundaries include ____.
- ocean ridges
 - deep-sea trenches
 - continental mountains
 - island arc volcanoes
- ___ 15. Continental-continental plate collisions produce ____.
- island arcs
 - rift valleys
 - deep-sea trenches
 - very tall mountain ranges
- ___ 16. Crust is neither destroyed nor formed along which of the following boundaries?
- convergent
 - divergent
 - transform
 - magnetic
- ___ 17. One of the driving forces of tectonic plates are related to convection currents in Earth's ____.
- crust
 - mantle
 - inner core
 - outer core
- ___ 18. A vast, underwater mountain chain forms at a(n) ____.
- deep-sea trench
 - seamount
 - ocean ridge
 - submarine canyon
- ___ 19. A narrow, elongated depression in the seafloor is called a(n) ____.
- deep-sea trench
 - seamount
 - ocean ridge
 - submarine canyon
- ___ 20. _____ is defined as the study of the history of earth's magnetic field.
- paleogeology
 - ocean topography
 - paleomagnetism
 - magnetic symmetry
- ___ 21. Some early mapmakers thought that the coastline of South America matched the coastline of _____.
- Asia
 - Africa
 - Antarctica
 - Europe
- ___ 22. _____ is a process that occurs at subduction zones.
- ridge push
 - retrograde motion
 - peristalsis
 - slab pull
- ___ 23. The _____ states that Earth's crust and rigid upper mantle are broken into enormous slabs called plates that move slowly over Earth's surface.
- theory of the adaptable planet
 - theory of plate tectonics

b. theory of continental drift

d. theory of seafloor spreading

24. The _____ explains how new ocean crust is created at ocean ridges and destroyed in deep-sea trenches.

a. theory of the adaptable planet

c. theory of plate tectonics

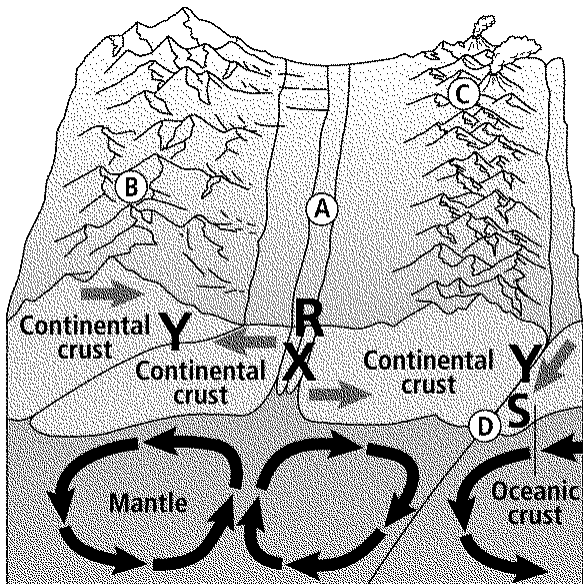
b. theory of continental drift

d. theory of seafloor spreading

Completion

Complete each statement.

Match each letter that appears on the diagram with the appropriate feature below. Then answer the questions.



1. The type of boundary marked by the letter *X* is a(n) _____.
2. The type of boundaries marked by the letter *Y* are _____.
3. _____ is the process occurring in the area marked by the letter *R*.
4. _____ is the process taking place in the area marked by the letter *S*.
5. The arrows in the mantle and oceanic crust indicate the direction of flow of _____ beneath the plates.

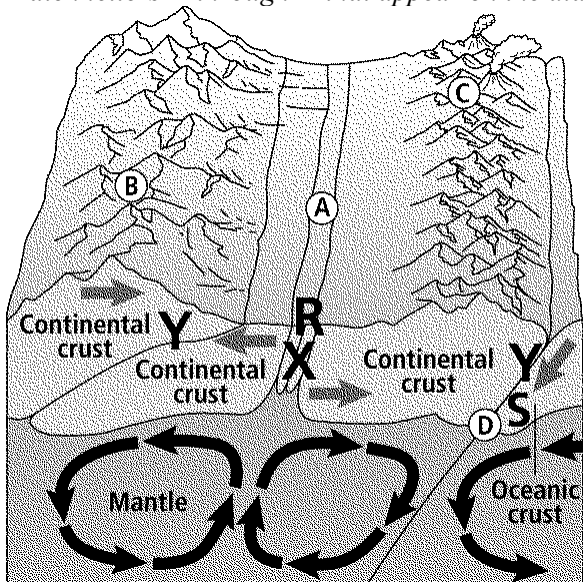
Matching

Match each item with the correct statement below.

- | | |
|------------------------|--------------------|
| a. magnetometer | e. Pangea |
| b. convection currents | f. transform |
| c. rift valley | g. deep-sea trench |
| d. plate tectonics | h. ridge push |

- ___ 1. A landmass comprised of all of Earth's continents
- ___ 2. A device that measures changes in Earth's magnetic field
- ___ 3. A narrow, elongated depression in the seafloor
- ___ 4. A narrow, long depression in continental crust
- ___ 5. Type of boundary characterized by long faults and shallow earthquakes
- ___ 6. Theory that states that Earth's crust and upper mantle are broken into enormous slabs
- ___ 7. The mechanisms thought to be associated with plate movements
- ___ 8. The process that helps to move an oceanic plate toward a subduction zone

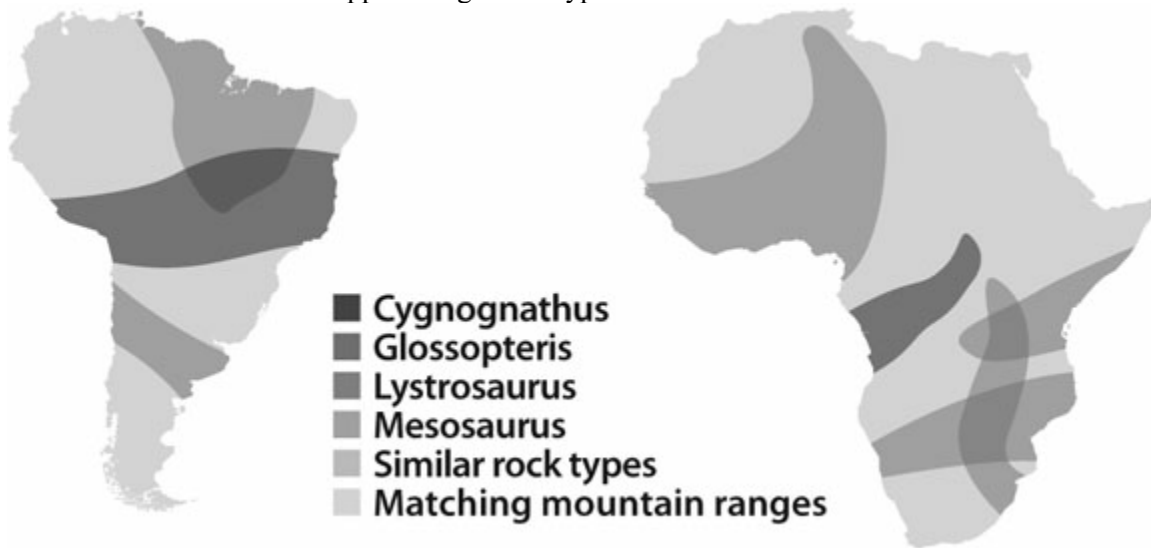
Match letters A through D that appear on the diagram with the appropriate feature below.



- ___ 9. Subduction zone
- ___ 10. Rift valley
- ___ 11. Volcanoes
- ___ 12. Highly-folded mountains

Short Answer

1. Select a specific piece of rock formation evidence utilized by Wegener to support his theory of continental drift. Use this piece of evidence to support Wegener's ideas.
2. Using the Figure shown, analyze the significance of the mesosaurus fossil appearing in both South America and Africa. How does this support Wegener's hypothesis?



3. Summarize the two major objections to Wegener's theory, which were raised in the early 1900s.
4. Use the concept of sea-floor spreading to hypothesize how the distance between the United States and Europe might be affected over time.
5. Would you expect the ages of oceanic crust near the beach and oceanic crust in the middle of the ocean to be the same? Explain your answer.
6. Name three pieces of evidence Wegener used to support his hypothesis of continental drift.
7. Listed below are the steps involved in the process of seafloor spreading. Sequence the steps in the correct order.

	The seafloor at a subduction zone sinks.
	Crust spreads along an ocean ridge and magma fills the gap that is created.
	New seafloor moves away from the ridge, cools, and becomes more dense.
	Hot magma which is less dense than surrounding material, is forced toward the crust.
	New ocean floor forms as the magma hardens.

Essay

1. Explain what is happening in the following diagram.

