THE INFLUENCE OF THE SCIENCE STATIONS APPROACH IN A SIXTH-GRADE EARTH AND SPACE CLASSROOM

by

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A professional paper submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

July 2021

ACKNOWLEDGEMENTS

Wes, Lily, Verlin, and Hazel got me through by encouraging me and expressing their pride for me throughout this experience. Morgan helped with me find the right words. With her help and kindness, I was able to create a polished paper.

The science stations used in this research were created by Kesler Science. They have worked to provide great resources for middle school science teachers. My project advisor, Marcie Reuer, had the kindness, patience, and feedback that got me through all stages of action research project development. My science reader, Joe Bradshaw’s advice and suggestions helped make this project a success. The proofreading from Jessica Anderson helped me take this paper to a professional level. My success of this project came with the help of all these wonderful people.

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ABSTRACT

The purpose of this study was to determine the influence of the science stations approach in a sixth grade Earth and space classroom. Multiple intelligences, Next Generation Science Standards (NGSS), and student engagement were examined during research. A student sample of 28 sixth graders completed science stations in tangible and digital modes within nine units of the middle school Earth science curriculum. All units were taken into account to gauge science stations' effect on student engagement and multiple intelligences. A performance task map and pre- and post- tests covering the topics of plate tectonics, volcanoes, and the rock cycle were used to examine NGSS achievement. Students also completed a "Getting to Know You" survey, Science Stations Student Self-Assessment Survey, and a Learning Preferences Interview. The stations utilized in this study were created by Kesler Science.

Results showed that every multiple intelligence was represented in at least two stations, except for musical intelligence, covering a diverse group of learners. Nearly all of the science and engineering practices and cross-cutting concepts stated in the NGSS standards were represented in at least one station as well. Findings for student engagement expressed positive responses and higher completion rates for tangible modes. Additionally, students favored stations that involved illustrations and hands-on activities, but found reading and writing tasks undesirable. By the end of data analysis, it was determined that the science stations approach supported and strengthened multiple intelligences, NGSS standards mastery, and student engagement.

INTRODUCTION AND BACKGROUND

Paola, Kansas

In East Central Kansas lies a town about 43 miles South of Kansas City. This town, Paola, is in rural Kansas about 10 miles West of the Missouri state line. Here, you'll see the occasional expanse of crops, but not wheat fields for endless miles as many people envision Kansas to be. Instead, in spring and summer, you'll be surrounded by lush, green rolling hills hosting cattle and prairie grasses cascading in waves as constant gentle breezes blow with an occasional gust of wind that takes your breath away. Really! It sounds like a dream, but it's our reality.

According to City-Data.com, our population is around 2,620 males and 2,960 females totaling 5,580 people. Of that 5,580 91.6% are White, 2.3% are Black, 3.0% are Hispanic, 0.6% are American Indian, 0.3% are Asian, and 2.2% identify as having two races. The median age is 31.7. The median income is $51,785 and 15.2% of people in Paola live in poverty. As of 2018, the crime rate is below the US average. The prominent industries are as follows: "Construction (13.3%), Educational services (8. 9%), Health care (8.0%), Finance & insurance (7.0%), Department & other general merchandise stores (4.4%), Food & beverage stores (3.9%), and Professional, scientific, technical services (3.7%)" (City-Data, 2000).

Context of the Study

I teach at Paola Middle School in Paola, Kansas within the USD 368 school district. According to the USD 368 website "the city of Paola has a population of over

5500 and the district is home to approximately 2000 students housed within two elementary schools, a middle school, and a high school" (2019). Kansas State Department of Education (2020) reported for the 2018-2019 school year that 37.8% of students qualified for free or reduced school lunch. It is important to note that we have adopted a 1:1 initiative, which means that all students in grades 3-12 are provided a Chromebook by the school district.

Our sixth-grade teaching team set-up allows for one teacher per core subject (Science, Math, Communications, and Social Studies). In addition to the single subject teachers, we have two combination teachers (Math/Science and Communications/Social Studies), a physical education teacher, and a special education teacher all creating a team of eight. I am the single subject science teacher in sixth grade and I have been in this position for seven years. My sixth graders learn Earth and space science, while seventh graders learn life science, and eighth graders learn physical science.

I'm certified to teach kindergarten through sixth grade. I'm fortunate to work with sixth graders at the middle school level. I simply can't see myself working in the lower grades. Science has been my favorite subject all throughout life and I am passionate about earth science and geology and this really is the perfect job for me. Prior to my coursework at Montana State University, I had never received any formal training on the NGSS standards, so this Master's program has taught me a lot about how to teach them. I'm gradually putting more time and energy into the science and engineering practices, and cross-cutting concepts. I appreciate and incorporate the 5-E model in my classroom and try to make real-world connections as frequently as possible.

Purpose of Research

For my action research project, I wanted to explore the use of science stations and their influence on student learning, an approach I have incorporated at least three years. As we try to meet the learning needs of our kids, one of our goals is to find ways to encompass diverse methods of instruction. What works for one child may not work for another. In traditional teaching methods such as lecture and textbook readings, we find that some students lack understanding or interest and we need an array of different approaches to a single topic to fulfill the gamut of student abilities and interests. Cathy Weselby (2020) said in an online article, The Resilient Educator, on the topic of differentiated instruction that "differentiating instruction may mean teaching the same material to all students using a variety of instructional strategies, or it may require the teacher to deliver lessons at varying levels of difficulty based on the ability of each student" (para. 3) It's with the implementation of science stations that I sought to cover this array.

I used science stations created by Kesler Science for my research. These station sets in particular have become very popular with science teachers all over the United States, especially at the middle school level. My research will provide insight for my colleagues, as well as for, any teachers across the country who use these stations in particular or the science stations approach in general.

Focus and Research Questions

My focus question was, What influence does the science stations approach have on student learning in a sixth-grade Earth and space science classroom?

My sub-questions included the following:

1. How effective are stations in meeting multiple intelligences?
2. How do stations influence understanding of certain content under the NGSS standards?
3. Which station's delivery method (tangible vs. digital) optimized student engagement?

CONCEPTUAL FRAMEWORK

Most often, when someone thinks of the stations approach, elementary reading and math centers come to mind. This strategy has been in use for quite some time. In science class, stations are a useful addition to any instructional approach, especially the 5-E model. What are the effects of utilizing stations on multiple intelligences, mastery of NGSS standards, and student engagement? Before these questions are answered, it's important to understand what science stations are, the best practices for implementing them, and the variety of ways students can work with them.

What Are Science Stations?

The science stations approach is a method in which students explore a topic in a variety of ways and utilize several different skills. Delivery modes can be tangible or digital. In the journal, Science Scopes, an article by Denise Jones highlights stations in the science classroom. Jones (2007) defines them as: "… a method of instruction in which small groups of students move through a series of learning centers, or stations, allowing teachers with limited resources to differentiate instruction by incorporating students' needs, interests, and learning styles" (p. 17).

Best Practices for Using Science Stations

There are a variety of ways to set up science stations in a classroom, but there are some criteria that should be followed. The stations should be coherent throughout based on a single topic or theme. Jones (2007) concurs, suggesting that the stations approach allows students to see the same concept in different ways. The stations should be spread out around the room to allow for student movement and designed to accommodate a variety of skills, interests, or level of readiness. Each station should require about the same amount of time to complete and be easy to set up, resupply, and take down. Students must also be provided with clear directions and objectives, and given a way to record responses.

Importantly, stations should allow students to direct their own learning, while the teacher serves as a facilitator or guide. Ocak (2010) mentions, in his study on stations' efficacy on learning in the elementary setting, that one of the strengths of the stations approach is that it allows teachers to give one-on-one support to individuals or groups. Ocek (2010) "they help students become self-motivated, learn independently at their individual pace, develop their own goals, evaluate their own progress, and use different ways of communicating ideas. A selection of carefully planned activities in a centre can give students a chance to work in ways they learn the best – and strengthen other areas at their own pace" (as cited in Novelli, 1995, p. 147). Hands-on learning with a student-centered approach brings to mind Piaget's constructivism theory. It promotes learning from experiences and learned knowledge. As Ackermann (n. d.) puts it: "To Piaget, knowledge is not information to be delivered at one end, and encoded, memorized, retrieved, and applied at the other end. Instead, knowledge is experience that is acquired through interaction with the world, people and things" (p. 3). Therefore, science stations promote constructivism within their inherent mechanisms in a student-centered, exploratory nature.

Tangible and Digital Modes

Each Kesler station set provides a differential approach to expose a topic through tangible task cards or a digital slideshow depending on the modality. Each set includes task cards and a lab sheet for students to record their answers. The digital versions have these exact same task cards, but in a slideshow format.

When using the tangible modality, task cards are printed out and placed around the classroom. Students can visit and work through these task cards and record their responses on a printed-out lab sheet. When using the digital modality, students complete task slides in PowerPoint, Google Slides, or similar platform. The same task cards that come in tangible mode are presented in the slides. In this case, students type instead of write and drag and drop images or text boxes instead of manipulating cards.

Collaboratively, Individualistically, or Both

Students can complete either mode of delivery in a variety of ways. They can work collaboratively as a group for every station, individually for every station or a combination of the two. The stations approach is flexible in this way. This flexibility is important in education because humans tend to work interdependently in two ways: cooperatively and competitively. If they are not, then they are working independently (Johnson & Johnson, 2011, p. 2). Cooperative learning seems to be an important part of life. Johnson and Johnson (2011) state:

> The human species seems to have a cooperation imperative: We desire and seek out opportunities to operate jointly with others to achieve mutual goals. Cooperation is an inescapable fact of life. From cradle to grave we cooperate with others in family, work, leisure, and community by working jointly to achieve mutual goals (p. 5).

Successful cooperative learning starts with five key elements (1) group members need to realize that not only do they need to do their part, but ensure others do as well, (2) they need to realize they are individually responsible for their part, (3) members must show respect for others in constructive ways, (4) members need to encourage others' efforts in a positive way, and (5) members should reflect on what went well and what needs to be changed (Gillies, 2014, p. 129). While it is up to the teacher to assign a learning objective, the students in a group must also make it their common goal to achieve content mastery, completion, and a feeling of accomplishment. Individualistic learning has its merits, too. Simply put, it's learning that requires no dependence on others. Students can usually work at their own pace and the work goals they set are theirs alone. Additionally, individualistic learning allows for more teacher-student interaction as there are no peer-to-peer interactions. There is usually adequate space for learning and generally, the noise level is low in this setting as well. When there are simple tasks that need to be completed or clear and known skills that can be utilized, individualistic learning may be best. Johnson and Johnson (2011) believe "the essence of an individualistic goal structure is giving students individual goals and using criterion-referenced evaluation system to assign rewards" (p. 155).

In regard to stations, either situation can be used separately. Collaboration is important in the science classroom, so the cooperative scenario is usually best. This allows them to collaborate and draw conclusions with a consensus for final answers at each station. The individualistic approach is a bit different. Since the Kesler stations use task cards, multiple copies can be made to accommodate each student in the individualistic situation. However, it is quite possible to combine the two since stations have multiple tasks, all differentiated in form and delivery. As an example, stations that require drawing and labeling can be done independently, and another station that requires classifying and organizing can become a group effort. The stations can be organized so that half of the class are completing stations independently while the other half is collaborating. For example, half of students can watch a video with headphones on, while the other half are grouped together, discussing a hands-on station

Can Stations Help Meet Multiple Intelligences?

Someone by the pen name of Aesop Jr. wrote an article called An Educational Allegory that was first published in *The Journal of Education* in 1899. It focused on the unreasonable tendencies of educational systems to measure intelligence and success in individuals based off of impossible expectations of skills that some simply do not possess at all (Aesop Jr. 1899). Think about a fish being graded on its ability to climb a tree or a duck's ability to win a foot race against a cheetah. Everyone can excel at something but not everything.

There is a theory that says every person has multiple intelligences (MIs) and within them, some are stronger than others for different people. The theory of multiple intelligences was first introduced by Howard Gardner in 1983. It includes the following intelligences and their adeptness (1) verbal/linguistic-word, (2) mathematical/logical-logic, (3) musical-music, (4) visual/spatial-pictures, (5) bodily/kinesthetic-physical movement, (6) interpersonal-social, (7) intrapersonal-self-reflection, and (8) naturalistic-nature (Gardner, 1998). Every person possesses these, but some are more dominant, which may impact what the best modalities for learning are in an individual (Herndon, 2018).

Because stations are so flexible and versatile, many of these intelligences can be tapped not only via station content and topics, but in the way the stations approach works. Making sure that the stations are designed with enough variation to tap into these intelligences will make sure that an array of abilities are matched. Those who are intrapersonally and interpersonally dominant have their intelligences tapped simply by working with others (interpersonal) and writing down their thoughts (intrapersonal). Multiple intelligence in a classroom was researched in "The Effectiveness of Multiple Intelligences-Based Teaching Strategy in Enhancing the Multiple Intelligences and Science Process Skills of Junior High School Students" published by Winarti et al. (2018) in *The Journal of Technology and Science Education*. The study focused on how a teaching strategy based on multiple intelligences affected science processing skills in junior high school students. Over 12 weeks, they conducted the study in one high-achieving school and a low-achieving school. In each school, there was one class as a control group and one class as an experimental group. Both groups were taught by the same teacher to avoid bias. The MI strategy consisted of six steps according to Winarti et al.:

> The MI-strategy consists of six stages namely (1) Self-reflection, where students tell about themselves, their study habits and hobbies, etc. , (2) Introduction of concept by teachers, using activities which involve all aspects of MI, (3) Formulation of questions about the subject matter by the students, (4) Deepening the concept through SPS practices which involve all aspects of MI, (5) Expressing understanding on the concepts through activities which are appropriate with students' dominant types of intelligence, and (6) Concluding the lessons. The activities at stage (1) to

> (4) were carried out in a group with various dominant types of intelligence while activities at stage (5) were carried out in a group of students who have similar dominant intelligence. Then, activities at stage (6) were carried out individually. The characteristic of this learning strategy lies in step (5), in which students were grouped based on the dominant type of intelligence.

The researchers used t-test and simple linear regression to analyze the results. After analysis it was found that MI-based instructional strategies had a significant effect on student development of MI and science processing skills.

What do Science Stations Have to do With the NGSS Standards?

The Next Generation Science Standards (NGSS) were rolled out in 2013 and were the result of a collaborative effort from states across the United States to revamp the previous state science standards to include grade level disciplinary core ideas (DCI) as well as cross-cutting concepts (CC) and science and engineering practices (SEP). The Next Generation Science Standards explains, "A big part of understanding the innovations of the NGSS is understanding why new science standards were needed in the first place. Resources in this section outline some key advances in science education research and describe how the NGSS reflect these advances by enabling students to *learn science* by *doing science"* (NGSS Lead States, 2013, para. 1).

The 5-E Model

Implementing the 5-E instructional model is a great way to ensure NGSS standards are being met. The 5-E model, also known as the 5E's, was created by Roger Bybee and the Biological Sciences Curriculum Study (BSCS) in the late 1980s (Bybee et al. 2018). This model includes five stages of a lesson: Engage, Explore, Explain, Elaborate, and Evaluate. Bybee et al. (2006) describes each stage as the following:

- Engage. Activities that promote curiosity and gauge prior knowledge.
- Explore. Usually, lab activities or investigations that explore possibilities.
- Explain. Teachers directly introduce or reinforce concept or skill.
- Elaborate. Students apply new understanding to additional experiences.
- Evaluate. Students and teachers assess the new understanding or skills (p. 2).

Science stations, if planned and executed carefully, can not only help students learn science that is outlined in the standards, but the "doing" part of science as highlighted in the SEP sections can be included in any stations approach. Stations can include a multitude of tasks and components. They can include hands-on activities, graphing, drawing, collecting and analyzing data, making models, computation, organizing, classifying, finding relationships, making connections to the real world, reading, writing, making observations and inferences, etc., all of which can be found in the 5-E model and the NGSS standards. The stations approach is used frequently in the explore stage of the 5-E model. According to Bybee et al. (2006)

> The teacher's role in the exploration phase is that of facilitator or coach. The teacher initiates the activity and allows the students time and opportunity to investigate objects, materials, and situations based on each student's own ideas of the phenomena (p. 9).

The natural framework for the science stations approach is student centered-teacher facilitated and the explore stage echoes this.

Which Mode Keeps Students Engaged?

Because of the COVID-19 pandemic of 2020, instead of having the choice between digital and tangible stations and resources of any kind, many teachers were forced to provide digital versions of all materials for every lesson, in part because some school districts chose either an exclusively distant learning model or a hybrid one (alternating in-person and remote). Digital learning is more prevalent than ever before, but it was already on the rise for many years before the pandemic. Lin et al. (2017) stated as part of their study comparing digital methods to traditional classroom methods "utilizing the shared education resources on the computer network for shortening the urban-rural education gap has become a common trend globally" (p. 3554). And while this approach might feel new to some, it is proving to have many advantages. As more school districts adopt the 1:1 initiative that states each student have their own personal device provided by the school, teachers' resource banks broaden immensely. From universities to government agencies such as NASA and the National Parks Service, teachers can extend the horizons of their students to places and ideas from around the world and beyond which aren't readily available in places such as rural or isolated areas. Additionally, many students in adolescence already find leisure in technology such as video games, social media, and video platforms. Lin et al. (2017) stated on the benefits of digital learning "enhancement of learning interests: instruction could be more vivid and lively through information technology and the presentation of various media to enhance learners' interests, make learning more efficient, and promote learners' learning persistence" (as cited in Kaklamanou, 2012, p. 3558). Students can interact with digital station slideshows in a variety of ways: typing, drawing, drag and dropping, viewing and responding to media, and even voice responding. Students can digitally interact with the teacher and others in an online platform as well.

There is much to say about the benefits of hands-on learning, in-person collaboration, or whole-class instruction. Class discussions seem livelier in a room full of students. In a study conducted by Titthasiri (2013), an interview was conducted among the subjects in a sample of higher education students. The study compared an e-learning class to a traditional class. Some positives that came from the interview in regards to the traditional class set-up included the ease of class discussion with peers and the teacher, more friends, a comfortable classroom, and required computer skills were less advanced. Although this study was in the context of higher education, middle school students would agree to these benefits. In contrast to the digital mode, the tangible mode of stations promotes social interaction, physical movement, and an energetic environment.

What Do Assessments Look Like with Science Stations?

There are lots of different ways to approach assessments when using science stations. To assess the stations, a common method is to give students an answer sheet to record responses, then assign each section a points value. Each station can be graded individually for skills or content knowledge or the entire sheet can be assessed for both. The Kesler stations are assessed in this way. Jones (2007) also suggests grading for safety and work ethic (p. 21). Sometimes, stations can be a piece of a bigger unit or model. Since stations can be a part of the 5-E model, assessment will be formative until the evaluation stage. Concept maps, minute papers, and two-sentence summaries are great ways to formatively assess stations after their completion.

Studies presented in this literature review sought to find efficacy in multiple intelligence-based instruction, stations' general effect on learning, digital versus traditional modes of learning and motivation for digital learning and its outcomes. In order to study the efficacy of stations in elementary level instruction, Ocak's study with a treatment (learning stations) and control group (traditional instruction) utilized the pre-test/post-test method and analyzed them using their means and a t-test. The results showed levels significantly higher with the treatment group. When Winarti tested MI based instruction on science processing skills, the treatment group (MI-based instruction) performed better than the control group (traditional classroom techniques). Winarti analyzed data using an analysis of variance (ANOVA) test and Wilcoxson's Signed Rank Test. When comparing e-learning to traditional classroom techniques, Titthasiri utilized student interviews for the student satisfaction portion of the study. Answers were put into a table comparing student opinions about e-learning to traditional methods.

This study of the influence of science stations in a sixth grade Earth and space class used similar methodologies and data analyses as seen in these literature review papers such as the use of treatments and non-treatments, t-tests, ANOVA tests, and interview comparisons. In the review paper, the authors used control and treatment groups of students, whereas, treatment and non-treatment units were used in this study with the same sample of students. Studies in this conceptual framework reflect the work done in this study.

METHODOLOGY

Demographics

The research for this project occurred within a sixth grade Earth and space science classroom. Treatment and data collection came from a sample of 28 students from two sections consisting of 50% girls and 50% boys. Student achievement levels are 46% high, 25% average, 29% low. Research occurred between September and April of the 2020-2021 school year.

At the end of March 2020, Kansas Governor Laura Kelly announced that schools would remain closed for the remainder of the 2019-2020 school year due to the COVID-19 pandemic. This was an unprecedented circumstance that forced school districts to navigate the unknown, and the 2020-2021 school year looked much different than a normal one. According to *Education Week*, no order was put into effect in Kansas statewide "the Kansas Board of Education voted July 22 to reject an order by Gov. Laura Kelly that would have delayed the start of school until Sept. 8. The vote put the decision on when to reopen back in the hands of local school districts" (*Map: Where Are Schools Closed?*, 2020). In-person classes in the Paola school district resumed in August for the 2020-2021 school year. This school year, however, did not resemble a typical one. Parents had the option to allow their students to come to school face-to-face or remotely, and were asked to commit to one or the other for a semester at a time. Teachers were to teach in-person classes, and concurrently instruct students remotely via Google Meets. The number of remote learners fluctuated because kids who went into quarantine had to join remotely until they were cleared to come back in person. Masks were mandated for everyone who stepped foot inside the school and thermometer cameras were installed at the two main entrances. Anyone with symptoms resembling COVID-19 symptoms were sent home immediately. Students also had to be seated six feet apart everywhere in the building including classrooms and eating areas. Research for this project was often ambiguous due to the uncertainty of whether in-person learning would suddenly become exclusively distant learning at any given time.

Treatment

The science stations approach during a pandemic school year looked very different than it does during a typical school year. In a typical year, stations are placed around the classroom while groups of students would move from station to station, completing each task collaboratively; however, modifications had to be made to accommodate the new pandemic requirements. Students either worked on stations alone or in partners, maintaining their six-foot distance, so tangible task cards had to be printed as a class set to accommodate each individual or paired group. The digital version of the stations did not change. The digital stations were easier to implement not only for the distance learners, but for the in-class students as well. I simply attached the slideshow in Google Classroom for the students to access. Part of my research was changed due to this. I added my final sub-question to find out whether students were more engaged with the tangible stations or the digital versions.

Kesler Science describes their stations approach as “a plug-in play system that allows the station to remain somewhat consistent throughout the year, but allows the teacher to interchange the content very quickly” (Kesler, 2016, para. 1). These stations are named according to the task. In total, there are nine stations. Eight of them are listed below for treatment and data collection purposes. The ninth station, Challenge It!, was not used in this research. This station is for enrichment and was not a requirement for the students. While you can use the stations in any order, I've found that it's effective to ensure that certain stations fall on specific days as some stations are dependent on others. To assess learning directly after implementation, the lab sheets are graded. Each station's point value varies depending on the requirements.

Day One: Input Stations

Input stations provide new information to the students. Students should complete these stations before moving on to the output stations.

- *Read it!* Students read a one-page passage to answer short-answer questions.
- *Watch it!* Students watch a short video online to answer short-answer questions.
- *Explore it!* This station provides a hands-on activity and follow-up questions to answer.
- *Research it!* Students do an interactive online activity with follow-up questions

Day Two: Output Stations

Output stations provide the opportunity for students to demonstrate what they learned from the input stations that were previously completed.

- *Illustrate it!* Students draw a diagram or picture (usually with labeling) related to the topic.
- *Organize it!* This hands-on station has students using cards as manipulatives to label diagrams or categorize key vocabulary words or ideas.

- *Write it!* This station must work off of knowledge obtained from the previous stations to provide short answers to questions.
- *Assess it!* This station is simply task cards that provide multiple choice questions to answer based on learned content from all stations.

For each major 5-E model theme in this research, students completed a tangible station and a digital station set, as well as, a non-treatment lesson without stations. The lessons chosen to be non-treatments already had successful activities that have historically been popular with the students. Tangible stations were implemented when the entire sample of students (N=28) were expected to be present for the duration of station days. Digital modes were implemented when there were more online students than in-person since they could be completed remotely. Each 5-E theme had subtopics. Water and Atmosphere contained the topics of oceans, atmosphere, and weather maps. The Dynamic Earth unit encompassed plate tectonics, volcanoes, and the rock cycle, and the Space Science unit included the topics gravity, the solar system, and seasons (Table 1).

Table 1. Treatments and non-treatment distribution by unit and date.

Unit	Dates	Type of treatment
Oceans	September 28-October 10	Tangible stations
Atmosphere	October 12-October 14	Digital stations
Weather Maps	October 19-October26	Non-treatment
Rock Cycle	January 13-January21	Non-treatment
Plate Tectonics	January 26-February 9	Tangible stations
Volcanoes	February 10-February 18	Digital stations
Gravity	March 8-March 12	Tangible stations
Solar System	March 23-April 2	Non-treatment
Seasons	April 6-April 8	Digital stations

Before data collection began, the students completed two modalities of science stations. The first modality was tangible task cards and a hard copy lab sheet covering the topic of heat transfer. They then practiced the digital slideshow stations covering the topic of the water cycle. It was important for the students to become familiar with science stations procedures prior to data collection. I did not want confusion over procedures to skew data results.

For this research in the context of working with human subjects, compliance was maintained per Montana State University's Institutional Review Board rules. Additionally, exemption status was obtained (Appendix A).

Data Collection

Data Triangulation Matrix

Table 2. Data Triangulation Matrix.

	Data Collection Instruments		
Research SQ. 1: How effective are science stations in meeting multiple intelligences?	Getting to Know You survey	Learning Preferences Interview	Table of station content/skills to Multiple Intelligence congruity
Research SQ. 2: How do science stations influence understanding of certain content under the NGSS standards	Pre-/post-tests over plate tectonics, volcanoes, and rock cycle	Formative Assessment (stations lab sheet)	Performance task-Tectonic plate/volcano/earth quake map
Research SQ. 3: Which science stations delivery method (tangible vs. digital) optimized student engagement?	Science Stations Student Self-Assessment	Informal Observations	Learning Preferences Interview

Multiple Intelligences

Data collection began in September of 2020 by distributing the Likert survey titled Getting to Know You (Appendix B). It was written and circulated by Laura Candler in 2011. The survey asks: Which of the following are true about you? Each student answered this in regard to 24 statements and rated each statement with a number from 0-5, zero meaning not true at all to five meaning very true. When they completed each statement, the number values were then transferred to a multiple intelligence category (naturalistic, mathematical-logical, verbal-linguistic, musical-rhythmic, visual-spatial, bodily-kinesthetic, interpersonal, and intrapersonal). For each category, the numbers were added up to reveal the intelligence strength and weakness of each student. This was a one-time-only survey and was administered before any other data was collected. Then, I visualized the survey data as a bar graph to identify trends with MI strengths and weaknesses (Figure 1). In order to help answer the sub question How effective are stations in meeting multiple intelligences?, I created two tables. The first shows multiple intelligence-to-station congruity (Table 6) and the other shows trends with the MIs and low-, medium-, and high-achieving students (Table 8). These tables allow a visualization of how well matched the stations are to the MIs of the students.

I also employed the Learning Preferences Interview in November (Appendix C). Titthasiri used an interview to compare student opinions on e-learning and traditional classroom learning. I used a similar approach with The Learning Preference Interview. These questions fit into three categories: learning preference, science stations, and multiple intelligences (Table 3). This interview helps surface qualitative data for sub question one pertaining to multiple intelligence and sub question three pertaining to student engagement (Table 2). The interview was conducted with a focus group of four students (two boys and two girls) who were diverse in achievement levels, multiple intelligence strengths, and personality. The interview was recorded in one session and was transcribed by me. Quotes from student responses were used for qualitative data analysis to augment quantitative data.

Table 3. Interview questions by category.

Question Category	Interview Question
Learning preferences	Q1. Order the following activities in order from the ones you learn **best to worst**. Q2. Why did you order them in this way? Q3. Do you think you learn better in groups, a whole class, or by yourself? Why? Q7. Do you think the different activities in stations help different learners? Why? Q9. Which do you prefer: Online delivery of stations or in-person delivery of stations? Why?
Science stations	Q4. Thinking about the science stations, which one is your favorite? Why? Q5. Which science station is your least favorite? Why? Q6. If you were to choose one station to use to pass a quiz, which one would it be? In other words, which station do you learn best from whether it's one you like or not? Q8. If you were to create your own station, what would learners be doing?
Multiple intelligences	Q 10. Do you like activities that are: Logical/mathematical? Why or why not? Q11. Linguistic? Why or why not? Q12. Musical? Why or why not? Q13. Kinesthetic? Why or why not? Q14. Naturalist? Why or why not? Q15. Interpersonal? Why or why not? Q16. Intrapersonal? Why or why not? Q 17. Visual/spatial? Why or why not?

NGSS achievement

The gravity unit was broken down by science and engineering practices (SEPs), disciplinary core ideas (DCIs) and cross-cutting concepts (CCs) to see where they belonged in the stations (Table 4). Most of the SEPs and CCs were present except SEP: Asking questions, Planning and carrying out an investigation, and CC: Energy and matter: flows, cycles and conservation. The missing components are in other station units. The gravity unit was simply used as one representation.

Table 4. DCIs, SEPs, and CCs in Gravity unit.

	Gravity	Stations
Performance Expectations	MS-ESS1-2 Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system	All
	MS-ESS1-3 Analyze and interpret data to determine scale properties of objects in the solar system	All
DCI's	ESS1. A: The Universe and Its Stars *Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. (MS-ESS1-2)	All
	ESS1. B: Earth and the Solar System *The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. (MS-ESS1-2),(MS-ESS1-3) *The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. (MS-ESS1-2)	All
SEP's	Developing and using models	Explore Illustrate
	Analyzing and interpreting data	Explore Illustrate
	Using mathematics and computational thinking	Explore Illustrate
	Constructing explanations and designing solutions	Research Illustrate Watch
	Engaging in argument from evidence	Write
	Obtaining, evaluating, and communicating information	Read Write
CC's	Patterns	Organize
	Cause and effect: mechanism and explanation	Research
	Scale, proportion, and quantity	Research Write Illustrate
	Systems and system models	Illustrate
	Structure and Functions	Watch
	Stability and Change	Watch

To look at academic achievement and growth in relation to the NGSS standards, I gave a pre-test and post-test for each topic of plate tectonics, the rock cycle, and volcanoes which are within the "Dynamic Earth" unit (Appendices D, E, and F). Ocak, Titthasiri, Winarti et al., and Lin et al. used the pre-test/post-test method to analyze achievement. In order to show gains, I took data from the pre-tests and post-tests, displayed results in box and whisker plots, then determined their maximum, minimum, median, outliers, and normalized gains. Normalized gains below 0.3 percent were considered low, gains of 0.3-0.7 percent were considered medium, and gains above 0.7 percent were considered high (Hake, 1998).

In order to show statistical significance, a paired t-test was performed with each of the pre- and post- test topics with a confidence interval of 0.05 (Table 7). An ANOVA test was performed on all three units. A Pearson correlation test was performed on the station lab scores for plate tectonics and volcanoes with a map task performance assessment. The performance assessment was a map the students had to create (Appendix G). The students were tasked to draw the tectonic plate boundaries, label the plates, and plot and label volcanoes with the name and type. They also had to plot recent earthquakes to include a label with the date and magnitude. Performance assessments are encouraged in the NGSS standards, so I treated it as a different type of assessment that could be compared to the formative station lab sheet scores seen in the Dynamic Earth unit. Ultimately, the statistical tests ran for academic scores were t-tests, analysis of variance, and Pearson correlation.

Student Engagement

An instrument used to measure student engagement in stations was a Likert survey called Science Stations Student Self-Assessment distributed in March (Appendix H). It had two parts. Part 1 asked the students to rate statements on a scale of 1-4 (one meaning never and four meaning always). Statements from the survey were divided into two categories: effort and understanding. Results from these statements were displayed in stacked bar graphs. Comparisons were made for each category between digital and tangible stations in an effort to analyze students' opinions of their own effort and understanding per modality. There was an additional question in the survey to see how many would consider a career in STEM; this question was included to provide an idea of opinions of STEM in the general sense. The results were displayed as a pie chart to visualize the ratio between positive and negative responses. Part 2 of the survey asked students which individual stations they liked least, most, found the easiest, and the hardest. For this section, they could circle all stations that applied. The responses were put into a frequency chart to find trends (Table 10).

Informal teacher observations and anecdotes were used to measure student engagement for treatments and non-treatment (Table 5). Teacher comments and observations were recorded in a notebook. Data analysis for this instrument was presented in the form of comments.

Table 5. Teacher Observations.

Type:	On task behaviors:	Off task behaviors:	75% or more on-time turn in rate
Tangible Stations	Lively discussion or constructive argumentation Good station time management Taking turns reading or answering questions	Off-topic conversations Goofing off One member not participating or just copying answers from group members	Yes
Digital Stations	Quietly working through slides Asking questions when confused	Even in partners, not much collaboration Emailing friends or unrelated web searches Playing with slideshow tools Mindlessly tapping keyboard	No
Non-treatments	Lively whole class discussions on topic Using appropriate resources Asking appropriate questions	Talking to peers at inappropriate times Goofing off during independent work time	Yes

DATA AND ANALYSIS

Results

Realizing that every person possesses all of the multiple intelligences at varying levels allows educators to determine students' strengths and weaknesses to find instructional strategies that work for everyone. Seven intelligences had representation in at least two stations. Kinesthetic and interpersonal are exhibited in all stations when implemented in a collaborative setting where students are moving from station to station. Those with a dominant musical intelligence did not have representation (Table 6).

Table 6. Station to multiple intelligence congruity.

Natural-istic	Math-logical	Linguistic Verbal	Musical	Visual-spatial	Kinesthetic	Inter-personal	Intra-personal
Watch Research	Research Explore	Read Write	N/A	Illustrate Organize	All stations Explore	All stations	Assess Write

Results of the Getting to Know You Survey measured each multiple intelligence that was present among students as dominant or weak (*N*=28). Some students had more than one for each category, therefore, the sample size does not match the total frequency.

The MIs that surfaced as the most as dominant are visual/spatial and bodily/kinesthetic, each having a frequency of eight. Naturalistic came close with a frequency of seven. No student had verbal/linguistic as their dominant MI. Also, each intelligence was present as a weakness except for naturalistic. The MI with the highest frequency of weakness was verbal/linguistic with a total of eight (Figure 1). In the Learning Preferences Interview, questions 10-18 belonged to the category of multiple intelligence (Appendix C). Of the four students interviewed, 100% said that they like activities that are logical/mathematical, musical, and naturalistic. Some comments about logical/mathematical included: “it gets the brain working,” and “I like conquering difficult challenges.” On music, one student replied: “music calms me down.” Another student said they “liked to sing, even though I’m not good at it.” For linguistic, kinesthetic, and interpersonal 75% said they like those activities and 50% said they liked visual/spatial activities and 50% said they didn’t. The two students who said they didn’t like visual/spatial activities were the boys. They both commented that they can visualize something without pictures, but graphs and charts do help them remember it. Finally, 25% said they liked intrapersonal activities. The one student who liked intrapersonal activities claimed to be an introvert and said “I’ve learned to have conversations in my brain” in regards to reflection and processing events that happen.

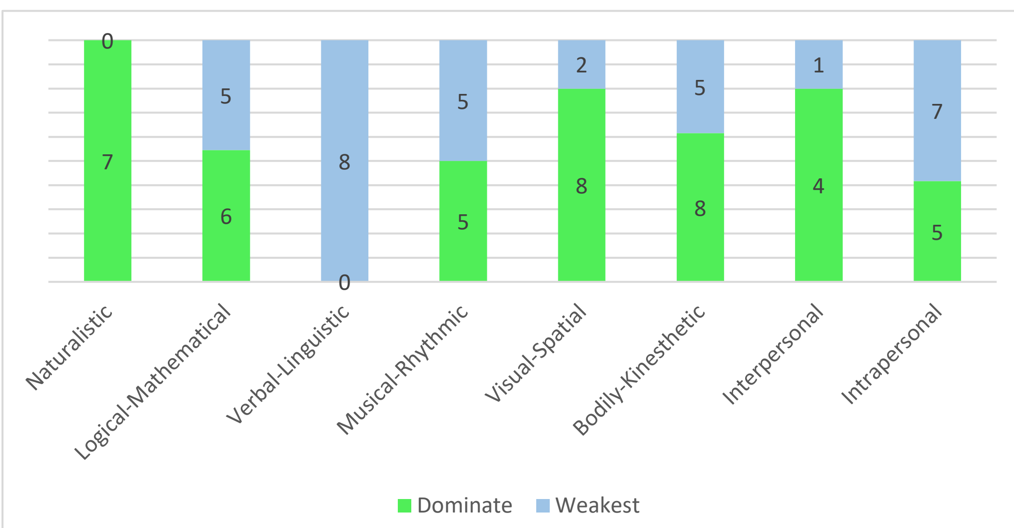

Figure 1. Frequency of dominant and weak MI’s.

To further analyze these results, dominant intelligence frequency was broken down by achievement levels (Table 7). High achievers were strong in math/logical, visual/spatial, and kinesthetic intelligences. Average achievers were strong in naturalistic and visual/spatial intelligences and the low achievers were strong in kinesthetic.

Table 7. Dominant MIs by achievement levels.

	Low	Medium	High
Naturalistic	1	3	3
Math/logic	1	1	4
Linguistic	0	0	0
Musical	1	1	3
Visual/spatial	2	3	4
Kinesthetic	3	2	4
Interpersonal	2	1	1
Intrapersonal	2	1	2

The tangible stations treatment for NGSS understanding occurred within the plate tectonics unit. To determine academic growth a box and whiskers plot of the pretest and posttest show a maximum of 88, a minimum of 12, and a median of 41 on the pretest and a maximum of 100, a minimum of 65, and median of 82 on the posttest for plate tectonics. There were no outliers (Figure 2). The normalized gain was 0.68 percent. This means a medium gain was achieved. The range of scores shortened from a pre-test of 76 to post-test of 35. The spread didn't change much from Q1-Q3, but as a whole, jumped up and the biggest student gain was the minimum of 12 on pre-test to a 100 on the post-test. Finally, 21% passed the pre-test with a score of 60% or above, and 100% passed the post-test.

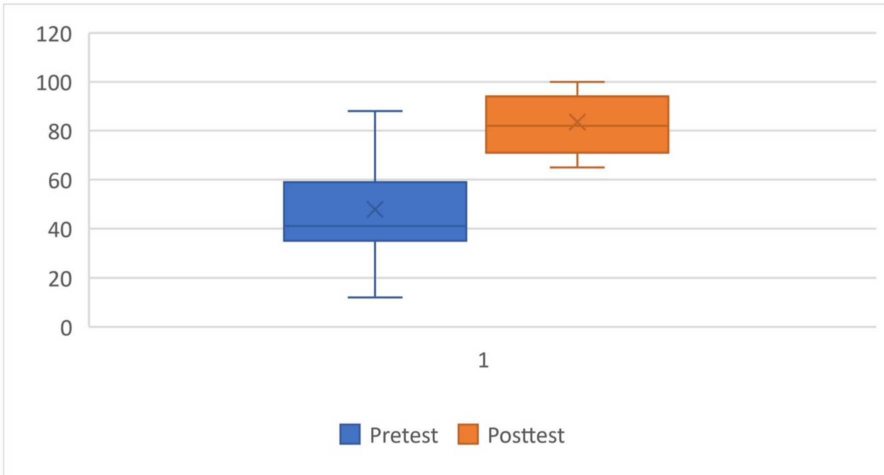

Figure 2. Distribution of scores-plate tectonics pre-test and post-test results.

The digital stations treatment covered volcanoes. To determine academic growth within in the volcanoes unit, a box and whiskers plot of the pretest and posttest show a maximum of 87, a minimum of 27, and a median of 63 on the pretest and a maximum of 100, a minimum of 47, and a median of 73 on the posttest for volcanoes. There were no outliers (Figure 3). The normalized gain was 0.14 percent. This means a low gain was achieved. Of the three units with pre- and post-data, the volcanoes unit had the highest pre-test median, but the lowest post-test median. Three students' scores remained stagnant. It's important to note that this unit was not as extensive as the other two. It didn't follow a true 5-E model like the plate tectonics and rock cycle units did.

The spread of post-test data closed in around the median, which indicated the lower scoring students brought their grades up to the median.

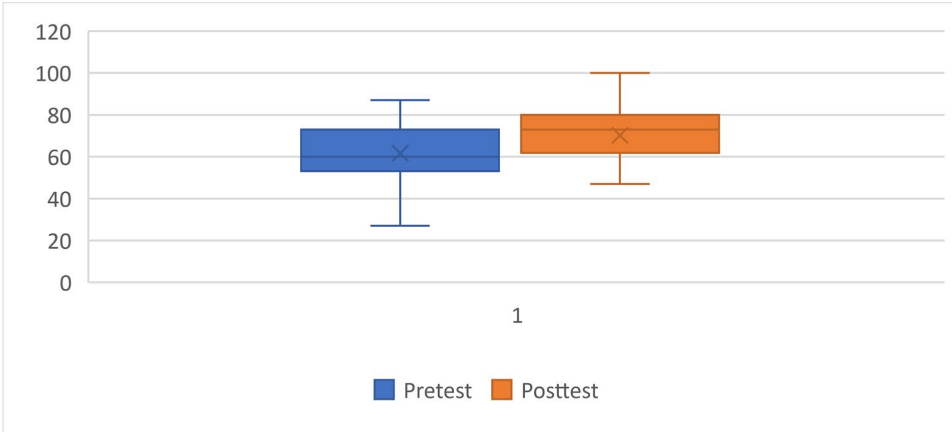

Figure 3. Distribution of scores-volcanoes pre-test and post-test results.

The non-treatment lesson covered the rock cycle and students completed a blank rock cycle diagram in leu of stations. To determine academic growth within in the rock cycle topic, a box and whiskers plot of the pretest and posttest show a maximum of 59, a minimum of five, and a median of 29. 5 on the pretest and a maximum of 100, a minimum of 18, and a median of 91 on the posttest for rock cycle. There were two outliers of 18 and 23 in posttest data (Figure 4). The normalized gain was 0.74 percent. This means a high gain was achieved. The rock cycle unit had the only post-test results with outliers (18, 23). This affected the mean, which was 81% with the outliers and 86% without them. Out of all three units, rock cycle had the lowest pre-test median of 29.5 and minimum of 5 indicating scant prior knowledge. Noteworthy, are the students that had substantial gains: 5% jumped to 68% and 9% jumped to 94%.

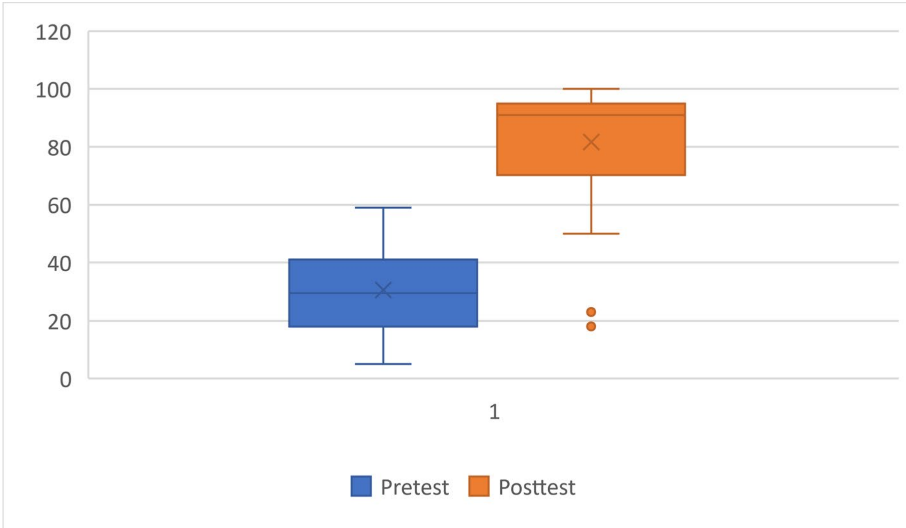

Figure 4. Distribution of scores-rock cycle pre-test and post-test results.

For these topics, each pretest and posttest were also subjected to a paired t-test. (Table 8). It is determined with a p-value of less than 0.0005 for all three units, we can we can be sure that the students made substantial gains over the course of the units, and scores were not the result of chance. Additionally, an analysis of variance (ANOVA) was performed on all posttests. With a p-value of 0.0006, we can determine there is a statistical difference between the three unit posttests.

Table 8. T-test and ANOVA Results.

Unit-pre-test/post-test	P(T<=t) two-tail
Plate Tectonics	0.0000
Volcanoes	0.0004
Rock Cycle	0.0000
All three-unit post-test analysis	ANOVA
	0.0006

Station lab sheet scores for plate tectonics and volcanoes were used to find correlation via a Pearson Correlation test with the performance task map score (Table 9).

After this correlation test was conducted, it was determined that the plate tectonics stations/map task had a correlation coefficient of 0.28. This suggests a weak positive relationship. For the volcanoes/map task correlation, a coefficient of 0.63 indicating a moderate positive correlation. So, if the stations scores were high, map scores were expected to be high as well.

Table 9. Pearson correlation of stations scores to map task scores.

Plate Tectonics Stations Score	1	0. 285434057
Map Score	0. 285434057	1
Volcanoes Stations Score	1	0. 631357753
Map Score	0. 631357753	1

Student engagement was measured using the Science Stations Student Self-Assessment Survey, teacher observations, and the Learning Preferences Interview. For the survey, scores of one and two were considered negative responses. A score or three and four were considered positive. In the category of effort, students' responses were nearly identical between digital and tangible modes (Figures 6 and 7). Negative responses equated to 17.3% of responses for digital and 16.7% for tangible. Meanwhile, positive responses in effort were 82.7% for digital and 83.3% for tangible indicating a larger percentage of students who believe they give the utmost effort regardless of modality (Figures 5 & 6). When it came to understanding, negative responses were 37. 5% for digital 25.9% for tangible. Positive responses were 62.5% for digital and 74.1% for tangible (Figures 7 & 8). These results showed that both modes had a higher positive percentage than negative. Students believed they had heightened understanding by means of the tangible modes.

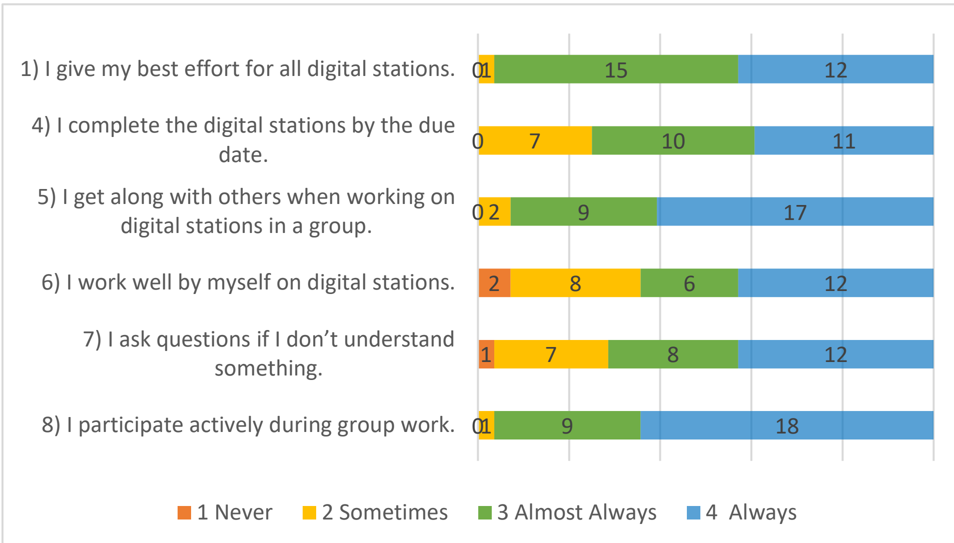

Figure 5. Opinions on effort in digital modes.

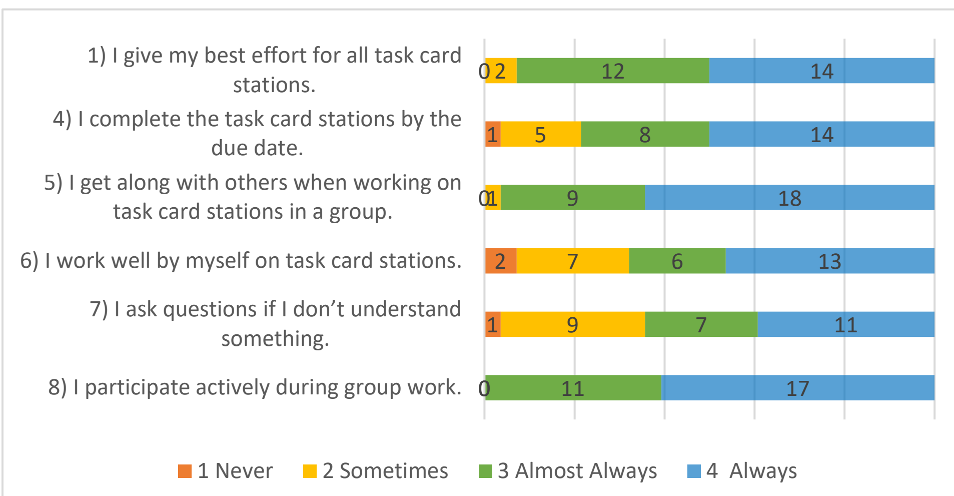

Figure 6. Opinions on effort in tangible modes.

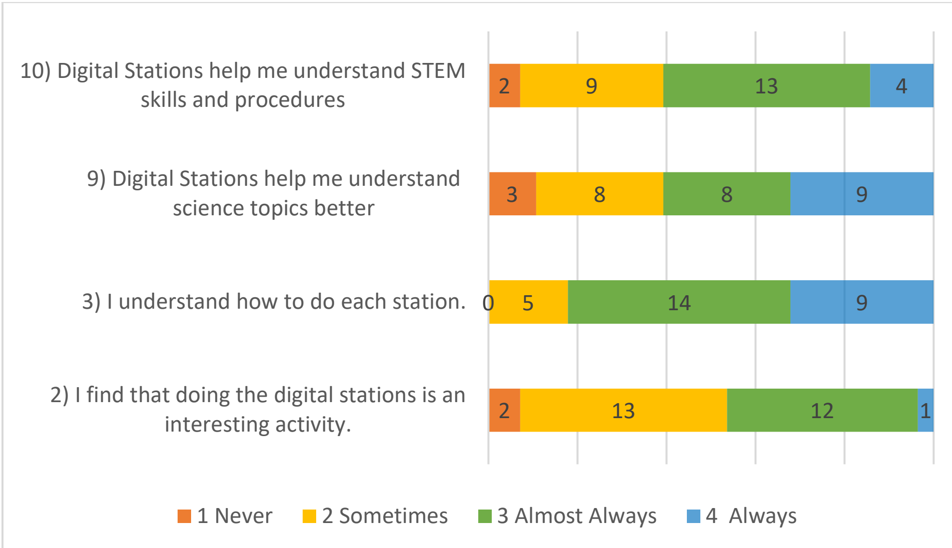

Figure 7. Opinion on understanding in digital modes.

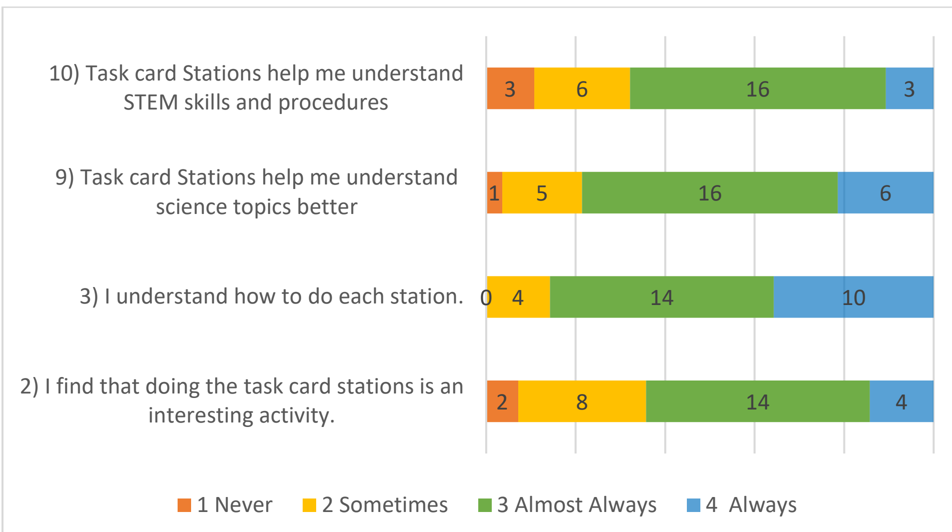

Figure 8. Opinion on understanding in tangible modes.

For the survey statement gauging interest in a career that includes STEM, positive and negative responses were not as skewed. Feedback showed that 47% of students had a negative response, while 53% were positive. This suggests that slightly more than half of the sample had an interest in STEM in general. In other words, 15 students had an interest in STEM and 13 did not. Of the 15 students who expressed a positive response, six were high achievers, three were average, and four were low.

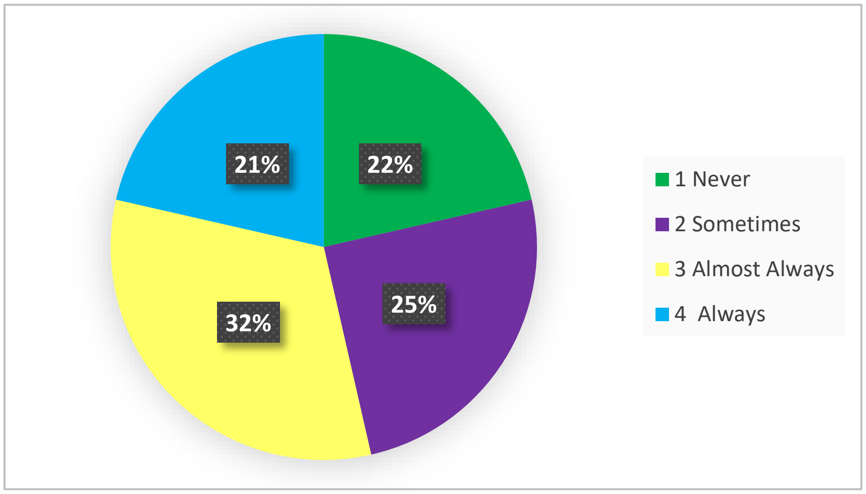

Figure 9. Opinion on a future career involving STEM.

When asked the question Which do you prefer: online delivery of stations or in-person delivery of stations? in the Learning Preferences Interview, three out of the four students preferred tangible mode versus digital mode. One student said “It’s easier to read. After looking at a computer screen for a while, it starts to hurt my eyes.” Another pointed out the reliability of tangible stations: “I like in-person because I have to have something to do. But I think what happens is I could accidentally delete or the technology crashes, but on paper, as long as you keep track of it, it will always be there.”

Outcomes of Part 2 of the survey determined which stations the students found to be easiest, hardest, and most and least interesting. The majority said that Illustrate it! was the easiest and most interesting, Assess it! was the hardest, and Write it was the least interesting (Table 10). The interview reflected some of this. When asked what their most and least favorite stations were, Illustrate It!, Write It!, Explore It!, and Research It!

were among their favorites while Read It! (3 out of 4) was the least favorite. However, they were also asked which station they would use to pass a quiz whether or not it was their favorite. The same number of students chose Read It! for this question as well. So, although it's the least interesting according to the students, it is also the station of choice for assessments.

Table 10. Frequency of individual station opinions.

	Watch	Read	Explore	Research	Organize	Illustrate	Write	Assess
Easiest	15	15	6	7	8	16	6	8
Hardest	5	4	9	10	9	5	12	13
Most interesting	10	6	13	8	7	14	4	3
Least interesting	3	13	3	8	10	7	16	9

Final analysis on student engagement came from teacher observations (Table 5). These were informal. In general, students were liveliest and energetic when working with tangible stations in collaboration with a partner for all units. Students were productive most of the time. Off-task behavior observed the most were off topic conversations, goofing off, and lack of participation from one member of the group. However, students turned in more complete work with the tangible lab sheets. When digital modes were completed, students were quieter, but had less peer-to-peer interactions, which resulted in a less-productive environment. Digital mode slideshows had a higher rate of incompletion and late submissions, as well. Off-task behaviors comprised of unrelated web searches, playing with slideshow tools, emailing friends, and mindlessly tapping on the keyboard.

In summary, all multiple intelligences were present in all stations except the musical MI. In the student sample, visual/spatial and bodily/kinesthetic were the two most dominant MIs and linguistic was the weakest. Further, high achievers were strong in math/logical, visual/spatial, and kinesthetic MIs. Average achievers were higher in naturalistic and visual/spatial, and low achievers were strong in kinesthetic. The focus group from the interview indicated that logical/mathematical, musical, and naturalistic activities were preferred. A medium normalized gain of 0.68 occurred for the unit of plate tectonics, a low normalized gain of 0.14 occurred for the volcanoes unit, and a high normalized gain of 0.74 occurred with the rock cycle unit. With a p-value of less than 0.0005 for all three units, students made substantial gains and were not the results of chance. An analysis of variance for all three post-tests determined a p-value of 0.0006 meaning there was a statistical difference between the groups. A Pearson correlation test between station lab sheets for plate tectonics and volcanoes with a performance assessment map revealed a correlation coefficient of 0.28 for plate tectonics with the map revealing a moderate positive correlation. A correlation coefficient of 0.63 indicated a moderate positive correlation between the volcanoes score and the map. Students believed they put equal effort into digital and tangible stations as indicated by the Learning Preferences Survey with positive responses of 82.7% for digital stations and 83.3% for tangible stations. Opinions from this survey showed the students believed they had a higher understanding of content when given stations in tangible modes with 62.5% positive responses for digital modes and 74.1% positive responses for tangible. Teacher observations found that tangible off-task behaviors included off-topic conversations, goofing off, and lack of effort from some students. Off task behavior observed when completing digital stations included unrelated web searches, playing with slideshow tools, emailing friends, and mindlessly tapping on the keyboard. STEM career interest showed that 53% of the sample indicated they would pursue a career in STEM. The Illustrate It! station was found to be the easiest and most interesting, while Assess It! was the hardest and Write It! was the least interesting. So, gains were made in all modes and treatments, MIs were covered well, and tangible modes produced the most understanding.

CLAIM, EVIDENCE, AND REASONING

Claims from Study

The science stations approach supports and strengthens multiple intelligences, NGSS standards mastery, and student engagement.

Multiple Intelligences

All multiple intelligences were represented in at least two stations, catering to the wide array of diverse learners in this research. Through the Getting to Know you Survey, I learned that most of the students from this sample were strong in the visual/spatial, kinesthetic, and naturalistic MIs. This fact is supported by other instruments. For example, the Science Stations Student Self-Assessment Survey revealed strong positive responses that highlighted the Illustrate It! station, supporting those dominant visual/spatial learners. Responses from the Learning Preferences Interview showed that the two girls needed visual representation to see data, while the two boys said they can already visualize things on their own, but charts and graphs help them to remember what they see. The inherent mechanisms of the stations approach support the kinesthetic MI. I observed a more energetic class when the students completed tangible stations, especially in a collaborative setting. In the "pandemic" classroom, they couldn't move from station to station, but they were still able to do hands-on activities through the Explore It! and Organize It! stations. The naturalistic MI was also dominant. Although the main reason students ranked high in the naturalistic MI was their affinity for animals, which was not represented in my curriculum, they did enjoy going outside and observing nature. The Watch It! and Research It! stations had lots of nature imagery. They were weakest in in the verbal/linguistic MI. The self-assessment survey indicated strong negative responses to the Write it! station. Most of the students said that Read It! was their least favorite in the interview. Interestingly, those same students chose the Read It! station above all others when asked which one they would choose to help them pass a quiz. So, although they didn't like it as much, they still found value in it. In the study by Winarti et al., results showed that students showed a significant gain in scores from the MI-based curriculum. Stations can follow some of those steps suggested by the authors when giving a MI-based lessons. Step 1 is to have students reflect on their study habits and hobbies; in my case, the surveys satisfied this step. The stations approach provides various MI-based activities for which steps 2-4 suggest. Stations cover the wide array of abilities matched by the multiple intelligences.

NGSS Understanding

As I try and incorporate more of the NGSS standards in my classroom, I wanted to know just how well they were represented in this stations approach. In just one unit, I found the standards were covered very well, giving me the green light to measure academic growth and achievement within the realm of the standards by way of the stations approach. I believe the stations supported NGSS mastery. Student's knowledge and skills grew from pre-test to post-test in all units assessed as shown by the data in the box and whisker's plots. Although the only high normalized gain appeared in the non-treatment unit, I attribute this to a much lower pre-test median score (29.5%) compared to digital (41%) and tangible (47%) treatments. Post-test medians for treatments and non-treatments ranged from 73% to 91%. Since NGSS standards mastery was measured only within the Dynamic Earth topic, results from the map task and their correlation with lab sheet scores proved that stations helped with mastery, at least as it is shown with the volcano/map correlation coefficient of 0.6 meaning a moderate positive correlation. This can be supported by teacher observations as well. The students were required to tap more prior knowledge learned from the volcano stations as opposed to the plate tectonic stations when it came to completing their maps. Ocak's (2010) study found that learning stations helped with post-test gains. In his study, he gave the post-test six weeks after the lesson. The results showed that students retained knowledge gained from the stations. I didn't test for retention, but my students did have significant gains after stations completion. Ocak used t-tests to ensure the results were in fact real gains. The results had a p-value of 0.000. I also performed t-tests with the very similar results. NGSS standards are covered well in the Kesler Science stations and students had significant gains, therefore stations positively influenced understanding.

Student Engagement

Before looking into interest and engagement in science stations, I wanted to get a snapshot of what students thought about their future aspirations involving STEM. This helped me see that there were not as many students who felt that science, technology, engineering, or math was part of their future ambitions as shown in the pie chart indicating only 15 students had a positive response. For now, this was secondary to the rest of the data when I looked into student engagement levels. I looked into which mode encouraged student engagement. Students showed in the self-assessment survey that nearly equal effort was given in both digital and tangible stations. My observations do not support this. Digital stations were more frequently incomplete and late at the time of submission. When it came to statements within the category of understanding, tangible stations received more positive responses. By observing the quality of their work samples, I can confirm this. When comparing e-learning to traditional classroom techniques, Titthisiri took mean scores from three tests and compared them for quantitative data and a conducted a student interview for qualitative data. Titthisiri's version of e-learning means following lessons in an asynchronous format, which was not the case in my study. Students had to work on digital modes of stations during class time in person or remotely. This way they could ask questions in real time. One of the negative responses in Titthisiri's interview stated that it was difficult to get answers to questions when needed. I also used an interview for qualitative data in my study. Interview responses provided insight that surveys and other types of data cannot. Although in general, students in the sample didn't have a high rate of STEM ambitions, tangible stations specifically encouraged student engagement, collaboration, and better work quality for those science units.

Value of the Study and Considerations for Future Research

The science stations approach has been a part of my teaching strategy for at least three years. I usually implement this as part of a 5-E model for the explore stage. I appreciate its variety of tasks and skills and the versatility of its delivery methods and content. When choosing the topic for this research, I struggled to find information or studies done on science stations. This study enlightened me to its effectiveness in my Earth and space classroom. Conclusions from the study will give other educators a picture of the influence science stations have in a middle school science class setting. I now have a reference to find which stations match the multiple intelligences and where the NGSS standards are found in them, hopefully helping other teachers who seek this information.

In future research, finding the multiple intelligences of students will likely be included again. This research strengthened the case for MI for me, and I feel as if it gave me great insight into how students learn best. STEM will be a bigger theme and serve a bigger purpose. Knowing that roughly half of my students see themselves in a STEM career is not enough for me. I didn't have a clear picture of this until now, but I'm motivated to bring that percentage up. I get the feeling that a lot of my students do not realize there is a huge variety of careers that fall into STEM fields and that creativity is needed in addition to logic, math, technology, or science skills.

Impact of Action Research on Author

This research helped me get to know my students on a deeper level and helped me see why they succeeded at times and failed at others. They surpassed all of my expectations, especially on the performance task map. This research forced me to work harder than I ever have and I found strength at times when I thought I had none left. Going forward, the findings in this research strengthened my case to continue using the 5-E model, but also correct the weaknesses in my own instructional methods. Inquiry should have a bigger part in my instructional practices. I know that some parts of STEM are often not incorporated enough such as the engineering and math components. The rigor of action research kept me on top of my own teaching and reminded me that data analysis has important value, not just in student academic scores, but in the overall picture of a middle school Earth and space classroom.

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APPENDICES

APPENDIX A

IRB EXEMPTION

MONTANA STATE UNIVERSITY

INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

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MEMORANDUM

TO: Stephanie Snouffer and Marcie Reuer

FROM: Mark Quinn *Mark Quinn* *cy*
Chair, Institutional Review Board for the Protection of Human Subjects

DATE: October 26, 2020

RE: *"The Influence of the Science Stations Approach in a Sixth Grade Earth and Space Classroom" [SS102620-EX]*

The above research, described in your submission of October 26, 2020, 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:

_X_ (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.

_X_ (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

GETTING TO KNOW YOU SURVEY

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

Name ______________________________

Getting To Know You Survey

Directions:

Fold the paper on the dark vertical line so that the eight columns on the right are folded back. Then read each statement below. Rate each statement from 0 to 5 according to how well the description fits you (0 = Not at All to 5 = Very True) Next unfold the paper and transfer each number over to the outlined block on the same row. Finally, add the numbers in each column to find the total score for each multiple intelligence area. The highest possible score in one area is 15. How many ways are you smart?

Which of the following are true about you?	0-5	Naturalist	Mathematical-Logical	Verbal-Linguistic	Musical-Rhythmic	Visual-Spatial	Bodily-Kinesthetic	Interpersonal	Intrapersonal
I enjoy singing and I sing well.									
I love crossword puzzles and other word games.									
I like spending time by myself.									
Charts, maps, and graphic organizers help me learn.									
I learn best when I can talk over a new idea.									
I enjoy art, photography, or doing craft projects.									
I often listen to music in my free time.									
I get along well with different types of people.									
I often think about my goals and dreams for the future.									
I enjoy studying about the earth and nature.									
I enjoy caring for pets and other animals.									
I love projects that involve acting or moving.									
Written assignments are usually easy for me.									
I can learn new math ideas easily.									
I play a musical instrument (or would like to).									
I am good at physical activities like sports or dancing.									
I like to play games involving numbers and logic.									
My best way to learn is by doing hands-on activities.									
I love painting, drawing, or designing on the computer.									
I often help others without being asked.									
I enjoy being outside in all types of weather.									
I love the challenge of solving a difficult math problem.									
Having quiet time to think over ideas is important to me.									
I read for pleasure every day.									
Totals →									
		Nature	Math	Word	Music	Art	Body	People	Self

APPENDIX C

LEARNING PREFERENCES INTERVIEW

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

Learning Preferences Interview

1. Order the following activities in order from the ones you learn best to worst. *See card below for students to view

a) Textbook readings

b) Posters

c) Hands-on color/cut/paste

d) Videos with worksheets

e) Science stations

f) Digital lessons

g) Online research

h) Labs (such as paper rocket lab or penny water drop lab)

2. Why did you order them in this way?

3. Do you think you learn better in groups, a whole class, or by yourself? Why?

4. Thinking about the science stations, which one is your favorite? Why?

5. Which science station is your least favorite? Why?

6. If you were to choose one station to use to pass a quiz, which one would it be? In other words, which station do you learn best from whether it's one you like or not?

7. Do you think the different activities in stations help different learners? Why?

8. If you were to create your own station, what would learners be doing?

9. Which do you prefer: Online delivery of stations or in-person delivery of stations? Why?

10. Do you like activities that are: Logical/mathematical? Why or why not?

11. Linguistic? Why or why not?

12. Musical? Why or why not?

13. Kinesthetic? Why or why not?

14. Naturalist? Why or why not?

15. Interpersonal? Why or why not?

16. Intrapersonal? Why or why not?

17. Visual/spatial? Why or why not?

18. Is there anything else you would like for me to know?

*****Explain what each one means to the interviewee**

APPENDIX D

PLATE TECTONICS PRE- AND POST-TEST

Plate Tectonics Pre- and Post- Test

1. Created by a divergent boundary.

a) Rocky Mountains
b) Mariana Trench
c) Mid Atlantic ridge

2. Mountains form from . . .

a) Plates sliding past one another
b) Collision of plates
c) Plates moving away from each other

3. During sea floor spreading, molten material rises up from the mantle. . .

a) Along the continents
b) At the mid ocean ridges
c) Deep ocean trenches
d) At north and south poles

4. Which of the following is an area where one plate slides under another plate?

a) Submarine zone
b) Divergence zone
c) Subduction zone
d) Lower zone

5. The area around the pacific plate where boundaries form is called. . .

a) Death ring
b) Fire zone
c) Ring of fire
d) Zone of fire

6. These are associated with transform boundaries.

a) Volcanoes
b) Mountains
c) Trenches
d) Earthquakes

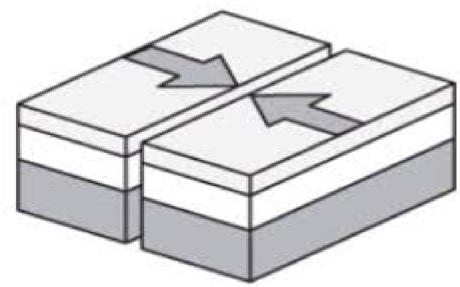
7. This land formation occurs at a divergent continental/ continental boundary.

a) Mid ocean ridge
b) Deep ocean trench
c) Pacific hot spot
d) Rift valley

8. What happens to temperature as you go deeper in the Earth?

a) Decreases
b) Increases
c) Fluctuates
d) Remains the same

9. Name the boundary

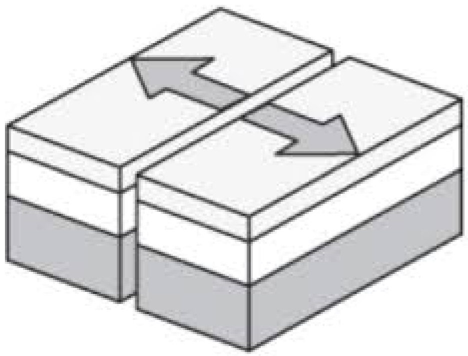


a) Convergent boundary
b) Divergent boundary
c) Transform boundary
d) Sergeant boundary

10. What is represented by the picture?

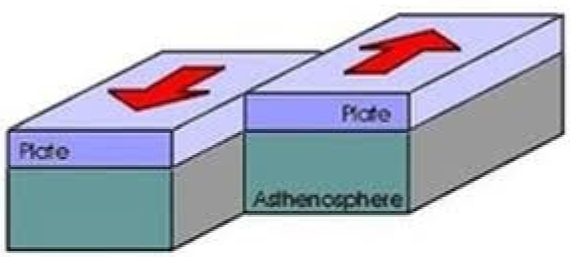
a) Sea-floor spreading
b) Pangea
c) How the continents are arranged today
d) Volcanoes

11. Name the boundary



a) Convergent boundary
b) Divergent boundary
c) Transform boundary
d) Sergeant boundary

12. Name the boundary



a) Convergent boundary
b) Divergent boundary
c) Transform boundary
d) Sergeant boundary

13. Which type of crust is more dense and thinner?

a) Continental
b) Asthenosphere

c) Oceanic
d) Byers

14. What was Wegener's hypothesis called?

a) The Pangea
b) Moving Continents
c) The Continental Drift
d) Tectonic Plates

15. Why was Alfred Wegner's theory of Continental Drift not immediately accepted by scientists?

a) There was no mechanism to explain how Continental Drift happened.
b) The theory of Continental Drift was immediately accepted by the scientific community.
c) There was no evidence to support his theory.
d) Scientists did not think it was possible for the Continents to move.

16. A location where two tectonic plates collide is known as a _________ boundary.

a) Convergent
b) Divergent
c) Transform
d) Spreading

17. Which answer describes the formation of a volcanic island arc?

a) Islands are created along the mid ocean ridge as new oceanic crust is formed.
b) Islands are created one at a time as the plate moves across a hot spot in the mantle.
c) Islands are created along a subduction zone as oceanic crust is forced back down in to the mantle.
d) Islands are created as pressure is released when two tectonic plates are pulled apart.

APPENDIX E

VOCANOES PRE- AND POST-TEST

Volcano Pre- and Post- Test

1. What is a dormant volcano?

a) Molten rock
b) The center of a volcano
c) Will never erupt again
d) Volcano that is sleeping, but could erupt again

2. What is magma?

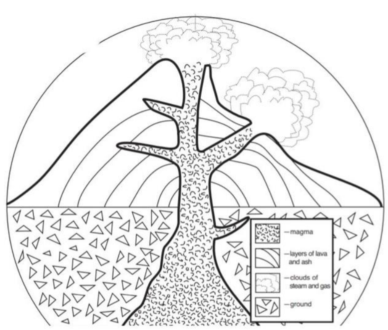
a) Pieces of the Earth's crust
b) Molten rock inside of a volcano
c) Small rock
d) Plates that meet

3. What is lava?

a) Molten rocks inside a volcano
b) Molten rock outside a volcano
c) Small rocks
d) Magma

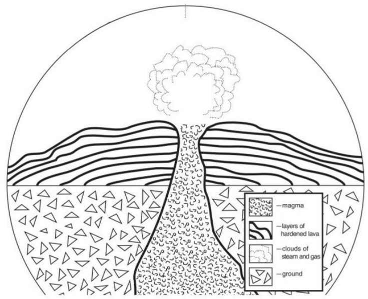
4. A dead volcano is called what?

a) Active
b) Dormant
c) Extinct



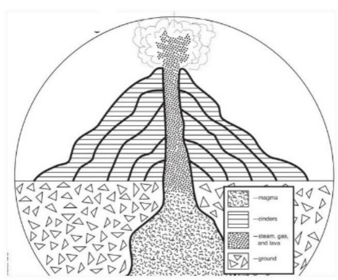
5.
What type of volcano is shown on the model above?

a) Composite Volcano
b) Shield Volcano
c) Cinder Cone Volcano



6.
What type of volcano is shown on the model above?

a) Shield Volcano
b) Composite Volcano
c) Cinder Cone Volcano



7.
What type of volcano is shown on the model above?

a) Cinder Cone Volcano
b) Composite Volcano
c) Shield Volcano

8. Which of the following terms are used to describe a volcano that may erupt at any time?

a) Dormant volcano
b) Active volcano
c) Extinct volcano
d) Shield volcano

9. Magma becomes lava when it reaches a volcano's ______.

a) Vent
b) Crater
c) Chamber

d) Mantle

10. In a volcano, magma collects in a pocket called ________.

a) Magma flow
b) Magma chamber
c) Magma pipe
d) Hot spot

11. A ______ is a duct connecting the magma chamber and the outside of the volcano.

a) Vent
b) Crater
c) Lava flow
d) Volcanic cone

12. An opening on the Earth's crust through which hot molten rock flows out from deep inside the Earth.

a) Volcano
b) Fault line
c) Fold
d) Crater

13. Rank the volcanic stages from LEAST likely to MOST likely to erupt.

a) Active, dormant, extinct
b) Extinct, dormant, active
c) Dormant, extinct, active
d) Dormant, active, extinct

14. Why does the volcanic eruption happen?

a) When the pressure on magma chamber inside earth increase and push magma to the surface.
b) When it forms by eruption lava and ash.
c) When rock underground suddenly breaks along a fault.

15. A volcano is a mountain that has an opening to allow hot vapor, and gas to escape from the pool of magma below.

a) True
b) False

APPENDIX F

ROCK CYCLE PRE- AND POST-TEST

Rock cycle pre- and post- test

1. What are the three rock types?

____

2. How can subsidence lead to the formation of sedimentary rock?

____

3. Why are rift zones common places for igneous rock to form?

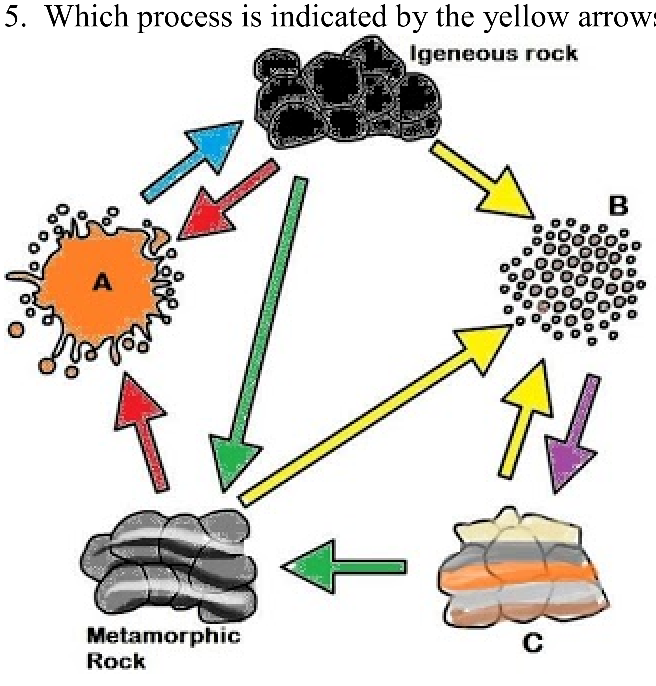
____

4. Granite is an igneous rock that forms from magma cooled below Earth's surface. Why would granite have larger crystals than igneous rocks formed from lava cooled above Earth's surface?

____

____

5. Which process is indicated by the yellow arrows?



a) Melting
b) Heat and pressure
c) Erosion and weathering

d) Compaction and cementation

8. Which choice best identifies "B" in the diagram?
a) Dirt
b) Magma
c) Cooling
d) Sediment

9. Over the span of a million years, a metamorphic rock became an igneous rock. After ten million years, that igneous rock then became part of a sedimentary rock. Determine the order of Earth's processes the rock took through the rock cycle.
a) Heat and pressure, cooling, melting, sedimentation
b) Melting, cooling, sedimentation, compaction and cementation
c) Compaction and cementation, heat and pressure, cooling, melting
d) Sedimentation, melting, compaction and cementation, heat and pressure

10. Name two ways igneous rock can become a metamorphic rock. Include all of the components and processes. (Remember that the igneous rock may change several times before becoming metamorphic. Include all steps). Feel free to use the diagram above to help you.

____

____

____

____

APPENDIX G

TECTONIC PLATE, VOLCANO, EARTHQUAKE MAP

Tectonic Plates, Volcano, Earthquake Map

In Google classroom, use the top link (map) to draw all tectonic plate boundaries on your own map and label the plates: https://www. dkfindout. com/us/earth/tectonic-plates/where-are-earths-tectonic-plates/

Then use the bottom link to plot and label the currently active volcanoes and recent earthquakes. https://earthquakes. volcanodiscovery. com/

You will need to click on the individual volcano (indicated by red or orange) and earthquake (indicated by circles) to get the info from it.

Checklist:

_____ Compass rose showing N, S, E, W

_____ Legend or key for the volcanoes, earthquakes, and plate boundary lines

_____ Plate boundaries are drawn in BLACK

_____ The following plates are named:

- African
- Eurasian
- Philippine
- Indo-Australian
- Antarctic
- Pacific
- Juan de Fuca
- North American
- Cocos
- Caribbean
- South American
- Nazca
- Scotia
- Arabian

_____ **Seven** volcanoes colored RED

_____ Each volcano has a name

_____ Each volcano has a type (ex: stratovolcano, shield, etc.)

_____ **Three** recent earthquakes colored PURPLE

_____ Each earthquake has the magnitude (shown with an M in front; Ex: M4. 4)

_____ Each earthquake has the date it occurred

APPENDIX H

SCIENCE STATIONS STUDENT SELF-ASSESSMENT SURVEY

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

Name: ___________________________ **Hour:** _____________________

Science Stations Student Self-Assessment

Digital Stations:

1=never, 2=sometimes, 3 almost always, 4=always	**Never**	**Some times**	**Almost Always**	**Always**
1) I give my best effort for all digital stations.	**1**	**2**	**3**	**4**
2) I find that doing the digital stations is an interesting activity.	**1**	**2**	**3**	**4**
3) I understand how to do each station.	**1**	**2**	**3**	**4**
4) I complete the digital stations by the due date.	**1**	**2**	**3**	**4**
5) I get along with others when working on digital stations in a group.	**1**	**2**	**3**	**4**
6) I work well by myself on digital stations.	**1**	**2**	**3**	**4**
7) I ask questions if I don't understand something.	**1**	**2**	**3**	**4**
8) I participate actively during group work.	**1**	**2**	**3**	**4**
9) Digital Stations help me understand science topics better (example: atmosphere, gravity, plate tectonics, etc.)	**1**	**2**	**3**	**4**
10) Digital Stations help me understand STEM skills and procedures (example: using or making models, interpreting graphs, constructing a scientific explanation, etc.).	**1**	**2**	**3**	**4**

STEM Interest

11) I am interested in a career that includes STEM (Science, Technology, Engineering, or Math)	**1**	**2**	**3**	**4**

Task Card with Lab sheet stations:

1=never, 2=sometimes, 3 almost always, 4=always	**Never**	**Some times**	**Almost Always**	**Always**
1) I give my best effort for all task card stations.	**1**	**2**	**3**	**4**
2) I find that doing the task card stations is an interesting activity.	**1**	**2**	**3**	**4**
3) I understand how to do each station.	**1**	**2**	**3**	**4**
4) I complete the task card stations by the due date.	**1**	**2**	**3**	**4**
5) I get along with others when working on task card stations in a group.	**1**	**2**	**3**	**4**
6) I work well by myself on task card stations.	**1**	**2**	**3**	**4**
7) I ask questions if I don't understand something.	**1**	**2**	**3**	**4**
8) I participate actively during group work.	**1**	**2**	**3**	**4**
9) Task card Stations help me understand science topics better (example: atmosphere, gravity, plate tectonics, etc.)	**1**	**2**	**3**	**4**
10) Task card Stations help me understand STEM skills and procedures (example: using or making models, interpreting graphs, constructing a scientific explanation, etc.).	**1**	**2**	**3**	**4**

Stations you find to be the ***easiest:*** (circle all that apply)

Watch	Read	Explore	Research	Organize	Illustrate	Write	Assess

Stations you find to be the ***hardest:*** (circle all that apply)

Watch	Read	Explore	Research	Organize	Illustrate	Write	Assess

Stations you find **MOST** ***interesting***: (circle all that apply)

Watch	Read	Explore	Research	Organize	Illustrate	Write	Assess

Stations you find **LEAST** ***interesting***: (circle all that apply)

Watch	Read	Explore	Research	Organize	Illustrate	Write	Assess

Created by Stephanie Snouffer