THE CONNECTION BETWEEN ARGUMENTATION AND SCIENTIFIC EXPLANATIONS

by

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ABSTRACT

Elementary students often focus on what they are doing during hands on science investigations that they fail to make accurate observations in order to explain what happened and why. This study analyzed the use of argumentation activities and the impact on students' abilities to explain scientific phenomena. Students engaged in argument through consensus building jigsaws and assigned audience roles that focused on specific aspects of explanations. The results indicate that students were more focused on making observations to enable them to make claims based on evidence after engaging in scientific argument.

INTRODUCTION AND BACKGROUND

Barnette Elementary School is a suburban public school in Huntersville, North Carolina that opened in August of 2008. There are approximately 650 students enrolled in grades PreK-5. Seventy-two percent of the students are Caucasian, 15% are African American, 7% are Hispanic, and 18% of the students are on free and reduced lunch (D.D. Newman, personal communication, April 6, 2014). I have been teaching for 19 years at the elementary level. I currently teach one fourth and two fifth grade science and social studies blocks. In 2014-2015, my school implemented the Student Success by Design model where students are flexibly grouped across two grade levels to better meet the needs of each student. This model allows teachers to focus on one or two content areas based on interest and based on data that demonstrates high levels of student growth.

Over the past several years, I have recognized a significant focus on literacy and math as a priority in elementary classrooms due to North Carolina's End of Grade testing for grades 3-5. As the focus for these two content areas became the primary focus, I would often run out of time for science lessons. This problem occurred regardless of the school I was teaching in or the grade level. In 2010 I decided to pursue the development of a science lab for my school. I wanted to set the expectations for the school community that science is necessary in developing higher level thinking skills that could be integrated into all content areas. For four years I taught the science lab for my school. All students attended weekly labs for forty-five minutes. I developed labs in collaboration with classroom teachers in order match the lab to the content being covered in the classroom.

After teaching the science lab for four years, I had noticed improvements in many areas. Students were able to make predictions based on prior knowledge, make observations, ask questions and use scientific vocabulary. One area that continued to need improvement was the students' ability to use evidence to make claims about the investigations they conducted. The students were often so focused on what they are doing that they failed to make observations about why it happened. Students tended to hold on to misconceptions even after faced with evidence. They also needed to learn how to distinguish evidence from opinions. Additionally, many of my students needed to develop listening skills in order to ask questions about others' arguments. I wondered if the use of argumentation activities would help my students develop explanations of scientific phenomena using claims, evidence and reasoning.

The purpose of this study was to determine the impact of argumentation through the use of argumentation scaffolding activities on fourth grade students' ability to explain scientific phenomena. My focus question was *How does engagement in argument impact students' abilities to form explanations of scientific phenomena?* My sub questions were

1. Do argument driven activities increase students' behavioral and cognitive engagement?
2. How do argument scaffolding activities affect student learning?

CONCEPTUAL FRAMEWORK

Science instruction has focused more on what students know, rather than how they know. Students often lack the ability to support claims with data or evidence and will often use opinions or seek the answer from the teacher. Science educators are seeing a shift that focuses more on the evidence and how students construct meaning from

explanations. In the past, curricula have been developed to expose students to many different scientific concepts without engaging students with in-depth understanding of content. Students are graduating from high school and college without sufficient understanding of science, engineering or technology, let alone an understanding of how work is done in those fields. *A Framework for K-12 Education* addresses eight practices that students should know and be able to do by the twelfth grade. One of the practices: *engaging in argument from evidence*, is a practice that can support student learning processes in the classroom (National Research Council, 2012).

Many students lack interest in science due to standards that focus on rote memorization of facts and tests that focus on recall of those facts. Due to increased testing, memorizing facts has become more important than developing critical thinking skills (Osborne, 2010). Critical thinking requires students to think reflectively. When students think reflectively, they are engaging in inner argument, trying to decide what to believe. They are being skeptical, which is a critical thinking skill. Students who are able to think critically will look for evidence to support their beliefs (Erduran & Jimenez-Aleixandre, 2007). Discussion will force students to explain what they know and defend that understanding by merging prior knowledge with new understandings to make sense of new content (Shemwell & Furtak, 2010).

Argumentation is a scientific practice educators can use to develop conceptual understanding of content. While engaging in argument, students will simultaneously increase their ability to reason. When students are engaged in discussions, higher-order thinking skills are developing. When students can reason, they are able to think critically

about the concepts they are learning (Osborne, 2010). Kuhn's (1991) approach to argumentation is that reasoning skills are developed when two or more individuals consider alternatives to their own ideas or claims and are open to the possibility of being wrong.

There are some misunderstandings in the research regarding the terms argumentation and discussion, and they are often used interchangeably. According to *Taking Science to School: Learning and teaching science in grades K-8* (NRC, 2007), argumentation is when any type of discussion takes place; at other times it is when claims are evaluated based on evidence. Shemwell and Furtak (2010) believe argumentation is a subcategory of discussion. They take the perspective that argumentation is persuasion, and the student must be able to critique the other person's ideas. Discussion is an exchange of ideas. Duschl and Osborne (2002) define scientific argumentation as "the special case when the dialog addresses the coordination of evidence and theory to advance an explanation, a model, a prediction, or an evaluation" (p. 55).

Research indicates there are two distinct types of argumentation. One is structural, where the focus is on claims, evidence and reasoning (McNeill, Lizottle, Krajcik & Marx, 2006). Some researchers will include justification as part of the structure of argumentation practices (McNeill & Knight, 2013). The second type of argumentation is dialogic. Dialogic argumentation is focused on the dialogue to persuade others about their claim (Erduran & Jimenez-Aleixandre, 2007; McNeill & Pimental, 2010). Dialogic arguments occur when different points of view or alternate claims are considered in the course of the argument (Driver, Newton, & Osborne, 1998).

Educators face many challenges in using argumentation as part of their instructional practice. One challenge is time. Educators need to provide more time for discourse and argument during class. This will give students the social environment needed to construct new knowledge (Erduran & Jimenez-Aleixandre, 2007). Additionally, most elementary science lessons tend to focus on activities that are fun, hands-on, and involve little connection to scientific concepts and principles (Zembal-Saul, McNeill, & Hershberger, 2013). Another challenge is the lack of professional development on how to incorporate argumentation as part of the instructional design. McNeill and Knight (2013) focused on professional development of pedagogical content knowledge in argumentation to center on knowledge of students' conceptions and knowledge of instructional strategies. There were four themes that emerged as teachers participated in this study on professional development in argumentation.

The first theme centered on the teacher's ability to analyze the structural components of written arguments by students. Teachers were found to be able to identify students' use of evidence before and after participating in professional development. They also increased their ability to identify claims and reasoning. However, reasoning continued to be the most difficult to teach. A continued focus of professional development on this aspect of argumentation was critical in developing capabilities to create learning opportunities for students to develop reasoning skills (McNeill & Knight, 2013).

The second theme found that teachers focused on the students' understanding of the content rather than the components of the argument. There was less analysis of the

structure of student arguments in a dialogic setting. The teachers also discussed the constraints of using argumentation in class discussions. This indicates the professional development was not effective in developing strategies to move past these barriers and develop the capability to support the argumentation practice (McNeill & Knight, 2013).

Developing the question to facilitate argumentation was the third common theme found among the teachers. Most questions developed by the teachers did not support students in making claims by using evidence. A majority of the questions tended to focus on building content knowledge. Forty-eight percent of the questions used in the study expected students to explain concepts instead of making claims and using evidence (McNeill & Knight, 2013).

The final theme indicated elementary teachers would make connections between scientific argumentation and other subject areas. Secondary teachers were more focused on the content of the arguments and never made any connections to how argumentation is used in other disciplines. Many teachers wondered how to teach argumentation skills along with science content. This conflict demonstrates how difficult it can be if teachers try to separate argumentation skills from science content. McNeil and Knight (2013) indicated teachers need to understand "strong student argumentation (regardless of the focus on structure or dialogic interactions) would include rich science content and offer opportunities to push students' conceptual understanding" (p. 964).

As a result of their study, McNeill and Knight found that although teachers developed an understanding of argumentation, they had difficulty analyzing oral arguments for both structure and dialogic interactions. This finding was similar to other

research in which teachers and students alike have difficulty identifying claims, evidence and reasoning (Osborne & Patterson, 2011; Duschl & Osborne, 2002). Consequently, McNeill and Knight believe teachers would benefit from building an in-depth understanding of claims and evidence used in argument before reasoning.

Argumentation in science will be difficult to implement effectively in the classroom setting unless research can come to a consensus on an argumentation model. Erduran and Jimenez-Aleixandre (2007) stated that argumentation is a social activity that allows students to "externalize internal thinking" (p. 12). Argumentation can occur any time a conversation is interrupted by questions, disagreements or alternate ideas. McDonald and McRobbie (2012) believe that argumentation skills cannot be developed until cognitive skills are in place. This means that students must learn the skills of argumentation before they can engage in argument (Fraser, Tobin, & McRobbie, 2012). Alternatively, Ryu and Sandoval (2012) believe students must engage in the practice of argumentation in order to develop argumentation skills that will build cognitive skills.

The goal of argumentation is to build explanations about the natural world using claims, evidence and reasoning. A review of studies found argument models that focus on explanations can cause students to fail to use evidence when making claims. Students often have difficulty understanding the difference between evidence, data and explanations (Kuhn, 2009). Students will often focus on what they were doing instead of what they were learning. By engaging in argument, students will focus more on evidence to support a claim (McNeill, 2011).

Students will learn to critique other's ideas based on their evidence when engaged in argument. When students engage in dialogue they are able to improve their own argument, increase their understanding of the concept and deepen their understanding of the scientific principle (Berland & Lee, 2012). In order to engage students in argumentative discourse, Herrenkohl and Guerra (1998) used scaffolding techniques with students to develop not only epistemological understandings, but also the social structure of argumentation. In order to increase student engagement in class discussions, Herrenkohl and Guerra assigned intellectual roles to the students. These roles have students asking questions about predicting and theorizing, summarizing results and coordinating theory with evidence. Students were also given audience roles such as questioners, clarifiers and commentators. The authors of this study found students were more actively focused on coordinating theories with evidence (Herrenkohl & Guerra, 1998).

Consensus building is another strategy teachers can use to facilitate argumentation in the classroom (Berland & Lee, 2012). The authors mention an activity used by Berland and Reiser (2011) called an Argument Jigsaw. In this activity, students are paired together to build an argument and then will join another pair with the goal of reaching a consensus among all four students in the group. There are challenges when trying to get individual students to reach a consensus because they tend to look for evidence that supports their original idea. Often, students will not entertain evidence that contradicts their explanation. This creates what Kuhn (1991) calls a confirmation bias.

Defending arguments helps students develop reasoning skills and consider other alternative ideas. Llewellyn (2014) uses four strategies "in scaffolding students toward argumentation" (p. 50):

Strategy 1: Making inferences from observations

Strategy 2: Agreeing or disagreeing with a statement

Strategy 3: Testing another person's claim

Strategy 4: Making your own claim from evidence

Activities used for Strategy 1 involve students sharing observations of the same phenomena and making inferences with models to explain what happened. The students will often have very different inferences. These types of activities introduce the student to components of scientific argumentation by having the student justify and defend their claim or inference using evidence from their observations. This type of activity can be used to help students understand the difference between observations and inferences. Strategy 2 involves students doing research to find evidence that agrees or disagrees with a statement. The students learn to make claims using supporting evidence. Llewellyn takes this a step further by turning the classroom into a courtroom. In Strategy 3, testing another person's claim, students are required to collect evidence to support or refute the claim. The students determine the question to be tested, design the experiment and collect data. The students use their evidence to support their reasoning for supporting or refuting the claim. Strategy 4 builds on Strategy 3, where students design their own investigations (Llewellyn, 2014).

Instruction must focus on opportunities for students develop scientific explanations. Argumentation activities can help students develop higher quality explanations by listening to, considering and critiquing other explanations. Argumentation can also help students learn to actively listen to each other in order to clarify their own ideas and begin to consider the reasoning behind explanations that differ from their own (Zembal-Saul, McNeill, & Hershberger, 2013).

METHODOLOGY

The treatment for this study included the development of lessons that focused on scientific explanations using argumentation through the use of scaffolding techniques daily during a three week period. I implemented the treatment with my fourth grade class of 23 students where lessons were taught daily during a 90 minute block of time. The unit of study for the treatment was Earth history with a focus on how the surface of the Earth changes slowly and rapidly. The research methodology for this project received an exemption from Montana State University's Institutional Review Board and compliance for working with human subjects was maintained (Appendix A).

During the first week, the content of the Lesson Plans on Rapid Changes of the Earth's Surface addressed how earthquakes, landslides, and volcanic eruptions affect the Earth's surface (Appendix B). In order to scaffold the students' explanations using argumentation, students were introduced to the components of scientific explanations. Students learned how to formulate an explanation by making a claim to answer a focus question and using evidence from observations. I reviewed with students about how observations were different than inferences. I provided examples of claims and evidence

for students to evaluate. We then held a discussion about what counted as a claim and what made one claim better than another. I engaged students in discussions on what counts as evidence. Then students were given different statements about changes a landform had undergone. The students evaluated statements to determine what counted as evidence and what did not. After students practiced making claims based on evidence, they were paired with someone who had an opposing claim about the cause of a landslide in a picture. The students worked towards consensus by providing evidence. After the pairs of students came to a consensus, they worked with another pair who had an opposing claim. Again, they worked toward consensus using evidence.

The content of the second week's Lesson Plans on Slow Changes of the Earth's Surface focused on weathering, erosion, and deposition (Appendix C). During the week, students were given statements and pictures to investigate and research to determine whether they agreed or disagreed with the statement. This guided students to focus on evidence when analyzing a claim. I introduced the students to the structure of scientific explanations using the Claims, Evidence and Reasoning (CER) method of developing explanations. I created a CER Anchor Chart for students with descriptions of each component to scaffold their explanation (Appendix D). Students conducted two investigations about weathering and erosion. While working through the investigation, students collected data during each investigation and wrote explanations using claims, evidence and reasoning.

During the third week, lessons were designed for students to make an argument about the best way to reduce beach erosion along the North Carolina coast. Students

conducted research and designed models to test their ideas. Student groups then presented their ideas to the class. In order to encourage students to be engaged in the presentations, I assigned one of three specific audience roles. The audience roles were assigned so that students focused on one specific aspect of the presentation. The roles were to ask questions about predictions, results and coordinating predictions with results. An Audience Role Anchor Chart was created with basic questions stems as a reference for students to use during the presentations (Appendix E). They also recorded the pros and cons of each beach erosion control method. At the conclusion of the presentations, students wrote an argument for which method would be best to reduce erosion.

In order to evaluate the impact of argumentation activities on building explanations using evidence, the Base Explanation Rubric (McNeill, Lizzotte, Krajcik & Marx, 2006) was used to analyze student explanations that were recorded in their science notebooks (Appendix F). Student notebooks were evaluated prior to treatment, mid treatment and again at the end of the unit. Each student score was evaluated based on three categories: claims, evidence and reasoning. The frequency of each score for each explanation component was tallied to identify strengths and weaknesses of each component. These frequencies were then compared before, during and after treatment.

To determine impact of argumentation activities on behavioral and cognitive engagement, students were given the Engagement Survey pre and post treatment (Appendix G). The survey asked students to rate their level of agreement with statements from strongly agree to strongly disagree. The survey asked questions that were not easily observed during instructional time about cognitive engagement, behavioral engagement

and behavioral disengagement. The data collected from the instrument compared the mode of each item pre and post treatment to determine trends in the class. Eight students were randomly selected to participate in the Argumentation and Engagement Interview (Appendix H). The student responses were analyzed for common themes regarding argumentation, motivation, learning and interest.

During treatment, students were assessed on content and conceptual understanding of the unit by taking an Earth History Pre Test and an Earth History Post Test (Appendix I). Normalized gains were calculated using pre and post assessment scores and shown using box and whisker plots so the range and median could be compared for each assessment. Formative assessments on the content were used to evaluate the students' understanding of content and ability to explain that understanding after engaging in classroom arguments (Appendix J). The data collection methods for the focus question and sub questions are shown in the Classroom Argumentation Triangulation Matrix (Table 1).

Table 1

Classroom Argumentation Triangulation Matrix

Research Question	Data Source 1	Data Source 2	Data Source 3
Focus Question: How does engagement in argument impact students' abilities to form explanations of scientific phenomena?	Pre-Treatment analysis of students' written conclusions for components of argumentation using the Base Explanation Rubric.	Mid-Treatment analysis of students' written conclusions for components of argumentation using the Base Explanation Rubric.	Post-Treatment analysis of students' written conclusions for components of argumentation using the Base Explanation Rubric.

Sub question: Do argument driven activities increase students' behavioral and cognitive engagement?	Student Engagement Survey-pre treatment	Argument and Engagement Interview Questions	Student Engagement Survey-post treatment
Sub question: How do argument scaffolding activities affect student learning?	Earth Changes Pre-Assessment	Formative Assessments: 1. Misconception Probe: Beach Sand 2. Earth Changes: Agree/Disagree Statements.	Earth Changes Post-Assessment

DATA ANALYSIS

The results of the Earth Changes pre-test indicate the class median score was 44% (*N*=23). The range of these scores showed a 56 point difference from 11% to 67%. Fifty percent of the students fell within 30% and 59%, a 29 point range. The results of the Earth Changes post-test show a median score of 89% with a range from 67% to 96%, a 29 point difference. Fifty percent of the students fall within 81% and 93%, a 12 point range (Figure 1).

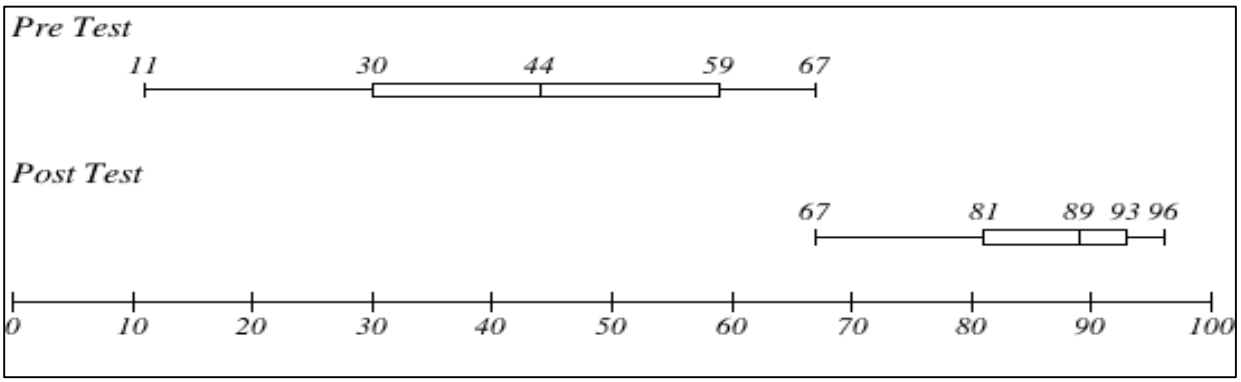


Figure 1. Comparison of pre/post earth changes tests, (*N*=23).

Normalized gains were calculated for each student to better understand each student's demonstrated gain in understanding of how the surface of the Earth Changes. Normalized gains greater than 0.7 were indicative of high gains, medium gains were between 0.31 and 0.7 while low gains were any score below 0.3. These results were tallied and show 17% of the students demonstrated minimal gains in their understanding of how the surface of the Earth Changes. Seventy percent of the students demonstrated medium gains, while 13% demonstrated high gains (Figure 2).

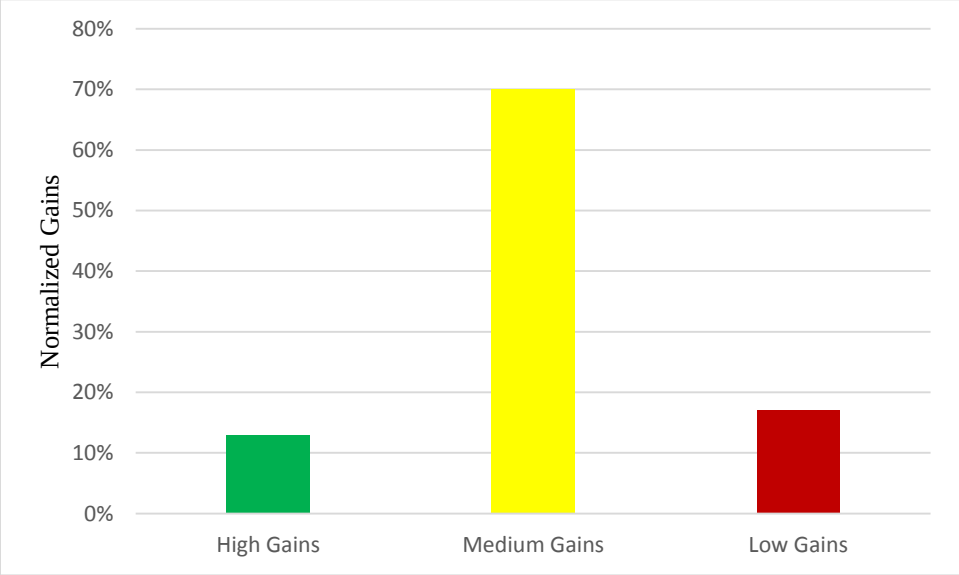


Figure 2. Pre/post earth changes test normalized gains, (*N*=23). *Note.* (High Gains>.7; Medium Gains=.31-.7; Low Gains<.3).

The results of the Engagement Survey given prior to treatment indicated 35% of the students strongly agreed that it was important to learn about how the surface of the Earth changes (*N*=23). Seventy-eight percent of the students *agreed* or *strongly agreed* they pay attention to the teacher during instruction. Seventy-four percent of the students reported they *strongly agreed* or *agreed* that they pay attention to what other students say during instruction 90% of the time. When asked about their level of participation during

group work activities, 83% indicated they *agreed* or *strongly agreed* that they stayed on topic 90% of the time (Figure 3). The same survey was given to the same students post-treatment. The post-treatment results demonstrate that 73% of the students *strongly agreed* that it was important to learn about how the surface of the Earth changes (*N*=22). Ninety percent of the students *agreed* or *strongly agreed* they pay attention to the teacher during instruction. Seventy-eight percent of the students *agreed* or *strongly agreed* that they pay attention to what other students say during instruction and 90% *agreed* or *strongly agreed* that they contributed during group work (Figure 4).

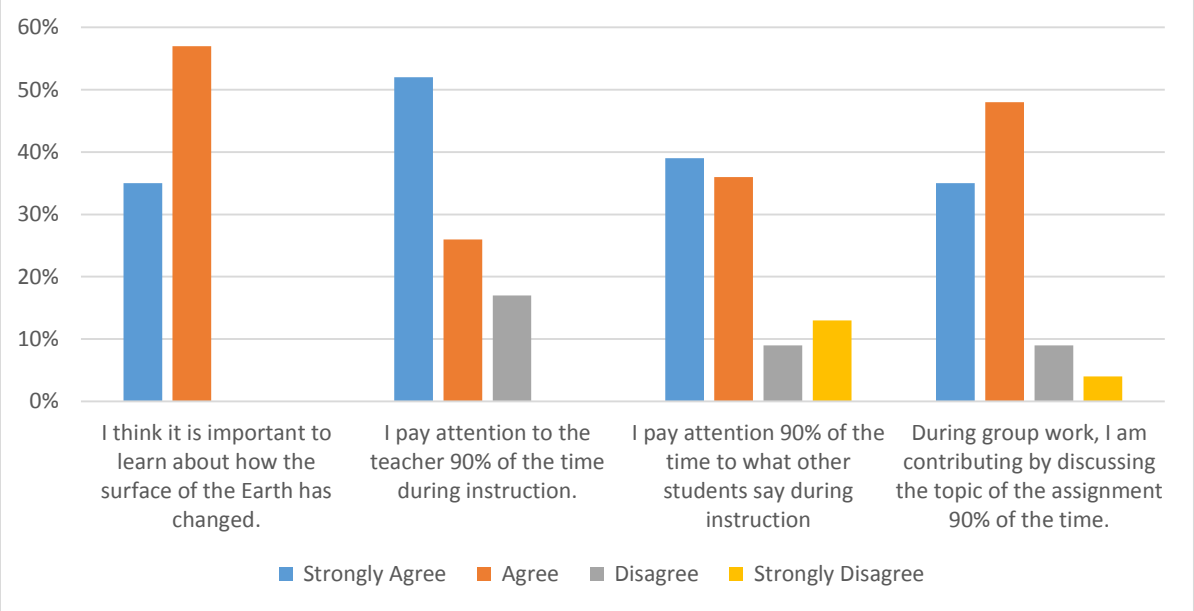


Figure 3. Pre-treatment engagement survey, (*N*=23).

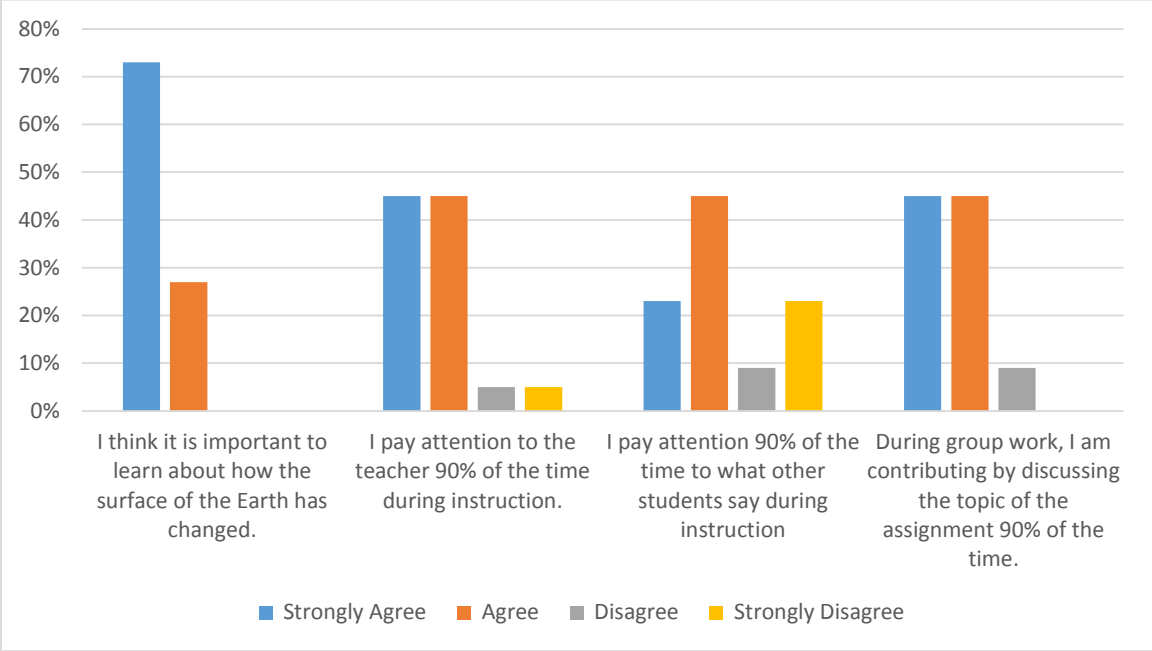


Figure 4. Post-treatment engagement survey, (*N*=22).

Level of agreement was compared pre and post treatment to determine a normalized gain (Figure 5). There was a 38% increase in agreement about the importance of learning about how the surface of the Earth has changed. This is considered to be a high or significant gain in the area of cognitive engagement. Students reported a 12% gain in their perceived ability to pay attention to the teacher during instruction, a four percent gain in the perceived ability to pay attention to what the other students said during instruction and a seven percent increase in staying on topic during group work. All of the behavioral engagement gains reflect low gains. When students were asked how argumentation impacted their interest in learning how the surface of the Earth changes, one student reported, "It helped me realize there is more than one idea about how Earth changes and that kept me interested in learning more." The same student also reported that she did not increase her ability to pay attention to what others were saying in group, "I usually listen to other's ideas when working on group projects."

When asked if they paid attention to others when arguing, one student responded, “I paid attention more because I listened to decide whether or not to change my statement or claim. I listened more to their evidence and considered it.”

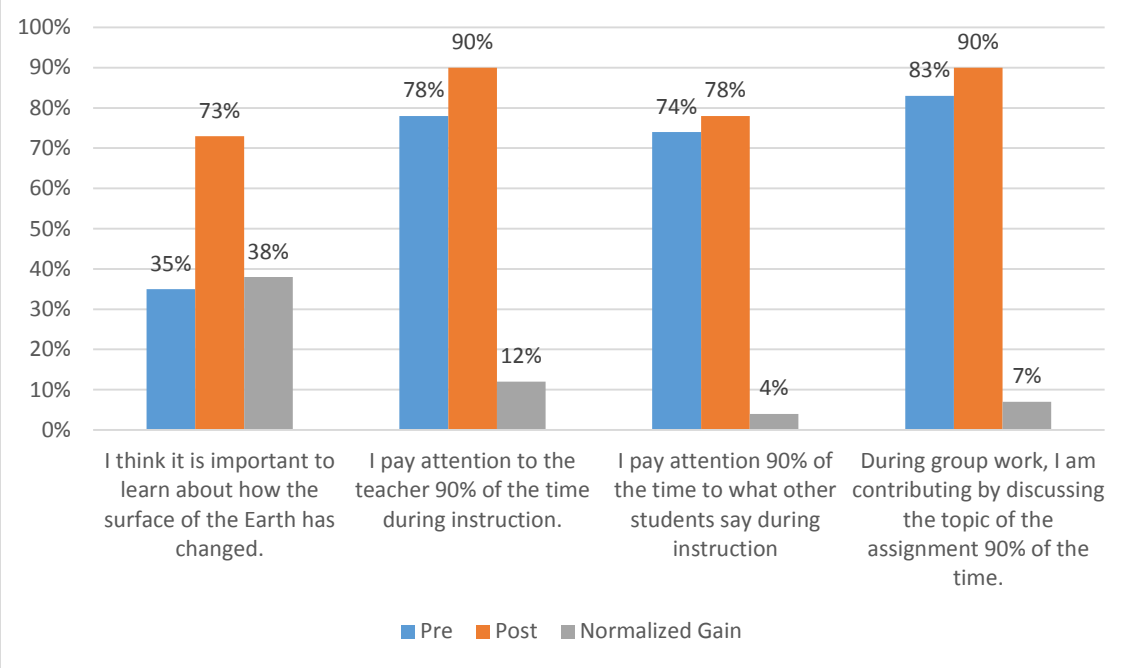


Figure 5. Student engagement survey: normalized gains, (*N*=23).

Students written explanations of scientific phenomena were evaluated prior treatment, during treatment and after treatment. Prior to treatment 18% of the students made claims that answered the original question investigated. After treatment, 73% of the students made claims that demonstrated mastery. Twenty-seven percent of the students did not make claims prior to treatment. One student wrote, “I was right!” None of the students provided sufficient evidence to support their claim. Post treatment shows that 41% could provide sufficient evidence and 59% could provide evidence that was appropriate, but not sufficient to support their claim. Ninety-five percent of the students

did not use reasoning in their explanation. Fifty-five percent of the students provided reasoning at the mastery or partial mastery level (Figure 6).

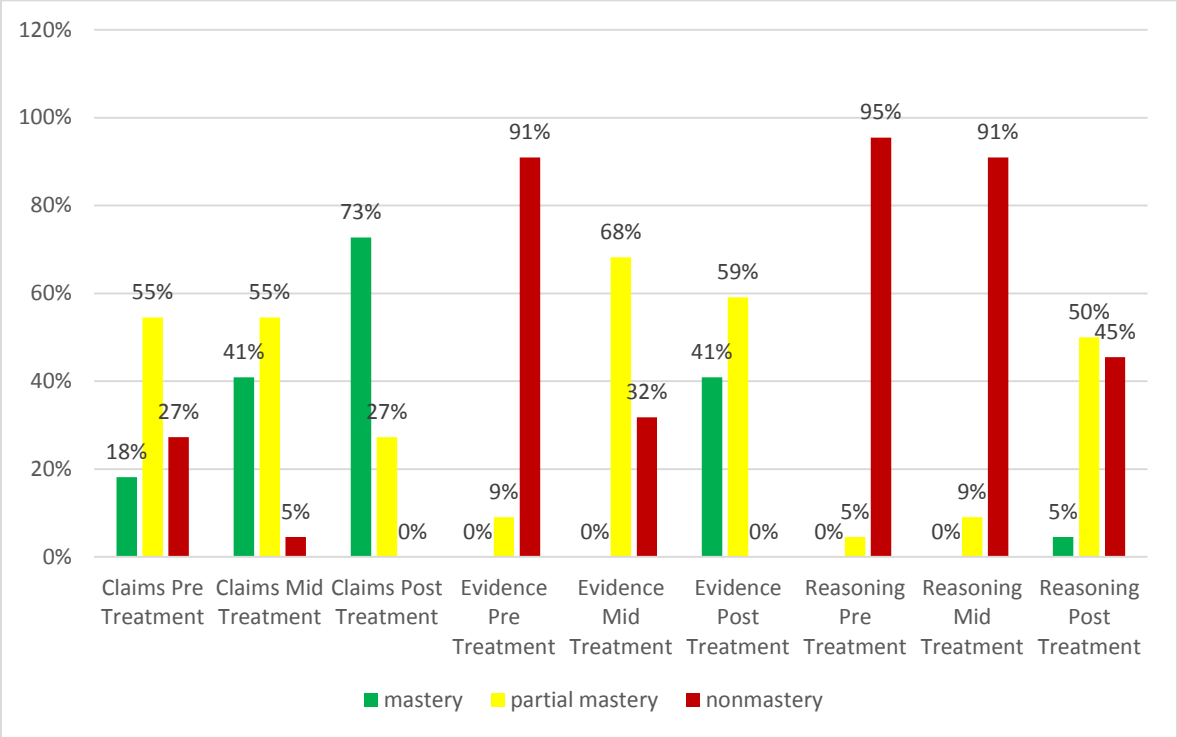


Figure 6. Evaluation of student explanations, (*N*=23). *Note.* (Using the Explanation rubric, a score of 2=mastery; 1=partial mastery; 0=nonmastery).

Normalized gains were calculated to determine the students' ability write explanations of scientific phenomena (Figure 7). There was a gain of .67 when making claims. Students who used evidence that was appropriate and sufficient demonstrated a .41 gain. Students' ability use reasoning showed a .05 gain. Student gains in using claims and evidence indicate moderate gains, while reasoning shows minimal gains.

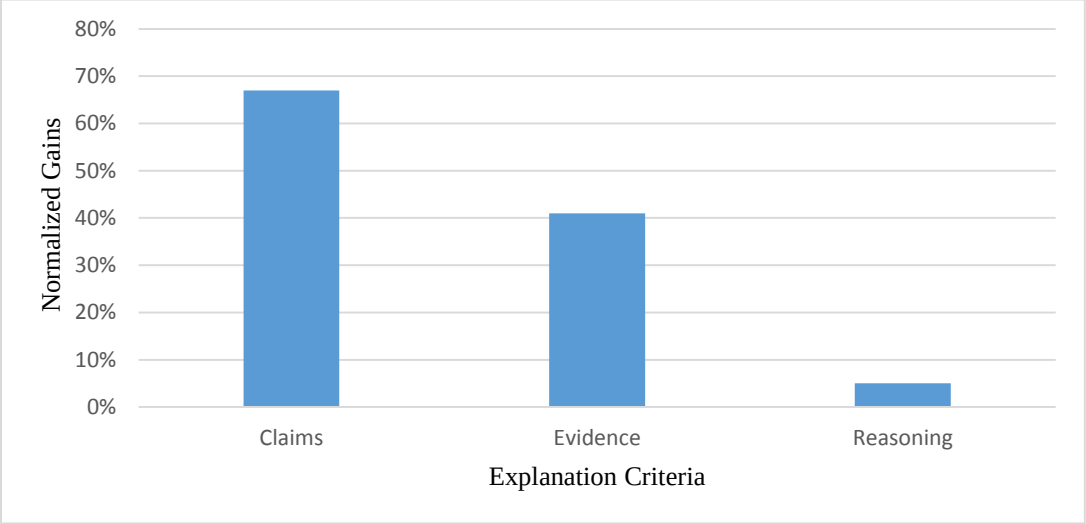


Figure 7. Normalized gains of scientific explanation criteria, (*N*=23). *Note.* (High Gains>.7; Medium Gains=.31-.7; Low Gains<.3).

INTERPRETATION AND CONCLUSION

The study demonstrated that using argumentation during class discussions can improve a student's ability to sufficiently and accurately explain scientific phenomena. Providing instruction on the Claims, Evidence and Reasoning (CER) framework, students immediately began to focus on the essential question for the lesson. This helped the students focus on what their observations from in class demonstrations, investigations and readings. With a focus on observations as evidence, students improved their understanding of the content. Prior to treatment, the class average on the Earth Changes pretest was 43%. After treatment the class average increased to 87%.

Written explanations of scientific phenomena showed a positive increase in focusing on evidence. Students made better observations after learning the difference between observations and inferences. This reduced the number of explanations that focused only confirming predictions. Students became more open minded to changing

their mind and learning more because argumentation reduced the students need to be right.

I had hoped to see more of an improvement in behavioral engagement. There were minimal gains regarding this aspect. This may be due to the amount of time provided for treatment or how data was collected for this criteria. Students self-reported their behaviors of contributions during group work, effort and attention. I had chosen to collect this data in survey form because these behaviors are not always observable. This allowed some bias from the students. However, I learned that students do not see how their behaviors affect their learning because they do not see a problem with their engagement behaviors. An independent observer tallying behaviors would provide more clarity.

The students reported they enjoyed using argumentation in class. There was a significant increase in cognitive engagement of the content. Using consensus building activities was well liked by students. Students felt like they had an opportunity to share their claim and evidence without judgment. One student reported, "It was fun sharing your ideas without feeling like there was a winner or loser." Another student said that she learned from other students when evidence was pointed out that she had not noticed. The use of argumentation really helped students focus more on what they were learning, rather than what they were doing.

VALUE

This study on the use of argumentation and how it impacted student explanations is a practice that I will continue to use. The transition from a focus on what the students

were doing to what they were learning from investigations is critical to helping students build an understanding of scientific phenomena. This has been the missing piece of my inquiry based, hands on lessons. Providing direct instruction using the Claims, Evidence and Reasoning (CER) method of explanations along with sufficient time for quality discussions/argument is the 'hook' that increased cognitive engagement.

When students were engaged in argument, they were taking responsibility for their learning. When they questioned each other's evidence, they were forced to clarify their explanation. However, there were a few students who did not participate unless I was part of their group. This led me wonder what would make our classroom environment feel safer to be wrong. I also observed students in groups where they only engaged in what I would call 'round robin' sharing. They didn't actively listen or respond to each other. These groups often had the most difficult time coming to consensus.

I also noticed that students sometimes used evidence to support claims that were not relevant. My research indicated the reasoning component of scientific explanations is the most difficult for students. My data supports that claim. I would like to research strategies to help students make this final connection to demonstrate an understanding of the concept.

By participating in this Action Research-based classroom project, I find that I focus more on the instructional sequence of my units. I begin planning lessons based on what concepts students need to know and understand. Then I developed focus questions that could be investigated. Next, I plan activities that where students can collect data and

make observations in order to answer the focus question. Finally, I plan for opportunities for students to engage in argument. I've learned that argumentation and explanations helps students focus more what they learn from hands on/inquiry based activities rather than what they are doing. My goals are to continue to develop student explanations, particularly the reasoning component.

REFERENCES CITED

Berland, L.K., & Lee, V.R. (2012). In pursuit of consensus: Disagreement and legitimization during small-group argumentation. *International Journal of Science Education, 34,* 1857-1882.

Driver, R., Newton, P., & Osborne, J. (1998). Establishing the norms of scientific argumentation in classrooms. *Science Education, 84*(3), 287-312.

Duschl, R.A., & Osborne, J. (2002). Supporting and promoting argumentation discourse in science education. *Studies in Science Education, 38*(1), 39-72.

Erduran, S., & Jimenez-Aleixandre, M.P. (Eds.) (2007). *Argumentation in science education: Perspectives from classroom-based research.* The Netherlands: Springer.

Herrenkohl, L., & Guerra, M. (1998). Participant structures, scientific discourse, and student engagement in fourth grade. *Cognition and Instruction, 16*(4), 431-473.

Kuhn, D. (1991). *The skills of argument.* Cambridge, England: Cambridge University Press.

Kuhn, D. (2009). The importance of learning about knowing: Creating a foundation for development of intellectual values. *Child Development Perspectives, 3,* 112-117.

Llewellyn, D. (2014). *Inquire within: Implementing inquiry- and argument-based science standards in grades 3-8.* United States of America: Corwin.

McDonald, C.V., & McRobbie, C.J. (2012). Argumentation and nature of science. In B.J. Fraser, K. Tobin, & C.J. McRobbie (Eds.), *Second international handbook of science education* (pp. 969-986). The Netherlands: Springer.

McNeill, K.L. (2011). Elementary students' views of explanation, argumentation, and evidence, and their abilities to construct arguments over the school year. *Journal of Research in Science Teaching, 48*(7), 793-823.

McNeill, K.L., Lizotte, D.J., Krajcik, J., & Marx, R.W. (2006). Supporting students' construction of scientific explanations by fading scaffolds in instructional materials. *Journal of the Learning Sciences, 15*(2), 153-191.

McNeill, K.L., & Knight, A.M. (2013). Teachers' pedagogical content knowledge of scientific argumentation: The impact of professional development on k-12 teachers. *Science Education, 96,* 936-972.

McNeill, K.L., & Pimentel, D.S. (2010). Scientific discourse in three urban classrooms: The role of the teacher in engaging high school students in argumentation. *Science Education, 94*(2), 203-229.

National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* Washington, DC: The National Academies Press.

National Research Council. (2007). *Taking Science to School: Learning and Teaching Science in Grade K-8.* Washington, DC: The National Academies Press.

Osborne, J. (2010). An argument for arguments in science classes. *Phi Delta Kappan, 91*(4), 62-65.

Osborne, J., & Patterson, A. (2011). Scientific argument and explanation: A necessary distinction? *Science Education, 94*(4), 627-638.

Ryu, S., & Sandoval, W.A. (2012). Improvements to elementary children's epistemic understanding from sustained argumentation. *Science Education, 96*(3), 488-526.

Sampson, V., Enderle, P., & Grooms, J. (July 2013). Argumentation in science education: Helping students understand the nature of scientific argumentation so they can meet the new science standards. *The Science Teacher, 80*(5), 30-33.

Shemwell, J.T., & Furtak, E.M. (2010). Science classroom discussion as scientific argumentation: A study of conceptually rich (and poor) student talk. *Educational Assessment, 15,* 222-250.

Zembal-Saul, C., McNeill, K.L., & Hershberger, K. (2013). *What's your evidence? Engaging K-5 students in constructing explanations in science.* United States of America: Pearson.

APPENDICES

APPENDIX A

IRB APPROVAL

MONTANA STATE UNIVERSITY

INSTITUTIONAL REVIEW BOARD

For the Protection of Human Subjects
FWA 00000165

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MEMORANDUM

TO: Leah Anne Key and John Graves

FROM: Mark Quinn, Chair Mark Quinn eyj

DATE: December 2, 2014

RE: *"The Connection between Argumentation and Scientific Explanation"* [LAK120214-EX]

The above research, described in your submission of December 2, 2014, 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.

____ (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

LESSON PLANS: RAPID CHANGES OF THE EARTH'S SURFACE

Elementary Science Lesson Plan

Monday 3/16	
Topic: Earth Changes (Surface-Rapid)	**Objective Number:**
Essential Question: What causes the surface of the Earth to change? What events cause the surface of the Earth to change rapidly?	
Materials: Textbook Pg E58-59 Notebook Flipchart	**Vocabulary:** • Rapid • Earthquake • Volcano • landslide

The Lesson

Engage 10:45-11:15

- Set up notebook: Table of contents pg 9-10 Earth Changes 3/16/15
- Focus Question: What causes the surface of the Earth to change over time?
- Have students go ahead and record predictions.
- Show students the pictures on the flipchart and ask "What do all of these photos have in common?"
- If students have trouble noticing that all the pictures show the surface of the earth changes, ask them to describe what they think is happening each picture.
- Ask if them if they know the names of these types of changes?

Explore 12:45-1:00

- Show the pictures on the next slide and ask: What is happening in these photos? (all of these pictures show evidence of something that took place or something that is taking place when the picture was taken.)
- Ask students whether they think the changes are rapid or slow (define rapid)
- Students should make a claim and share their reason.

Explain 1:00-1:15

- **Read pg E 58-59**
- Students should know that the surface of the Earth changes in natural ways. Sometimes the change can be caused by a very slow process and at other times it can be caused by a rapid process.
- There is often evidence on the surface that these processes have caused change.
- Have students record observations of what causes earth to change and then conclusions

Extend

Evaluate 1:15-1:30

- Have students illustrate on page 9. Divide the section in half. On one side illustrate a rapid change and on the other a slow change.

Homework:	**Science Notebook:**
Complete left side illustrations	

What do all of these photos have in common?









What do all of these pictures tell you about the earth's surface?

What is happening in these photos?





Deposition:	Earthquake:
	
Volcano:	Flood:
	
Landslide:	Weathering:

	
Weathering:	Deposition:

<table>
<tr><td>Topic: Rapid Changes: Earthquakes</td><td>Objective Number:</td></tr>
<tr><td colspan="2">Essential Question: How does the surface of the Earth change after an earthquake event? What is the evidence that an earthquake has occurred at a location?The effects of earth quakes on the surface of the earth are:

• solid rocks break with sufficient pressure
• rise/ fall/separation of fault lines.</td></tr>
<tr><td>Materials:

Flipchart

Quake Lake ppt (google)</td><td>Vocabulary:

fault

• earthquake
• tectonic plate
• converge
• diverge
• slip</td></tr>
</table>

Engage 10:45-11:15

- Yesterday you learned that the surface of the earth changes. Ask students to name some ways that cause the earth's surface to change.
- Tell students that some changes to the earth's surface are caused by external (exogenetic forces), while other changes are caused by internal (endogenetic forces). Internal forces are powered by the earth's internal heat, while external forces are powered by the sun's heat. Most rapid changes are caused by internal forces.
- Today we will learn more about a rapid change: Earthquakes
- Have students share what they know about Earthquakes.
- Table of contents pg 10-11 Earthquakes 3/17/15
- Focus Question: **Do earthquakes change the surface of the Earth?**
- Have students go ahead and record predictions
- Visit the website below to learn about plates and boundaries. On the first page, pay attention to the pictures and the evidence that a quake had occurred.
- http://www.classzone.com/books/earth_science/terc/content/investigations/es1001/es1001page01.cfm?chapter_no=investigation

Explore 12:45-1:15

- Share the ppt (or add what you want to the flipchart…I will edit some of the content)
- Point out the fault scarp, where the two plates slip due to the build up of tension where the plates converge. You will see in the pics the fault scarp from an aerial photo…the land dropped on the south side (right) this changes the landscape in many ways….changes the flow of rivers and creeks, caused landslides, created sudden waterfalls, etc
- Science Lab: Earthquakes on discovery education can be used to show the effect of different magnitudes in a populated area….compare the 7.1
- Show the video clip from discovery education Alaska: Most Extreme scroll down to the Earthquake segment…it is about 3 minutes
- Have students record observations about how earthquakes change the surface of the earth.

Explain 1:15-1:30

- **Discuss: Claims answer the focus question. What is your claim to the question: Do earthquakes change the surface of the Earth?**
- **Arguments must be justified with evidence. What is your evidence?**
- **Record conclusions**
- **Review…earthquakes change the surface of the earth by creating cracks along fault lines. They can change the flow of rivers, location of lakes, cause landslides, and if they occur on the ocean floor they may cause tsunamis-**

Extend

Evaluate

- **Show the following pictures and have students work towards consensus about whether or not the change was caused by an earthquake.**

Homework:	Science Notebook:





Wed 3/18	
Topic: Earth Changes: Volcanoes 39	Objective Number:
Essential Question: How do volcanoes affect the surface of the earth?	
Materials: Video Raging Planet: volcano 40 min	Vocabulary: • Constructive process • Deconstructive process • Ash

The Lesson

Engage

- What are volcanoes----record answers on board
- How are volcanoes similar to one another? Different?
- Are all volcanoes mountains?
- Are all mountains volcanoes?
- Table of Contents page _____ Volcanoes Change the Earth
- FQ: Do volcanoes change the surface of the earth?
- Record predictions-tally yes/no claims for the class after they record predictions

Explore

- Watch the video from discoveryed.
- Record observations about how the volcanoes cause changes to the surface of the earth.
- Include drawings and labels-ABCD drawings!

Explain

- Revisit predictions: Discuss how the claims made during predictions may or may not be correct….and that's okay.
- Have students share what they recorded for their observations with a partner-focus should be on the changes to the Earth's surface.
- Volcanoes can construct new land when lava cools and hardens-Constructive Process
- Ash from the eruption can settle on the ground and change the soil composition
- Volcanoes, such as the Mt. St. Helens eruption can change the shape of the mountain-deconstructive process

Evaluate

- Record your conclusions/explanations

Homework:	Science Notebook:
• Research a volcano that has erupted • Draw a picture of the city, town, or rural area near the volcano • Draw the same place after a volcanic eruption • Use titles and captions to describe how the land changed	

3/19/15 Thursday	
Topic: Landslides	**Objective Number: 4.E.2.3**
Essential Question: What is a landslide? How does gravity affect a landslide? How do landslides change the surface of the earth?	
Materials: Different soils Metal trays 5-6 Spray bottle 5-6 Toy houses/trees (monopoly games?) Landslides ppt (NASA's GSM)-saved to Pdrive	**Vocabulary:** • Gravity • Landslide • Debris • slope

The Lesson

Engage 10:45-11:15

Background Info:

Landslides occur in all U.S. states and can be caused by a variety of factors including earthquakes, storms, volcanic eruptions, fire and by human modification of land. Landslides can occur quickly, often with little notice and the best way to prepare is to stay informed about changes in and around your home that could signal that a landslide is likely to occur.

In a landslide, masses of rock, earth or debris move down a slope. Debris and mud flows are rivers of rock, earth, and other debris saturated with water. They develop when water rapidly accumulates in the ground, during heavy rainfall or rapid snowmelt, changing the earth into a flowing river of mud or "slurry." They can flow rapidly, striking with little or no warning at avalanche speeds. They also can travel several miles from their source, growing in size as they pick up trees, boulders, cars and other materials.

1. Set Up Table of Contents: Pg _____ Landslides
2. FQ: What processes cause landslides? How do landslides affect the surface of the earth? How does gravity affect a landslide?
3. Predictions:

- give the students different types of soil, sand, and rocks, a tray),
- Challenge them to transport the sand and rocks from one end of the container to the other using as many different methods as they can.
- Students should record their methods and then share out to the class (blowing, pushing, running water, tipping the pan, etc.)
- Ask students to identify the processes they are demonstrating. Alternatively, this could be a thought experiment – showing the students the trays of soil, and asking them to think about how to move the soil around.

Explore 12:45-1:15

- Play a short video (length 0:19) of the La Conchita, California landslide from 2005 (slide 4).
- Have students brainstorm what they know about landslides, whether they've ever seen one and what they think causes the debris to suddenly go down a slope (slide 5), **before revealing** a definition and factors involved in landslides (slide 6 & 7).
- Using the Landslides Lab Instructions and Student Capture Sheet, students will simulate landslides in trays with different types of soil. In brief, they will spray each tray with a squirt bottle until a landslide begins and record data about how many squirts and the amount of water it took (slide 8).
- Some important reminders: students should **NOT** move the tray once the spraying starts, or the data between groups will be inconsistent. (If it happens, you can talk about how an earthquake can set off a landslide, especially if it's rained a lot recently.) Also, make sure you talk to students about the need to standardize what is considered a landslide. Making lines on the containers at a standard distance from the top will help, but it's important that students understand that if any part of the soil moves below that line, a landslide has occurred, even if some soil is still sticking above the line.
- Alternatively, you could get small toy houses to set on the slope, and when they have moved past the line, consider a landslide to have occurred.
- If students do not all use the same methodology, it can result in very inconsistent data and outliers.
- Optionally, students could also measure the amount of material moved. Each group will report back to the class about results, and compare the data for different types of soil (slide 9).

Explain 1:15-1:30

- Show students a map of where landslides occur (slide 10) and point out how widespread they are, and they type of damage they can cause, both in terms of property and human life (slide 11).
- Ask students to think about how we might be able to predict landslides and how we might get that data (slide 12). They should think about the experiment they just did, and how precipitation and soil type made a difference in when the landslides occurred. They may also think about the steepness of the slope and how quickly the rain is falling (not just overall quantity), although these were not variables in the experiment.
- Discuss what else besides type of soil might have an impact on landslides – for example earthquakes, volcanic activity, deforestation, human building of roads and structures, etc.
- On slide 19, you'll find a link to a video called "Too Much, Too Little" (length 4:44) explaining why we need to use satellites to measure precipitation and leading in to the societal impacts of landslides. (Watch the first half-----the second half discusses drought)
- Discuss the evidence of a landslide-record these observations

Extend

Evaluate

- **Record your explanation/conclusion-share with a partner and evaluate your evidence that supports your claim-revise if necessary**

If time allows begin the (Step book) foldable below----**Complete Tomorrow! Collect for a grade.**

- Title: Rapid Changes to Earth's Surface
- Tab 1 Earthquakes- must include words describing 1-2 ways the surface of the earth change and model/diagram
- Tab 2 Volcanic Eruptions- must include one destructive change and one constructive change along with a model/diagram
- Tab 3 Landslides- must include 1 change to earth's surface along with a model/diagram.

Changing the Earth's Surface (rapid Events)	Earthquakes	Results
	Colored Illustration 5pts	written description of changes 5pts
	Landslides	Results
	Volcanic Eruptions	Results

Homework:	Science Notebook:

APPENDIX C

LESSON PLANS: SLOW CHANGES OF THE EARTH'S SURFACE

Friday 3/20

Topic: Rapid Changes complete and Intro to slow changes.	Objective Number: 4.E.2.3
Essential Question: **What are some examples of events that cause subtle (slow) changes to the earth's surface?**	
Materials: Foldable from yesterday Textbook C40-41	Vocabulary: • Subtle • Weathering-natural breakdown of rocks into particles • Erosion-transporting sediment to a new location • Deposition-depositing sediment

The Lesson

Engage 10:45-11:00

- Review how land can change rapidly or suddenly and the evidence of the processes that caused those changes.
- Ask students if they know of any ways the Earth changes slowly.
- Show students the slide with the picture of the Grand Canyon. Brainstorm how the canyon may have formed.
- Ask: Why do you think it has gotten wider and deeper over time?
- How long do you think it took for the Grand Canyon to form?
- Table of Contents pg _____ Wind and Water 3/20
- FQ: How do wind and water change the surface of the earth?
- Prediction:

Explore 11:00-11:15

- Read pg C 40-41 in the text. On the left side have students show what they learned by dividing the page in half and on top illustrate and write about Wind. On the bottom write and illustrate about water.

Explain 12:45-1:30

Introduce students to the CER method of writing scientific explanations.

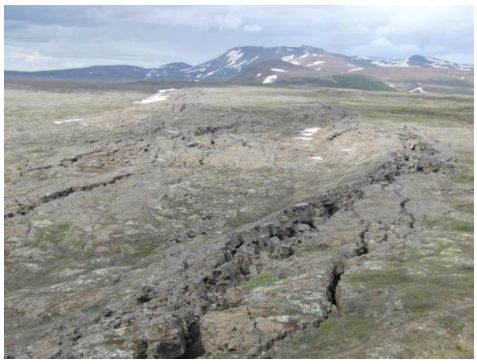
Show the anchor chart and discuss each component.

Post the following two explanations and have students discuss which explanation is better and why.

- Do cockroaches prefer dark or light environments?
- Explanation 1: Cockroaches prefer dark environments. They want to hide from us. Because cockroaches have those long antenna, maybe they can just feel their way around and don't need light to see.
- Explanation 2: Cockroaches prefer dark environments. When we let 10 cockroaches choose between the light and dark side of the box, 9 of them chose the dark side of the box. Since more cockroaches chose the dark side, we can tell which side they prefer.

Extend

Show students the following picture:



Were these cracks caused by earthquakes or erosion?

Silently choose…..if you believe the cracks were caused by erosion, stand at the front of the room.

***Then pair groups of students with different claims and instruct them to use evidence from the picture to support their claim in order to come to consensus.

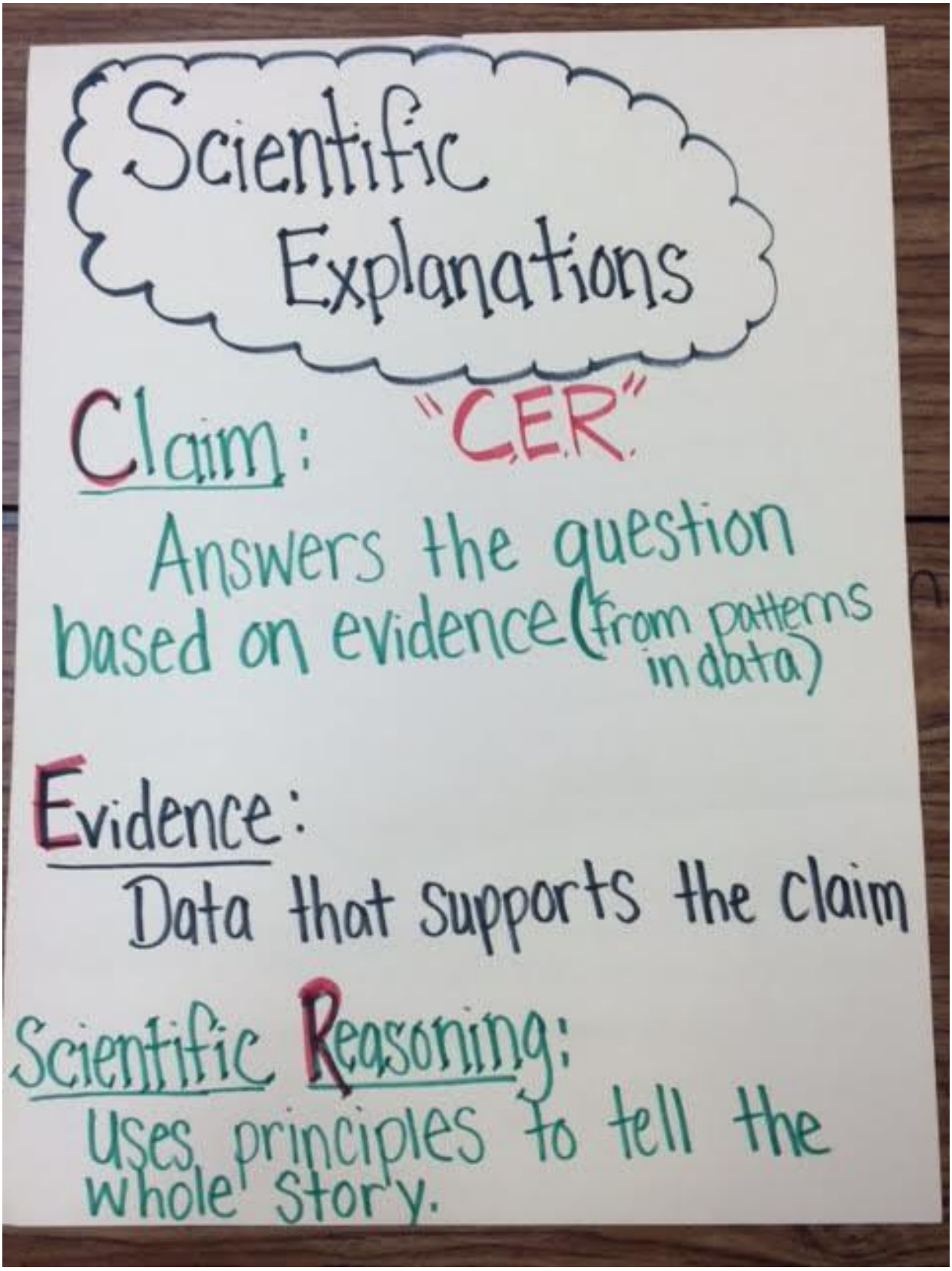
Evaluate

Complete the step book foldable from yesterday----collect for a grade

Homework:	Science Notebook:

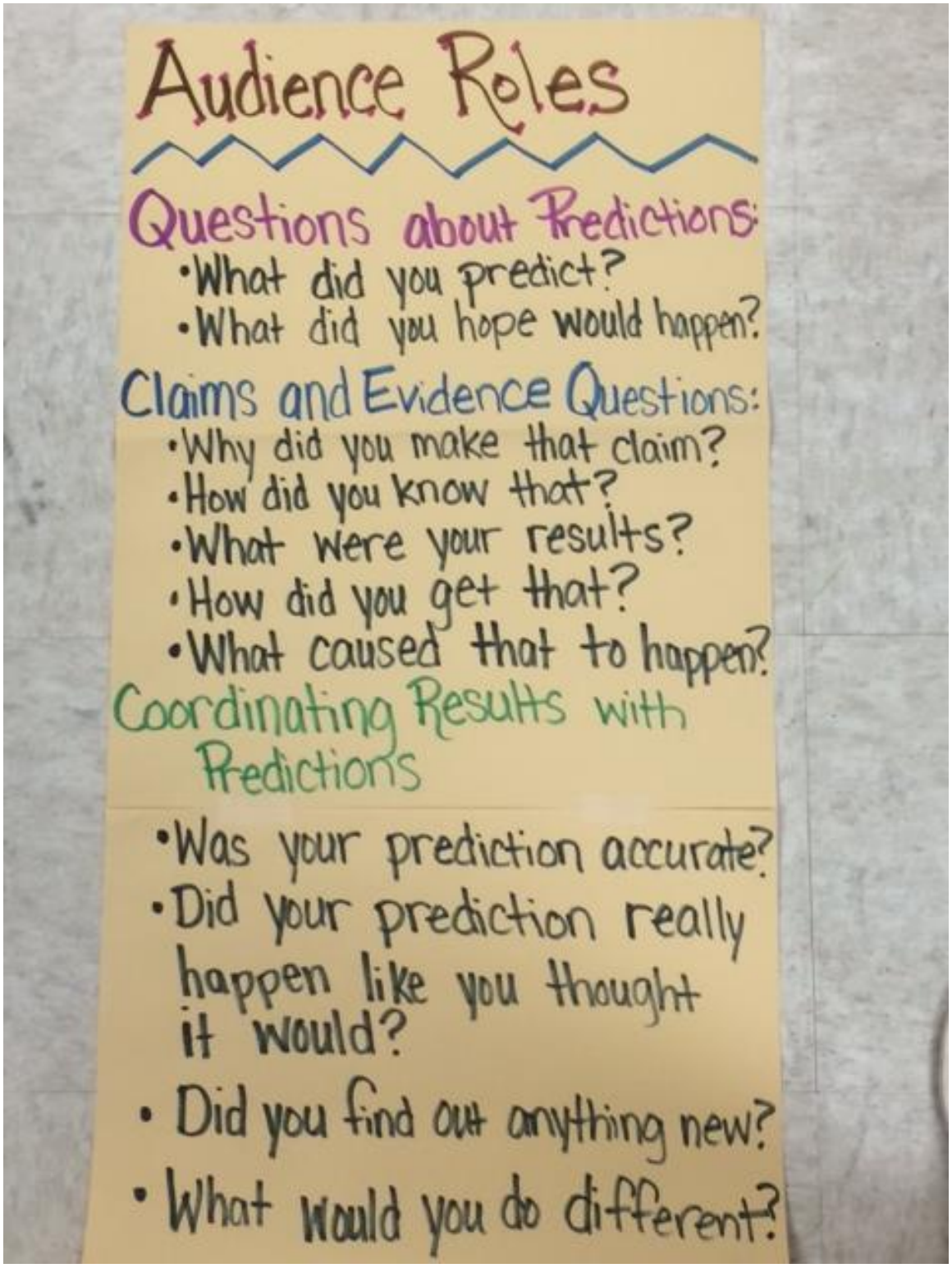
APPENDIX D

CER ANCHOR CHART


Scientific Explanations
"C.E.R."
Claim:
Answers the question based on evidence (from patterns in data)
Evidence:
Data that supports the claim
Scientific Reasoning:
Uses principles to tell the whole story.

APPENDIX E

AUDIENCE ROLES ANCHOR CHART


Audience Roles
Questions about Predictions:
•What did you predict?
•What did you hope would happen?
Claims and Evidence Questions:
•Why did you make that claim?
•How did you know that?
•What were your results?
•How did you get that?
•What caused that to happen?
Coordinating Results with Predictions
•Was your prediction accurate?
•Did your prediction really happen like you thought it would?
• Did you find out anything new?
• What would you do different?

APPENDIX F

BASE EXPLANATION RUBRIC

Base Explanation Rubric

Component	Level		
	0	1	2
Claim- A conclusion that answers the original question.	Does not make a claim, or makes an inaccurate claim.	Makes an accurate but incomplete claim.	Makes an accurate claim that answers the original question.
Evidence- Scientific data that supports the claim. The data needs to be appropriate and sufficient to support the claim.	Does not provide evidence or provides evidence that does not support the claim.	Provides appropriate, but insufficient evidence to support the claim. May include inappropriate evidence.	Provides appropriate and sufficient evidence that clearly supports the claim.
Reasoning- A justification that links the claim and evidence. It shows why the data count as evidence by using appropriate and sufficient scientific principles.	Does not provide reasoning or the reasoning does not connect the evidence to the claim	Provides reasoning that connects the claim and evidence, but the evidence does not include scientific principles.	Provides reasoning that connects evidence to the claim and includes scientific principles

(McNeill, Lizzotte, Krajcik & Marx, 2006)

APPENDIX G

STUDENT ENGAGEMENT SURVEY

Name _____Date _____ HR _____ #_____

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

Question	Strongly Agree	Agree	Disagree	Strongly Disagree
1. I think it is important to learn about how the surface of the Earth has changed.				
2. I think it is important to learn about the processes that caused the surface of the Earth to change.				
3. I think it is important to understand how the surface of the Earth changed later as an adult.				
4. I think it is important to understand the processes that cause the surface of the Earth to change as an adult.				
5. I pay attention to the teacher 90% of the time during instruction.				
6. I pay attention 90% of the time to what other students say during instruction.				
7. During group work, I am contributing by discussing the topic of the assignment 90% of the time.				
8. I don't try very hard at school.				
9. During class, I just pretend like I'm working.				
10. During class, I think about other things besides what we are learning.				

APPENDIX H

ARGUMENTATION AND ENGAGEMENT INTERVIEW QUESTIONS

Engagement Interview Questions

Name _____Date _____ HR _____ #_____

Say: Participation in this interview is voluntary and participation or non-participation will not affect your grades or standing in class in any way.

1. Did you enjoy using argumentation in class? Why or why not?

2. Do you think argumentation activities helped you learn about changes to Earth's surface? Why or why not?

3. How did argumentation impact your interest on changes to the Earth's surface?

4. After engaging in argument activities, did you do any research on your own to better understand something someone made a claim about? Why or why not?

5. What impact did argumentation have on your motivation to learn about the changes to the Earth's surface?

6. Did you pay attention to what others were saying more, less or the same when arguing? Why or why not?

7. Is there anything else you would like me know about your experiences with argumentation?

APPENDIX I

PRE/POST TEST: EARTH'S CHANGES

Name _____

4.E.2.3. Assessment

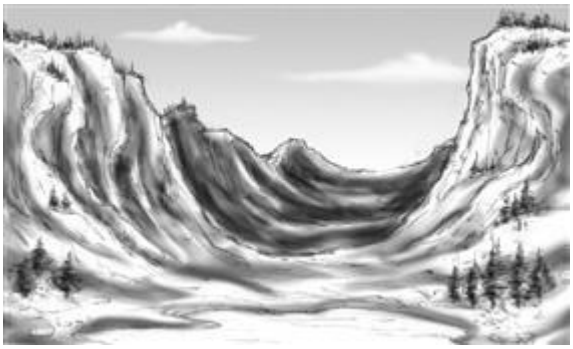
1. Which is a quick process that can form new land near an ocean?

A. earthquake
B. landslide
C. volcano erupting
D. weathering from waves

2. Rocks sometimes show evidence of ancient glaciers. Which is the best sign that glaciers once covered an area?

A. Rocks have many scratches.
B. Rocks contain fossils
C. Rocks are covered by moss,
D. Rocks are deep underground.

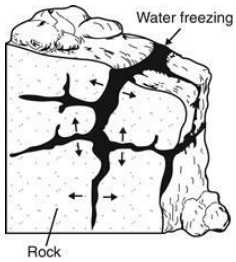
3. The picture shows a U-shaped valley.



The valley most likely was formed by

A. a glacier.
B. a volcano.
C. a landslide.
D. an earthquake.

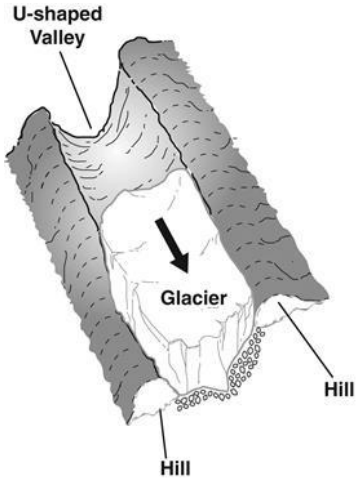
4. The picture shows water freezing in the crack of a rock. Which will likely occur next?



A. The rock will grow back together
B. The ice will remain as part of the rock.
C. The rock will get bigger.
D. The rock will break into pieces once the ice melts.

Changes in the Earth's Surface

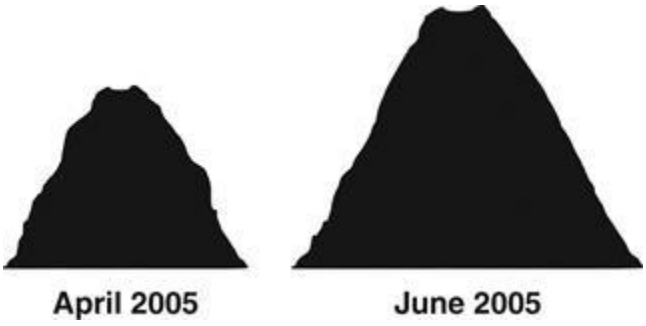
5. Glaciers can form on the top of mountains as snow in the picture below. As _____pulls a glacier down a mountain, it can leave behind a U-shaped valley. Hills can also form on either side of the valley as the glacier moves. The picture shows these two changes.



Which word below fits in the blank in the paragraph above?

A. water
B. gravity
C. mud
D. sediments

6. The figure shows the change to a mountain over a few months.



Which event most likely caused the increase in the size of the mountain?

A. erosion
B. volcanic eruption
C. landslide
D. earthquake

7. Geologists were investigating some large boulders and they concluded that they were transported by a form of erosion.



What caused the erosion that most likely transported these boulders?

A. glaciers
B. gravity
C. water
D. wind

8. Which rapid changes are caused by heat from inside Earth?

A. landslides
B. volcanoes
C. avalanches
D. floods

9. Heavy rain can cause soil to flow quickly downhill. What is this change called?

A. a tornado
B. a flood
C. a landslide
D. an earthquakes

10. Which rapid changes can be caused by storms?

A. landslides and flooding
B. flooding and earthquakes
C. landslides and volcanoes
D. volcanoes and earthquakes

11. How does ice change the shape of rocks rapidly?

A. It dissolves the rock by pooling on surfaces.
B. It breaks the rock by expanding in openings.
C. It smoothes the rocks by colliding with them.
D. It moves the rocks by pressing on them.

12. Which land form is the result of the constructive force of a glacier?

A. valleys carved by a moving glacier
B. piles of rocks deposited by a melting glacier
C. grooves created in a granite surface by a glacier
D. bedrock hills roughened by the passing of a glacier

13. The grasslands ecosystem once had a deep layer of topsoil which was protected by the

grasses that covered it. Removal of these grasses for farmland is causing the soil to be eroded mainly by

A. wind and rain.
B. animal movement.
C. Corps growing in the soil.
D. increased temperatures.

14. Which change makes a structure on Earth's surface?

A. A flood makes people leave town.
B. An earthquake makes waves in a field.
C. Lava from a volcano erupting makes new land.
D. A landslide into a bay makes a tidal wave.

15. The picture shows an unusual rock formation.



Which is most likely responsible for the unusual shape of this formation?

A. wind
B. animals
C. plant roots
D. running water

16. In some places, sand on the beaches is being reduced. New sand is brought from other areas and spread on the beaches. What process causes this decrease to the beach sand?

A. earthquakes
B. erosion
C. landslides
D. weathering

17. During a rainstorm, leaves wash down a valley on a hillside. The water slows down at the foot of the hill and *fans* out, depositing the leaves. What structure is formed in a similar way?

A. a pillar
B. an icicle
C. a fault line
D. a delta

18. Which would be the best title for the list?

?
Earthquakes
Landslides
Volcanoes

A. Slow changes to the Earth's Surface
B. Rapid changes to the Earth's Surface
C. Changes Caused by Storms
D. Changes Caused by Gravity

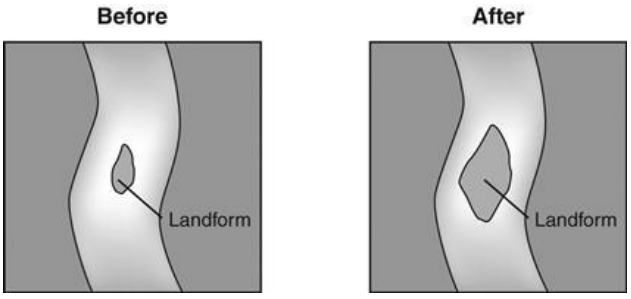
19. Which process is most directly related to constructing, the building up of, new land?

A. erosion
B. polluting
C. deposition
D. weathering

20. Which process turns a large rock into a pile of smaller stones?

A. deposition
B. sedimentation
C. fossilizing
D. weathering

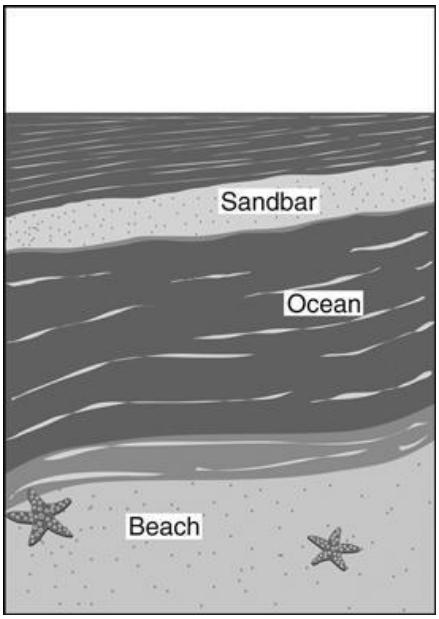
21. The pictures show some changes to a river over time.



Which best explains how the landform in the river changed over time?

A. The river wore away sediments from the landform.
B. Rocks under the river were pushed up by the faulting.
C. Sediments were deposited on the landform from the river.
D. Weathering caused the landform in the river to become larger.

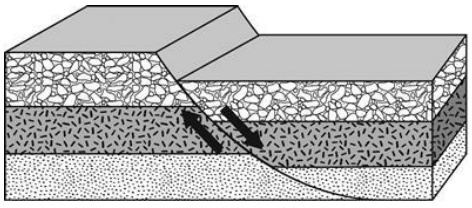
22. Madison visited the beach. She saw the top of a sandbar in the ocean.



Which most likely helped to form the sandbar?

A. boats sailing near the beach
B. children playing in the sand
C. wind and waves moving the sand
D. birds and crabs nesting on the beach

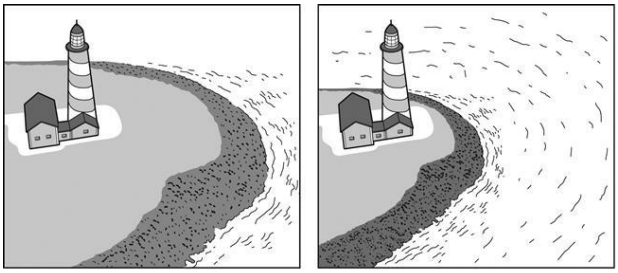
23. **A section of rock layers is shown in the diagram.**



Which most likely caused the rock layers to move?

A. flooding
B. mudslides
C. weathering
D. earthquakes

24. The pictures show the same beach. The first picture was taken 25 years ago and the second picture was taken 2 years ago.



Which is the most likely cause of the beach getting smaller?

A. deposition of sand
B. erosion of sand by waves
C. sand dissolving in the water
D. gravity pulling sand away from the beach

25. Which event caused the changes to the earth's surface and destroyed homes in the pictures below?



A. an earthquake
B. a landslide
C. a tornado

D. tidal waves

26. On the lines below write your response.

Will a fast moving river or slow moving river weather rocks faster? Why?

APPENDIX J

FORMATIVE ASSESSMENTS

Name _____HR _____ #_____Date _____

Agree or Disagree Statements-Earth's Surfaces

Directions: Read each statement below. Decide if you agree or disagree with the statement and explain your reason for agreement or disagreement.

Statement:	Agree/Disagree	Explanation
1 Landforms stay the same forever.	_____Agree _____ Disagree	
2 It is okay to build houses next to rivers or oceans.	_____Agree _____ Disagree	
3 Glaciers and rivers have a similar impact on the surface of the earth.	_____Agree _____ Disagree	
4 The surface of the earth only changes slowly.	_____Agree _____ Disagree	
5 Slow moving water causes rocks to weather faster.	_____Agree _____ Disagree	
6 Only earthquakes make new land.	_____Agree _____ Disagree	
7 Volcanic eruptions are always bad for the earth.	_____Agree _____ Disagree	
8 Weathering and erosion are the same process.	_____Agree _____ Disagree	