MEASURING STUDENT SUCCESS IN THE SCIENCE CLASSROOM THROUGH
INQUIRY-BASED DISCUSSION FORMATS
AND STUDENT DISCOURSE

by

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ABSTRACT

Scientific communication and discourse have become key components in scientific pedagogy today. Traditional classroom discussion techniques follow a teacher-led format in which students typically respond to short, close-ended questions, resulting in lower-level thinking and decreased student participation. Past research supports the use of inquiry-based, student led discussion formats to promote higher-level thinking and increase student success in the science classroom.

Over the course of a two-month period in 2017, one high school earth science class engaged in inquiry-based discussion formats with the goal of determining the impact of this discussion format on student success in the science classroom. Students participated in daily discussions designed to share ideas and analyze major concepts. At the culmination of each unit, students also participated in an argumentation framework to create claims, collect evidence and defend their claims to their peers. During the same time period, the remaining three earth science classes received the same content, delivery, and assessments, but did not participate in the discussion activities.

Student success was defined by content comprehension, participation, and scientific communication skills. The treatment group was compared with the control group by analyzing assessments, student journaling, student interviews, teacher field notes, and Likert surveys. Data analysis from these tools revealed a higher performance in student participation and scientific communication skills among the treatment group. Content comprehension was measured through assessments, and did not show a significant difference between the two groups in terms of fact recall. However, students in the treatment group demonstrated a higher conceptual knowledge and performed better on the essay responses of the assessments. These findings could be strengthened by a longer treatment period.
INTRODUCTION AND BACKGROUND

Florence-Carlton High School is a smaller school located in Florence, Montana about 20 miles south of the city of Missoula. The Florence community is one of the smaller communities located in Ravalli County, but closely resembles the county demographics. Census data obtained in 2014, lists Ravalli County’s population size at 41,030 people with approximately 95.6% being a Caucasian (American Fact Finder, 2014).

The school serves about 270 students in grades 9-12 with core classes averaging about 15 students per class. Florence-Carlton High School is designated as a Montana Class B school, meaning it has between 120 and 339 students (Mazzolini, 2014). These class designations are used to help organize state athletic competitions. There are eight other high schools within a 40 mile radius of Florence, and most of these schools are larger than Florence-Carlton High School. Often, the school accepts out of district students from outlying areas, but also loses some students to the larger high schools in Missoula. With Florence being a smaller community, most of the residents of Florence commute to Missoula for work.

Classroom Environment

As one of three high school science teachers at Florence-Carlton Schools, I teach earth science, forensic science, ecology, and occasionally a biology section. Earth science is a freshmen level class that explores science and engineering methods, geology, meteorology, oceanography, and astronomy. Every year, I have observed freshmen who transition to high school with little experience in scientific discourse and communication.
Often, my students appear unengaged in classroom discussion settings, and unconfident in communicating their own ideas, observations, and questions. Without these discussion skills, students struggle to engage in higher level thinking processes. While I use a variety of inquiry-based teaching methods, student discourse has not been a major component of my lesson design, and I do not always implement a student-centered classroom discussion format. However, when I have used a more student-centered approach, I have noticed an increase in student engagement.

**Project Focus Question**

I think student discourse is essential to inquiry-based learning and higher-level thinking. With this in mind, I changed my classroom atmosphere and teaching methods to promote student discourse. My overall project goal was to increase student success in the science classroom measured through student content comprehension, participation, and scientific communication skills. To accomplish this, I designed a study that focused on a student-led discussion atmosphere and student discourse with one of my four sections of earth science. With this class, I used research-based methods to incorporate group discussion and argumentation into every class period. I challenged students to construct their own questions and knowledge, formulate scientific claims, and defend those claims to their peers. Alternatively, I engaged in my normal teaching methods with my other three sections of earth science. This research design provided me with a standard for comparison in my study of the effects of inquiry based discussion formats on student success.
The overlying research question this project addressed was: how do student-led, inquiry-based discussion formats affect student success in the science classroom? This research project also addressed the following sub-questions: 1) What type of relationship exists between inquiry-based discussion formats and student comprehension? 2) In what ways do inquiry-based discussion formats affect student participation? and, 3) How do inquiry-based discussion formats affect students’ scientific communication skills?

CONCEPTUAL FRAMEWORK

Learning through inquiry has become the central focus of numerous education research studies in recent years. Many traditional teaching approaches are no longer considered best practice, and inquiry-based approaches have become the preferred science pedagogy. One of the main areas devoted to improving inquiry in the classroom is student discourse. In 2012, the National Research Council issued *A Framework for K-12 Science Education: Practices, Cross-Cutting Concepts, and Core Ideas*. This framework is the basis for the Next Generation Science Standards already adopted by many states. Scientific inquiry is a major focus of the scientific and engineering practices outlined in this framework, with the goal of encouraging students to question, reason, and construct their own knowledge rather than memorizing content (National Research Council, 2012). The following literature review will explore traditional science practices in relation to discourse, inquiry-based science practices, and strategies to improve questioning and classroom discussion.

Traditionally, teacher questioning and classroom discussions have followed a teacher-centered approach (Renne, 1996). Often, the format of questions results in
closed-ended responses from students as a teacher checks for understanding (Swartz et al., 2009). The Initiation-Response-Evaluation (IRE) format is a common discourse pattern used in many past practices to facilitate discussion (Renne, 1996). A study conducted in 1992 (see Renne, 1996) explored the relationship between classroom rep order and discussion formats. Initiating this study was a push from the National Council of Teachers of Mathematics (NCTM) to promote classroom discourse when the IRE format was common practice. The study (Renne, 1996) followed the discussion exchanges in a fourth grade math classroom. The teacher primarily engaged in the IRE format, but when she allowed her students to deviate from this format, she lost classroom order. She continually returned to the IRE format to reestablish control. As the study concluded, the author supported the IRE method stating: “The highly efficient IRE pattern allows teachers to control who talks, for how long, and about what topic” (Renne, 1996, p. 12). However, recent research (Saglam, Kanadli, Karatepe, Gizlenci, & Goksu, 2015, p. 326) suggests that the IRE discussion pattern may deter student ideas, as discussed in a study comparing authoritative discourse with dialogic discourse. In this study, the authors equate the teacher in an authoritative discourse setting with that of a “gatekeeper to student point of view.”

More recently, Alozie and Mitchell (2014) conducted a study implementing an inquiry-based discussion format called Dialogic Discussion Supports (DDS). They argue that teachers often diverge from meaningful discussion due to time limits and lack of supports (Alozie & Mitchell, 2014). Instead, teachers tend to resort to the IRE model in which Alozie and Mitchell point out: “In IRE recitation exchanges, students generally
respond with short or one-word answers as responses to recall questions” (Alozie & Mitchell, 2014, p. 501). To assist teachers in getting away from the IRE model, a committee made up of teachers worked together to develop supports for use in scientific classroom discourse. These supports are geared towards helping teachers generate discussions, implement problem-solving discussions, and guide reviewing discussions. Tables 1, 2, and 3 on pages 502-504 outline the classroom discourse supports, provide strategies, and offer a rationale for why these methods are used. For example, to generate a discussion, one method used is the Think/Pair/Share support. Students are provided with questions to guide their small group discussion. The class later comes together to discuss these questions as a whole. The rationale for this support is that it increases student participation as students must interact with a partner about the discussion topic (Alozie & Mitchell, 2014).

Alozie and Mitchell (2014) documented the use of these strategies in the classroom, and followed one teacher, Ms. Ina, as she used the DDS model with her tenth grade biology classes. In conjunction with using the discourse supports, Ms. Ina also forced her students to lead the discussion. Upon conclusion of the study, the teacher did note some student frustration with the change in the discussion format (Alozie & Mitchell, 2014). However, she also stated, “From these practices, students started to make changes in their participation. They worked together, supported, assisted, and challenged each other’s ideas” (Alozie & Mitchell, 2014, p. 505).

Moreover, traditional questioning techniques, and those most often used in the classroom today, do not promote higher-level thinking. As Patricia Blosser (2000) points
out, “We would probably discover that most questions are designed to determine only whether a student does or does not know a particular item of information” (p. 2). Blosser goes on to cite research conducted by Gall, Dunning, and Weathersby in 1971 on the types of questions teachers ask: “Research on the questions teachers ask shows that about 60 percent require only recall of facts, 20 percent require students to think, and 20 percent are procedural” (Blosser, 2000, p. 3).

With a shift occurring from the traditional IRE model to more inquiry-based discussion formats, several studies have explored the impact of inquiry-based discussion on student understanding, engagement, and interest in science. In 2008, Li-hsuan Yang followed a physics class through a lesson on circuits. In the study, students were asked to work together to create models, make claims, and defend their claims using evidence. The teacher recognizes that while the topic of circuits can be complex, the students were largely engaged in discussion with one another (Yang, 2008). He also claims that his students gained a better understanding of circuits and electricity because they “listened to each other’s reasoning, tested their ideas with empirical observations, and reflected on how they knew what they knew” (Yang, 2008, p. 56).

In another study, conducted in 2012, Smart and Marshall examine the relationship between classroom discourse and student cognitive engagement. Ten middle school science teachers enrolled in a two-week professional development workshop on the 4Ex2 Instructional Model that follows a sequence of engage, explore, explain, and extend (Smart & Marshall, 2012). After the professional development, teachers used this model throughout the following school year. During this time, researchers collected data
through formal observations and interviews with the teachers. Upon its conclusion, the study found that a direct correlation between classroom discourse and student cognitive engagement (Smart & Marshall, 2012). The study also concluded that lower-order questioning tends to follow teacher-centered instruction (Smart & Marshall, 2012).

In a similar study conducted by Saglam et al. in 2015, 17 primary school teachers engaged in a one month professional development workshop comparing authoritative and dialogic discussion formats. The dialogic discussion format developed by Saglam (see Saglam et al., 2015) is called Sociocultural Dialectic Model (SDM), and focuses on the following three stages in discussion: "creating a meaningful context, contextualizing action, and labeling action" (Saglam et al, 2015, p. 323). Before the workshop, each teacher taught five video-taped lessons. These lessons were used as a baseline for comparison after the professional development activity. Prior to the intervention, data from Figure 1 shows that seven teachers did not engage in dialogic discourse at all, while another seven used it in a low percentage (Saglam et al., 2015). This finding is important as it demonstrates the prevalence among science teachers of using traditional discussion practices in science classrooms today. After the intervention, more than 70% of the teachers increased their use of dialogic discussion, and as the authors argue, increased their engagement in meaningful dialogue (Saglam et al., 2015).

With the goal of studying inquiry and its relationship to student discussion, Kerlin, McDonald, and Kelly (2008), implemented a study on a ninth grade earth science class. During a five-day unit on seismology, students collected data from a USGS website. The main methods in this study involved students making claims, collecting
evidence, and arguing their claims in small group and whole class discussions. To analyze the data, each lesson was broken down by time into teaching practices such as lecture, discussion, and investigation, and further broke down into topics of study. During the discussion portions of the unit, students were able to share their claims and evaluate each other’s claims (Kerlin et al., 2008). Researchers then analyzed each discussion by examining the number of students who participated in the discussion and the percent of total time students were the primary speakers in the discussion (Kerlin et al., 2008). Further analysis of this data supported student participation in discourse when given the opportunity. While the teacher helped to guide the discussions, all students were able to share their scientific ideas (Kerlin et al., 2008).

Most research studies conducted in recent years support inquiry-based classroom discourse rather than the traditional IRE format, and there are numerous studies supporting a variety of methods to increase meaningful classroom discourse. Frey and Fisher (2011) discuss the importance of using language frames to structure discussion, arguing that students struggle to engage in scientific discussion on their own. According to Frey and Fisher, the first step in structuring group and classroom discussion is to communicate the purpose; students need a place to begin (Frey & Fisher, 2011). They then support using language frames as a tool to increase student use of correct scientific vocabulary. A language frame provides the framework for students to use in their discussions, guiding students to acknowledge other’s claims, while also making their own claims, and supporting them with evidence (Frey & Fisher, 2011).
“A limitation of this experiment is ______. It could be further strengthened by ______.”

This language frame requires students to think about possible limitations to the experiment, and provide their ideas as to how the experiment could be improved.

In 2010, Shiller and Joseph published *A Framework for Facilitating Equitable Discourse in Science Classrooms* providing methods to support classroom discussion. They argue that many teachers engage in traditional classroom discourse where the teacher asks a fact-based question and one student responds (Shiller & Joseph, 2010). There is very little sharing of ideas. To promote an inquiry-based classroom discourse, Shiller and Joseph propose a tetrahedron model in which the teacher is just one corner of the tetrahedron and works with the students to construct learning (Shiller & Joseph, 2010). In this model, students get the opportunity to lead the discussion and interact with each other. However, the authors warn that this type of discourse only works in a supportive environment where students feel safe in sharing their ideas (Shiller & Joseph, 2010). To facilitate this type of environment, the author provides several techniques to support this model such as asking open-ended questions and allowing students with ample time to think. This will allow more students to participate in discussion. They also recommend using small group sharing, “think-pair-share” activities, journaling before responding, and assigning roles in small group discussions. Roles such as recorder, reporter, and leader can keep every student involved and active in the discussion (Shiller & Joseph, 2010). Lastly, the author emphasized the importance of communication. One strategy to help students to formally present their findings is to set-up a poster session. After conducting an experiment and analyzing their findings, students create a formal
poster to be used as a presentation tool. Half of the class sets up their posters around the room while the other students circulate the classroom and ask about their data collection and findings (Shiller & Joseph, 2010).

Types of discussions used can be just as important as facilitating discussion. Shwartz et al. (2009) provides an examination into the purpose of different types of classroom discussions and how these discussions support inquiry-based learning. They do acknowledge that the traditional classroom discussion format, or IRE format, has its place in the classroom as it can provide a “quick, whole-class review before moving on to new activities” (Shwartz et al., 2009, p. 44). However, they also acknowledge that this type of discussion format should not be the main format in an inquiry-based classroom (Shwartz et al., 2009). They go on to present three different types of discussions: brainstorming discussions, synthesizing discussions, and sensemaking discussions. Brainstorming discussions are primarily used at the beginning of the unit to allow the sharing of ideas and experiences among students. Synthesizing discussions are designed for students to build off their ideas and make connections to past knowledge. In this type of discussion, students share ideas, discuss and compare their findings, and organize their knowledge. Lastly, sensemaking discussions are designed for use at the conclusion of an investigation. These discussions incorporate argument and debate, while requiring students to analyze their experiences (Shwartz et al., 2009). In all three types of discussions, the authors emphasize the importance of establishing norms for discussion to provide a respectful classroom environment conducive to sharing ideas (Shwartz et al., 2009).
Lastly, Ying-chih and Steenhoek (2014) present a model to guide scientific argumentation. This model was used in a fifth grade-classroom during a unit on the human body. Ying-chih and Steenhoek note the important role argumentation plays in scientific inquiry stating, “That is, students need to use the argument structure to learn science concepts, just as scientists do” (Ying-chih & Steenhoek, 2014, p. 231). The framework is broken down into four parts: question, claim, evidence, and big idea with guidelines on how to approach each of these components by going through six “phases” (Ying-chih & Steenhoek, 2014). According to this framework, students need to first formulate a testable question to guide their investigation. Next, they conduct an investigation and collect data. From their data, they then make a claim and provide evidence to support that claim. In the fourth phase they present their argument to the class, receiving input from their peers. Phase five is devoted to collecting research from outside sources on the validity of their claim. Lastly, students communicate what they learned through reflection and writing (Ying-chih & Steenhoek, 2014).

In summary, current research supports the notion that while traditional discourse formats serve as a tool for the teacher to retain control and successfully manage discussions, it is not considered best practice. In traditional discussion formats, like IRE, the discussion is fairly one sided, with the teacher essentially controlling the dialogue. With inquiry at the center of today’s teaching methodology, classroom discourse is becoming an important tool to promote inquiry through higher-level questioning, establishing norms to guide classroom discussion, and shifting the discussion from teacher-centered formats to student-centered formats.
METHODOLOGY

As science pedagogy continues to evolve, inquiry-structured classrooms and student discourse have been the topic of many published research studies. I used practices implemented in other research studies to help guide the structure of this study. The primary focus of my study was to evaluate the effectiveness of inquiry-based discussions on student success in the science classroom. This study also addressed each of the following sub-questions: 1) What type of relationship exists between inquiry-based discussion formats and content comprehension? 2) In what ways do inquiry-based discussion formats affect student participation? and, 3) How do inquiry-based discussion formats affect students’ scientific communication skills?

Participants

In conducting this study, I collected data over the course of two science content units during the months of January, February and March in 2017. To keep data analysis manageable, I implemented this research study with only one of my four sections of freshmen level earth science classes. I engaged in my normal teaching practices with the other three earth science sections, as I used these classes as a standard for comparison. To gain a more accurate analysis of the intervention’s effectiveness on all freshmen earth science students, I chose one of the largest, and most academically diverse sections that best reflected the freshmen class as a whole. This class was composed of 17 students. Eight of the students were female and nine of the students were male. Academically, most of the students performed in the average range on homework and assessments. There was a small population that typically performed above average, and a couple of
students who received additional academic help and resources. Lastly, this class accurately represented the overall Florence, Montana population with 95% of the students in this class belonging to a Caucasian race. In comparison, the control group was made up of 43 students (the remaining three sections pooled together), with 95% of the students Caucasian. Like the treatment group, 53% of the students in the control group were male and 47% were female. Moreover, the control group was similar to the treatment group in terms of academic performance with a wide spectrum of abilities.

This action research project was granted exempt status by the Montana State University Institutional Review Board (Appendix A).

**Intervention**

With the goal of studying the impact of student discourse on content comprehension, participation, and scientific communication skills, I implemented the intervention with one section of my four earth science sections during an eight-week period beginning in late January. The intervention began with the initiation of a unit on earthquakes, followed by a unit on volcanoes. During the same time period, my other three earth science sections received the same content, delivery, and assessments, but did not take part in the discourse activities.

Over the next two months, I engaged in inquiry-based discussion formats with my fifth period earth science class, emphasizing a student-led atmosphere. During the intervention, each class period began with a brainstorming discussion. To initiate this discussion, students followed the general procedure of thinking about a question relevant to the day’s lesson, responding in their journal, and then sharing their responses with their
group. As a group, students shared their responses with the rest of the class, transitioning us into the day’s lesson that usually involved a lab investigation. Each class period closed with a sensemaking discussion. For this discussion activity, each student was assigned one of the following roles in their group: recorder, reporter, or group leader. Often guided by language frames, students were challenged to discuss a complex topic relating to the day’s lesson, formulate a response, and defend their response with evidence.

Lastly, for each unit, students engaged in one large student-led investigation following an adaptation of the scientific argumentation framework presented by Ying-chih and Steenhoek (2014). Following this framework, students worked in groups of three to research the question of interest. They spent two full class periods conducting research, developing a claim, collecting evidence, and creating a poster to present and defend their claim. During the poster session, half of the groups presented their claim, while the other half of the class walked around to each of the posters, took notes, challenged the claims, and evaluated the strength of those claims. After fifteen minutes, the groups switched places. I took field notes during this poster session to collect data on student interactions, and their skills in communicating their claims and evidence to their peers. Each week, I collected data on student content comprehension, participation, and their scientific communication skills.

**Data Collection**

In analyzing the impact of inquiry-based discussion formats on student success in earth science, I relied heavily on qualitative data collection in the form of field notes. I also implemented formative assessments, student surveys, student interviews, and student
journaling. An overview of my research questions and associated data collection tools can be found in Table 1.

Table 1

| Focus Question: How can inquiry-based discussion formats be used to increase student success in the science classroom? |
|---|---|---|---|
| **Sub-Questions** | **Data Source 1** | **Data Source 2** | **Data Source 3** |
| Sub-Question 1: What type of relationship exists between inquiry-based discussion formats and content comprehension? | Field Notes (group discussions) | Formative and Summative Assessments | Student Journaling |
| Sub-Question 2: In what ways do inquiry-based discussion formats affect student participation? | Field Notes (group discussions) | Student Surveys | Student Interviews |
| Sub-Question 3: How do inquiry-based discussion formats affect students’ scientific communication skills? | Field Notes (group discussions) | Formative Assessments (poster session, written responses - defending claims with evidence) | Student Surveys |

Field notes provided me with valuable data for each of my sub-questions. While video recording is commonly used in similar studies, field notes were more practical for my investigation. During small group discussions, I walked around the classroom taking notes about the types of questions exchanged, conceptual understanding, and student participation (Appendix B). I also utilized field notes to observe the argumentative process during the two student-led lab investigations. For each of these lab investigations, students participated in a poster session to communicate their research to their peers. I took field notes during this poster session to collect data on student interactions, and their skills in communicating their claims and evidence to their peers. I also used a rubric.
(Appendix C), adapted from Ying-chih and Steenhoek (2014), to analyze students’ scientific communication skills.

Furthermore, I implemented formative and summative assessments, as well as student journaling to measure content comprehension and scientific communication skills. Written responses to prompts, concept maps, and daily homework assignments were utilized throughout the intervention period. I used the same formative assessments for all of my earth science sections. This allowed me to make comparisons about content comprehension and scientific communication skills between the group receiving the intervention and the group not receiving the intervention. It is important to note the intervention group received three less instruction days in February than the other class periods due to snow delays and cancellations. Therefore, the intervention group received less time with the content and preparation for the unit assessment.

Lastly, Likert scale surveys and student interviews were applied to measure student participation and their feelings toward the inquiry-based discussion formats. I implemented the Likert scale surveys prior to the intervention and after the intervention focusing on students’ attitudes towards classroom discussions, communicating their ideas to their peers, and desire to participate in classroom discussions. I also interviewed three students at the conclusion of the study to analyze the effectiveness of inquiry-based discussion formats on student success. To select students for the interview, I first compiled a list of all students who were willing to participate in an interview. Then, using class schedules and student availability, I selected the first three available students to participate in an interview for this study. Using the microphone on my phone, I recorded
the interviews and later transcribed them for easier analysis. All students received the same interview questions, and were allowed to respond freely.

Data collection for this study began at the start of second semester on January 23rd, 2017. This day marked the beginning of a unit on earthquakes. At this time, students completed a Likert scale survey, developed classroom discussion expectations, and engaged in their first student-led discussion. Formative assessments were implemented throughout the unit, with group discussions occurring daily. Field notes were the main source of data collection for the group discussions. Each unit lasted about three and a half weeks, and concluded with a summative assessment. Before the summative assessment, students participated in an investigation lab and a research poster session. The goal of the poster session was for students to present their findings to their peers and defend their claims, with the focus on scientific communication skills. A final Likert scale survey and student interviews concluded the study on March 20th, 2017.

DATA AND ANALYSIS

Over the course of the study, student performance in science content comprehension, class participation, and scientific communication skills were compared between the treatment group and the control group to determine the impact of inquiry-based discussion formats on student success. Success between the two groups was measured through student journaling, Likert surveys, student interviews, field notes, and assessments. My analysis indicated that improvements to content comprehension and student participation were not significant, however, I observed a more notable improvement in scientific communication skills among the treatment group.
Content Comprehension

Assessments, field notes, and student journaling provided a basis for measuring student content comprehension. Content comprehension can be broken down into basic vocabulary and factual knowledge, or it can be conceptual, measuring a student’s ability to apply, analyze, and evaluate the larger concepts. There was no statistically significant relationship between inquiry-based discussion formats and normal content vocabulary or factual knowledge. However, students who received the intervention did demonstrate a deeper understanding and greater conceptual knowledge than those who did not receive the intervention. This is supported by the formative assessments completed throughout this intervention period, as well as the end of the unit summative assessments. Halfway through the earthquakes unit, students from both the treatment group and the control group were given 20 concepts to form a concept map about earthquakes (Appendix D). They were assessed based on their ability to accurately connect the concepts and identify the relationship between the concepts (Appendix E). The control group had a mean score of 77.84% with a standard deviation of 20.19. The treatment group average score was 87.94% with a standard deviation of 10.76. The difference in scores between the two groups was not quite statistically significant, t(58)= 1.95, p=0.0561. However, students from the treatment group did score about 10 percentage points higher than the control group, and had a smaller standard deviation between the scores. Overall, students from the treatment group did perform better than those from the control group (Table 2).
Table 2

<table>
<thead>
<tr>
<th></th>
<th>Treatment Group (n=17)</th>
<th>Control Group (n=43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (%)</td>
<td>87.94%</td>
<td>77.84%</td>
</tr>
<tr>
<td>Median (%)</td>
<td>90%</td>
<td>85%</td>
</tr>
<tr>
<td>SD</td>
<td>10.76</td>
<td>20.19</td>
</tr>
<tr>
<td>SE</td>
<td>2.61</td>
<td>38.28</td>
</tr>
</tbody>
</table>

Alternatively, the unit summative assessments did not follow the same trend as the concept map, instead showing little difference in scores between the treatment group and the control group. During the earthquakes assessment, both groups earned a class mean score in the C range with the control group scoring about 1.5% points higher (Table 3). A closer analysis revealed that the control group scored better on the multiple choice portion of the test while the intervention group scored about six percentage points higher on the essay portion of the test. Furthermore, these scores may be a reflection of differences in instructional time; the intervention group received three less instructional class periods (4.5 hours) than the control group due to weather cancellations and delays. Near the end of the treatment implementation, students completed the volcanoes unit assessment. The control group had an average score of 70.89% with a standard deviation of 14.02. The treatment group had a mean score of 75.49% with a standard deviation of 11.50. The difference in scores between the two groups was not significant, t(58)=1.2007, p=0.2347 (Table 4). Figures 1 and 2 show the group grade distribution for the earthquakes assessment and volcanoes assessment respectively.
Table 3  
**Earthquakes Summative Assessment Score Comparison**

<table>
<thead>
<tr>
<th></th>
<th>Treatment Group (n=17)</th>
<th>Control Group (n=43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (%)</td>
<td>73.54%</td>
<td>74.92%</td>
</tr>
<tr>
<td>Median (%)</td>
<td>74.15%</td>
<td>75.0%</td>
</tr>
<tr>
<td>SD</td>
<td>9.13</td>
<td>11.15</td>
</tr>
<tr>
<td>SE</td>
<td>2.21</td>
<td>1.70</td>
</tr>
</tbody>
</table>

Table 4  
**Volcanoes Summative Assessment Score Comparison**

<table>
<thead>
<tr>
<th></th>
<th>Treatment Group (n=17)</th>
<th>Control Group (n=43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (%)</td>
<td>75.49%</td>
<td>70.89%</td>
</tr>
<tr>
<td>Median (%)</td>
<td>76.2%</td>
<td>73.1%</td>
</tr>
<tr>
<td>SD</td>
<td>11.50</td>
<td>14.02</td>
</tr>
<tr>
<td>SE</td>
<td>2.79</td>
<td>2.14</td>
</tr>
</tbody>
</table>

Figure 1. Earthquakes test grade distribution.
Evidence from student journaling and group discussion field notes further supports a relationship between conceptual understanding and inquiry-based discussion formats. During one journaling activity, both groups were asked to discuss the tools and steps needed to calculate the location of an earthquake’s epicenter. As a whole, students from the intervention group provided more in-depth and scientifically accurate responses than students from the control group. Many students from the control group responded with broad, unspecific responses, leaving out key steps such as measuring the time between the P and S waves. Both groups received prior lab experience with this concept. However, the intervention group received an additional inquiry discussion activity before their formal lab in which they were given tools, seismograph data, and a map. They were challenged with the following prompt: “With your group, discuss how you can find the epicenter of the earthquake using the information and tools provided. Once you figure out how to find the epicenter, find it!” During this activity, I recorded notes about student
interactions, types of questions exchanged, and participation. All students from four of the six groups were actively engaged in solving this question. Dialogue from several of the groups is recorded below:

“Where do we start?”

“How do we find the time between the P and S waves? This graph looks different than the ones we’ve seen before.”

“I think we need to count the minutes between the two waves on the graph.”

“Why do we need three different seismograph stations?”

“This is so hard.”

“We figured it out!”

“I don’t think we did this right. The circles are supposed to intersect.”

This discussion activity allowed students to learn from each other and discover the solution through inquiry. Although some groups needed more instruction than others, students generally constructed their own knowledge, and gained confidence in applying this concept.

Student Participation

Student participation was measured through field notes during discussions, Likert surveys, and interviews. Field notes provided a direct observation of student participation, while the survey and interviews revealed student feelings toward participation. While feelings toward participation did not show a significant change, inquiry-based discussion formats increased the overall class-wide participation.
At the beginning of each class period, students responded in their journals to a prompt on the board such as: “What factors do you think are most significant when determining how destructive and earthquake will be?” After several minutes of responding to this prompt, students were asked to discuss their response with other students sitting at their table, and refine a group response. Lastly, they shared their response with the class. All ideas were written on the board, and were not corrected. This exercise served as a brainstorming discussion. On many occasions, students also participated in a sense-making discussion at the end of the class period relating to the day’s lesson. These discussions were often set up using language frames, and required students to perform as the group leader, the recorder, or the reporter. For the first sense-making discussion, students were asked to formulate a response using the following language frame: “The destructiveness of an earthquake is dependent on ___________. This is evidenced by ______________.” Using evidence from the day’s lesson, students worked with their group members to respond to this prompt. Student responses to this prompt are recorded in Appendix F. Not everyone came up with the same answer, and all groups backed up their claims with evidence. Each student in the group had a role to fulfill. During this discussion, only two of 17 students were off-task. In the first sense-making discussion, some students demonstrated confusion with the language frame, and struggled to provide evidence. With more practice, this became easier and students required less direction.

In comparing the control group with the treatment group, class-wide participation was much higher among the treatment group. In the control group, fewer total students
asked questions, offered responses, and showed active engagement in the lessons.

Students still responded to similar prompts in their journal, but they did not participate in small group discussions. This resulted in fewer, and often the same, students offering to share their response with the class, limiting the overall discussion.

Student feelings toward participation in inquiry-based discussion formats were mixed. Prior to the intervention and upon completion of the intervention, students engaged in a Likert scale survey (Appendix G) investigating student feelings and opinions toward inquiry-based group discussions. Four questions from the survey directly related to student participation. A comparison of student responses to these questions before and after treatment is recorded in Figures 3, 4, 5 and 6.

*Figure 3.* Distribution of student responses before and after treatment to the following statement: I feel comfortable sharing my scientific ideas with my peers in a group setting, \((N=17)\).
Figure 4. Distribution of student responses before and after treatment to the following statement: I feel more engaged in science class during group discussion settings than during class lecture settings, (N=17).

Figure 5. Distribution of student responses before and after treatment to the following statement: I prefer to learn science in a collaborative (group discussion) setting rather than a teacher-led lecture setting, (N=17).
Figure 6. Distribution of student responses before and after treatment to the following statement: I am more likely to share my scientific ideas in a group discussion setting than during a class lecture setting, (N=17).

According to the survey, there was not a major shift in responses from pre to post treatment regarding student participation. There was a slight increase in the number of students who responded to agree or strongly agree for question 2: “I feel comfortable sharing my scientific ideas with my peers in a group setting.” Prior to the treatment, zero students chose somewhat agree and only four students chose strongly agree. After the treatment, two students chose somewhat agree and six students chose strongly agree, indicating the treatment positively impacted student views on participating in group settings. However, responses to questions five, eight, and nine provided a more inconclusive result. Prior to the treatment, all students responded in the neutral to strongly agree range for the statement: “I feel more engaged in science class during group discussion settings than during class lecture settings.” After the treatment, two students changed their response to strongly disagree. Similarly, one student moved to the disagree range after the intervention in response to question eight: “I prefer to learn science in a
collaborative (group discussion) setting rather than a teacher-led lecture setting,” and question nine: “I am more likely to share my scientific ideas in a group discussion setting than during a class lecture setting.” When farther exploring these responses, I noticed that three students fell into the disagree column on each of these questions, and wrote about their reasoning on question 11. One student wrote an explanation to a strongly disagree response for question eight: “I like it when everyone is in on the discussion rather than just a small group. I feel like I can ask more questions and have a better understanding of the topic.” Another student had a similar explanation to this question: “My peers aren’t as knowledgeable on the subject compared to the teacher. I’d rather learn from somebody who knows the facts.” These responses indicate that while the majority of students responded positively to inquiry-based discussion formats, some students did not prefer this style of learning.

Three students were interviewed at the conclusion of the intervention in a semi-structured interview format. They were asked five open-ended questions (Appendix H) about their experience participating in inquiry-based discussions and student discourse. Student responses were fairly similar, with some opposing views. Two students responded that small group discussions positively impacted their learning. One of these students stated: “It really helped because you get more information on the subject and are able to see it in a different way.” The third student responded that small groups discussions are helpful, but she likes larger class discussions because she is able to see “more point of views” and “there are more people to learn from.”
Two of the three students also responded in favor of learning science concepts in a collaborative group discussion setting rather than a teacher-led lecture setting. Both of these students stated they feel more engaged in collaborative group settings, and that it is harder to pay attention when the discussion is teacher-led. The third student stated the type of setting doesn’t matter, and that she feels engaged in both type of settings. She did state “teacher-led discussions are more factual.”

**Scientific Communication Skills**

The most notable finding from this study was the impact of inquiry-based discussion formats on student scientific communication skills. Scientific communication skills were measured through field notes, formative assessments, and student surveys. Prior to the intervention, students had very little experience engaging in scientific discourse and communicating their scientific findings. During the first Likert survey, only four students agreed with the statement, “I can develop a scientific argument consisting of a claim and evidence.” Two students stated they didn’t know what a claim or evidence was. In the two-month intervention period, students gained experience in communicating scientific ideas through writing and engaging in scientific discourse. When the Likert survey was conducted at the end of the study, twelve students strongly agreed or somewhat agreed with the same statement, while only three students chose somewhat disagree to the statement (Figure 7).
Brainstorming discussions occurred daily, but were designed to provoke ideas rather than initiate scientific argumentation. Sense-making discussions occurred at the conclusion of many lessons, and provided an opportunity for students to practice scientific communication. The first sense-making discussion occurred on the first day of the intervention. Students were presented with a language frame and were prompted to respond by forming a claim and providing evidence. Initially, some students were confused with the language frame and struggled to provide a claim and evidence, stating: “providing evidence is difficult.” Several students wanted more direct instruction and assistance in forming their claims. After 15 minutes of formulating their responses in their groups, each group shared their response with the class. Student responses to this language frame can be found in Appendix G. With more practice, sense-making discussions became easier for the students, and allowed students to see multiple viewpoints, while also learning how to evaluate the strength of an argument.
Twice during the intervention, students engaged in a scientific investigation following an adaptation of the scientific argumentation framework presented by Ying-chih and Steenhoek (2014). For the first investigation, students researched the probability of a major earthquake (7.0 or larger) occurring at, or near, a location of their choice within the next 100 years. Using the United States Geological Survey (USGS) website (https://www.usgs.gov), among other sites, students collected data such as historical seismicity, plate movement, and fault movement. Next, they constructed their claim, organized their evidence, and created a poster supporting their claim. Lastly, each group presented their argument to their peers using a poster session format. Students listening to the argument completed a peer review of the argument stating why or why not the claim was adequately supported. Five of the six groups were well prepared and knowledgeable about their location. When pressed with questions, most students were able to respond by providing more evidence. More importantly, students challenged one another’s ideas, and stated after the poster session, they learned a lot and now have a better understanding of how earthquakes work.

The second investigation asked students to formulate a claim to the question, “Will the Yellowstone volcano erupt again, and if so, what will the eruption be like?” Through movies and social media, many students began their research with already formed misconceptions. However, by the end of the investigation, many of those misconceptions were eliminated. Using resources from USGS and the Yellowstone Volcano Observatory (https://volcanoes.usgs.gov), students found lots of evidence to support their claim. During the poster session, two groups were noticeably more prepared
than the other groups, presenting a strong case for their claim. Again, students questioned the evidence presented and engaged in authentic scientific discourse.

Lastly, students interviewed were asked “How did the Argumentation Framework of making a claim, supporting the claim with evidence, and defending the claim to your peers, affect your learning?” All three students interviewed responded positively to this experience. One student stated, “It was fun. It actually helped me in a way. It made it easier to write about it later.” Another student said the poster session forced her to find her own evidence and argue her claim through evidence. Because of this, she thought she learned more than if she were to just read about the concept.

In general, this study did not support any significant changes to content comprehension and student participation between the control group and the treatment group. Students in the treatment group did seem to better grasp the larger concepts, but did not show marked improvements in factual recall. As a whole, students in the treatment were group were also more engaged in class discussions than the control group, but did not indicate a noticeable preference for inquiry-based discussions. More notably, students in the treatment group demonstrated a greater aptitude for scientific communication, both verbally and written expression.

INTERPRETATION AND CONCLUSION

While the results did not indicate a strong correlation between inquiry-based discussion formats and student success in the science classroom, there were some noteworthy findings. To begin with, scientific communication skills among the treatment group improved significantly. Students began expressing their scientific findings using
claims and evidence through their written and verbal communication. This was most noticeable during the student research investigation and poster session. Students not only defended their claims, but they respectfully questioned their classmate’s claims. A study conducted by Alozie & Mitchell (2014), found similar results. By engaging in scientific discourse, students participated more and “worked together, supported, assisted, and challenged each other’s ideas” (Alozie & Mitchell, 2014, p. 505). With scientific communication being a major component of NGSS, this finding is significant in terms of future teaching practice.

Furthermore, student participation also increased among the treatment group. Prior to the intervention, classroom discussions largely revolved around four or five students actively participating in the discussion, while the majority of the class remained relatively quiet. During the intervention, discussion became more balanced, involving all of the students in one way or another. Methodology to increase student participation during discussions was largely based on methods supported by past research. By implementing discourse supports, outlined in an article written by Shiller and Joseph (2010), students were provided with tools to be more engaged in class discussions. During brainstorming discussions, students used Think/Pair/Share activities and journaling before responding to larger class discussions. This gave all students time to record their own ideas, share their ideas in a smaller group, and encourage them to participate in the class discussions. Later, during sense-making discussions, students were assigned roles such as recorder, reporter, and group leader to encourage participation. Language frames, as discussed by Frey and Fisher (2009), also supported students as they
prepared for sense-making discussions. The types of discussions used, brainstorming and sense-making discussions, were explained in an article by Shwartz et al (2009). These discussions provided the framework for daily discussions. Together, all of these supports and strategies pushed students to be more engaged in class discussions.

Lastly, student content comprehension as measured by fact recall, did not show any significant change between the treatment group and the control group. However, student responses to higher-order questions did increase among the treatment group, and was evidenced by the summative assessment essay questions and formative assessments such as the earthquakes concept map. This indicates a possible correlation between inquiry-based discussion formats and higher-order thinking. This is further supported by research conducted by Smart and Marshall (2012) where they observed lower-order questioning was often associated with teacher-centered instruction. This may explain why there was not a strong difference between the treatment group and the control group for the basic fact recall during the summative assessments. Smart and Marshall (2012) also claimed there was a direct correlation between cognitive engagement and student discourse.

VALUE

From this study, I have concluded that student discourse had a positive impact on student success in the science classrooms I investigated during my intervention. Student participation, scientific communication skills, and higher-order thinking improved among those students engaging in daily scientific discourse. I suggest that students have become comfortable with traditional teaching methods that often follow the Initiation-Response-
Evaluation format. This type of format encourages lower-order thinking, and does not build the scientific communication skills needed for students to be successful in the science field which requires strong science reasoning skills. When exposed to a more student-led, inquiry-based discussion format, students learned how to make scientific claims, provide evidence and reasoning for their claims, and evaluate the strength of other claims.

As an educator, I have experienced the importance and value of implementing student discourse in the science classroom. While more time consuming than traditional discussion formats, inquiry-based formats can potentially build a stronger science program by teaching students how to communicate as scientists. I experienced students questioning one another’s claims, defending their own claims using evidence, and verbally discussing the findings of scientific investigations. Rather than myself, as the educator, providing reasoning for scientific claims, students developed their own. Because of this, students moved away from basic memory-recall learning, and began learning science as scientists do.

Some methods worked better than others, and like any teaching methodology, these methods will need to be adapted and refined. For example, due to time constraints, I rushed students through their scientific investigations. This increased confusion and ill-preparation among some groups of students. More preparation would have allowed students to build better claims and gather more evidence before presenting their claims to their peers. It was also difficult teaching students the discussion expectations and behaviors. Students spent half of the year engaging in discussions one way, and then were
forced to break their habits, and engage in discussions in a different way. This resulted in some students struggling with inquiry-based discussion formats. Alternatively, other students became more engaged in class discussions, and really enjoyed this style of discourse.

In the future, I plan to continue to utilize brainstorming and sense-making discussions to promote student discourse. Claims and evidence will become a regular component of classroom dialogue, and students will periodically engage in an argumentation framework to communicate their scientific findings. These discourse activities not only improve scientific communication skills, but they increase participation and engage students in higher-level thinking processes.


APPENDICES
APPENDIX A

IRB REVIEW
INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

MONTANA STATE UNIVERSITY
900 Technology Blvd, Room 127
c/o Microbiology & Immunology
Montana State University
Bozeman, MT, 59715
Telephone: 406-994-6783
FAX: 406-994-3333
Email: cheryl@montana.edu

MEMORANDUM

TO: Vanessa Hatlich and Eric Brunsell
FROM: Mark Quinn
DATE: November 21, 2016
SUBJECT: “Measuring Student Success in the Science Classroom through Inquiry-Based Discussion Formats and Student Discourse” [VH112116-EX]

The above research, described in your submission of November 21, 2016, 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.

__(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.

__X__ (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.

__X__ (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.

__X__ (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.

__X__ (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

GROUP DISCUSSION FIELD NOTES OUTLINE
<table>
<thead>
<tr>
<th>Behaviors/Activities</th>
<th>Field Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual Participation in Group</td>
<td></td>
</tr>
<tr>
<td>(Utilization of roles, everyone participates)</td>
<td></td>
</tr>
<tr>
<td>Types of Questions Exchanged</td>
<td></td>
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<tr>
<td>Student Interactions</td>
<td></td>
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<tr>
<td>(group dynamics and atmosphere, respectful of one another’s ideas)</td>
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</tr>
<tr>
<td>Communicating Claims</td>
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<tr>
<td>Defending Claims with Evidence</td>
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<tr>
<td>Other Notes</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX C

ARGUMENTATION FRAMEWORK RUBRIC
Adapted from “Arguing Like a Scientist” (Ying-chih & Steenhoek, 2014).

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Poor (1)</td>
</tr>
<tr>
<td><strong>Claim and Question Relationship</strong></td>
<td>Claim does not relate to the question being investigated.</td>
</tr>
<tr>
<td><strong>Accuracy of Claim</strong></td>
<td>Claim is incomplete or is scientifically inaccurate.</td>
</tr>
<tr>
<td><strong>Presentation of Evidence</strong></td>
<td>Evidence is unorganized or fails to explain what was learned from the investigation.</td>
</tr>
<tr>
<td><strong>Claim and Evidence Relationship</strong></td>
<td>Evidence does not support the claim.</td>
</tr>
<tr>
<td><strong>Overall Argument</strong></td>
<td>Argument is confusing and not sufficiently supported.</td>
</tr>
</tbody>
</table>
APPENDIX D

EARTHQUAKES CONCEPT MAP
Earthquakes Concept Map

With your group, create a concept map about earthquakes that connects the following 20 terms together. On each connecting line, include a short description of how the concepts are related.

Terms:

1. Primary Waves
2. Secondary Waves
3. Surface Waves
4. Body Waves
5. Crust
6. Mantle
7. Core
8. Lithosphere
9. Asthenosphere
10. Focus
11. Epicenter
12. Fault
13. Elastic Rebound Hypothesis
14. Aftershocks
15. Foreshocks
16. San Andreas Fault
17. Seismograph
18. Seismogram
19. Richter Scale
20. Moment Magnitude Scale
APPENDIX E

EARTHQUAKES CONCEPTS MAP GRADING CHECKLIST
# Earthquakes Concept Map Grading Checklist

<table>
<thead>
<tr>
<th>Required Concepts</th>
<th>Included Concept</th>
<th>Included Relationship</th>
<th>Relationship Accurate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Primary Waves</td>
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<tr>
<td>2. Secondary Waves</td>
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<tr>
<td>3. Surface Waves</td>
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<tr>
<td>4. Body Waves</td>
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<tr>
<td>5. Crust</td>
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<tr>
<td>6. Mantle</td>
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<tr>
<td>7. Core</td>
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<tr>
<td>8. Lithosphere</td>
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<tr>
<td>9. Asthenosphere</td>
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<tr>
<td>10. Focus</td>
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<tr>
<td>11. Epicenter</td>
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<tr>
<td>12. Fault</td>
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<tr>
<td>13. Elastic Rebound Hypothesis</td>
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<td>14. Aftershocks</td>
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<td>15. Foreshocks</td>
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<tr>
<td>16. San Andreas Fault</td>
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<tr>
<td>17. Seismograph</td>
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<tr>
<td>18. Seismogram</td>
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<tr>
<td>19. Richter Scale</td>
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<tr>
<td>20. Moment Magnitude Scale</td>
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</tbody>
</table>

Total

Comments:
APPENDIX F

GROUP DISCUSSION RESPONSE USING LANGUAGE FRAMES
**Prompt:** The destructiveness of an earthquake is dependent on _________. This is evidenced by: _____________.

<table>
<thead>
<tr>
<th>Group Number</th>
<th>Group Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>The destructiveness of an earthquake is dependent on the location in which it occurs. If a massive earthquake hits an area that is unpopulated, it won’t matter as much as a smaller earthquake that hits a heavily populated area. This is evidenced by Quake Lake and the 1906 San Francisco earthquake. Quake Lake was caused by a massive earthquake, but it was nowhere near as devastating as the 1906 San Francisco quake because Montana has a lot less people and fewer buildings to destroy.</td>
</tr>
<tr>
<td>Group 2</td>
<td>The destructiveness of an earthquake is dependent on population. This is evidenced by the 1906 San Francisco earthquake. Population is one factor that determines how destructive an earthquake is because in cities, earthquakes are a lot more destructive than earthquakes where there’s not a lot of people. In the 1906 San Francisco earthquake, many buildings collapsed and people were killed.</td>
</tr>
<tr>
<td>Group 3</td>
<td>The destructiveness of an earthquake is dependent on the energy released and the building structures. This is evidenced by the earthquake that occurred in Haiti. All of the buildings were built close together and made of inflexible materials.</td>
</tr>
<tr>
<td>Group 4</td>
<td>The destructiveness of an earthquake is dependent on magnitude. This is evidenced by the 1906 San Francisco earthquake, Haiti, and Quake Lake in Yellowstone. All of these earthquakes were over 7.3 on the Richter Scale. There was a lot of destruction to buildings, bridges, and land. A lot of people were injured, killed, or became homeless.</td>
</tr>
<tr>
<td>Group 5</td>
<td>The destructiveness of an earthquake is dependent on amount of energy released, building design, ground type, and population. This is evidenced by the San Francisco earthquake. Lots of buildings fell down.</td>
</tr>
<tr>
<td>Group 6</td>
<td>The destructiveness of an earthquake is dependent on landscape. This is evidenced by the Yellowstone earthquake and the San Francisco earthquake. The Yellowstone earthquake may have not been as destructive if it was on flat land. The earthquake created a landslide which dammed the Madison River. San Francisco’s landscape is mainly buildings. The destructiveness was extreme because there were more things able to fall over on people.</td>
</tr>
</tbody>
</table>
APPENDIX G

PERCEPTIONS ABOUT GROUP DISCUSSIONS SURVEY
Perceptions about Group Discussions in Science Survey

The following survey will be used to help me determine the value of group discussions in the science classroom. Please respond to each of the following questions honestly. Participation in this research is voluntary and participation or non-participation will not affect a student’s grades or class standing in any way.

For each question, mark only one response that best describes the extent at which you agree or disagree with the statement.

<table>
<thead>
<tr>
<th>Question</th>
<th>Strongly Disagree</th>
<th>Somewhat Disagree</th>
<th>Neutral</th>
<th>Somewhat Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I enjoy discussing scientific concepts with my peers.</td>
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<tr>
<td>2. I feel comfortable sharing my scientific ideas with my peers in a group setting.</td>
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<tr>
<td>3. I feel like my peers value my scientific ideas.</td>
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<tr>
<td>4. I feel confident defending my scientific ideas to my peers.</td>
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<tr>
<td>5. I feel more engaged in science class during group discussion settings than during class lecture settings.</td>
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<tr>
<td>6. Participating in group discussions help me better understand science concepts.</td>
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<tr>
<td>7. Writing about scientific concepts is easier after engaging in group discussions.</td>
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<tr>
<td>8. I prefer to learn science in a collaborative (group discussion) setting rather than a teacher-led lecture setting.</td>
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<tr>
<td>9. I am more likely to share my scientific ideas in a group discussion setting than during a class lecture setting.</td>
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<tr>
<td>10. I can develop a scientific argument consisting of a claim and evidence.</td>
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</tbody>
</table>

11. Choose one of the statements above and explain your choice. Question Number: ________
____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________
APPENDIX H

INTERVIEW QUESTIONS
Semi-Structured Interview Questions

1. How did small group discussions affect your learning?

2. Do you prefer to learn science concepts in a collaborative group discussion setting or through a teacher-led lecture setting? Why?

3. How can I make collaborative group discussions better?

4. How did the Argumentation Framework (making claims, supporting with evidence, and defending your claim to your peers) affect your learning?

5. Do you like engaging in scientific discourse? Why or why not?