EFFECTS OF STUDENT REFLECTIVE WRITING ON UNDERSTANDING OF MIDDLE SCHOOL SCIENCE CONCEPTS

by

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Joshua David Abernethy

July 2014
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ABSTRACT

This project focused on using various writing activities, such as exit tickets, student indicator sheets, and participation log, in a middle school science classroom to investigate the effects on student understanding, problem solving skills, and motivation. In addition, teachers’ attitude and motivation was also studied. Writing-to-learn in the science classroom was shown to increase student retention in the content; however student motivation did not increase. The effect on the teacher was increased motivation to teach writing with a slight decrease in the enjoyment of teaching.
INTRODUCTION AND BACKGROUND

In my science classroom, students have had a difficult time comprehending the overlap in content between the different parts of the lesson: direct instruction, homework, labs, partner work, projects, and readings. At the beginning of each semester, the students in my class complete a survey that asks them about their learning style, interest in school, the way they think through questions on a test, and how they study for summative assessments. From reading their answers each year, I came to realize that they do not reflect during their preparation for summative testing experiences about how the content was introduced in the unit (worksheets, discussions, plays, songs, writing, poetry, lecture, practice, etc.). I also have observed that students were able to correctly answer the daily essential question yet were unable to answer a question of the same content on the test. This was puzzling to me as a variety of learning styles was taken into account when developing lessons.

I had been using an interactive notebook, which students used to record information that is pertinent to their learning: extension, homework, labs and notes, but it was not reflective. Upon my reflection about these survey data and the uses of the Interactive Science Notebook, I realized that students in my class have little time to reflect on that day’s lesson, which might contribute to why students do not remember how the content was introduced during class lessons. In my effort to change this, I decided to investigate the effects of reflective writing on student’s understanding and retention of content. It seemed to me that developing the Interactive Science Notebook with reflective writing would help to develop this important activity in a way that would better serve students.
Exploring the impact of reflective writing was important to me as I hoped it would have a positive effect on their summative assessments. It was important to the teachers at the school because we are looking at ways to increase the use of writing in the curriculum and need data to determine the strategies to implement in the classroom. Furthermore, I want to develop 21st century students that can adapt to their surroundings and apply strong problem-solving skills. Therefore, I investigated the effect of writing on those skills.

Wake County Young Men’s Leadership Academy is a public alternative middle and high school. It caters to first generation college students and students that are disadvantaged or underrepresented on college campuses. The school is a single gender school that develops adolescent boys into men of character and positive role models in the community. The classes in the capstone project were two year-long, eighth-grade science classes. I was their fourth teacher this year, as I started in January.

The project focus question is, “What are the effects of student written reflections on their understanding of eighth-grade science concepts?” The subquestions are: what are the effects of student’s written reflections on the ability to develop and transfer their understanding of eighth-grade science concepts; what are the effects of student written reflection on students’ long-term learning; what are the effects of student written reflections on problem-solving skills; what are the effects of student written reflections on students’ motivation; what are the effects of students’ written reflections on my teaching (motivation, change in lesson construction).

Written reflections are where the students write what they have learned during the lesson. Time was allotted at various times throughout the lesson or activity for the
students to summarize their own learning. Some assignments were completed outside of the classroom because of the type of writing.

There were many individuals who aided in this project. The committee chair, for the capstone project, is Dr. Peggy Taylor, Masters of Science in Science Education (MSSE) Program Director at Montana State University. My advisor and instructor for this project was Dr. Jewel Reuter of MSSE who was excellent in her guidance along the way. The individuals within my cohort were essential to the construction and implementation of this project. In this project my critical friends were my science vertical team member Jevar Bransome and teaching partner, Christi Chern. Christi Chern aided in the day to day orchestration of the project implementation and rating my motivation in this project. The university reader for this project was Dr. Thomas McMahon, Professor in Ecology Department at MSU and MSSE Program Instructor. They provided critical feedback and often made me reassess my delivery of the material both to the students and to the audience of this paper.

CONCEPTUAL FRAMEWORK

Writing-to-learn in content subjects is an effective way to provide an avenue for students to express their thoughts and knowledge of the lesson. The students that participate in these types of reflections are introduced to the way in which the scientific community displays and communicates their finding (Mason, 1996). Therefore, it is purposeful and original in nature (Dlugokienski & Sampson, 2008).

Writing is a means of communication; therefore, having the students express their voice in writing is better than summarizing what the teacher says. An international study
was conducted at the International College middle school in Beirut where students’ journal 5-7 minutes for a 12-week period. Overtime, the teacher noticed that the students’ understanding of the content increased in the mathematics class (Murad, 1998).

The Interactive Science Notebooks (ISN) is a location where such writing in the content can take place to increase their retention and understanding. This is because students have to create and express their learning (McDermott, 2010). In an article by Reinhart (2000), the author states that the words and connections should be made and discussed by the students. Their ISN is a location where they can internalize the content and make connections. Furthermore, the writing helps the students give a clearer and deeper explanation during discussion (Butler & Nesbit, 2008). Reviewing the ISN gives the teacher a clear idea of the students learning. Research conducted in six fifth-grade classrooms indicated that the higher the score a student receives on their notebook entry the higher their assessment score was on the postunit test (Ruiz-Primo, Li, Ayala, & Shavelson, 2004). A preunit and postunit test was given to each fifth grader in the study and the teachers classified them into six groups based on their achievement level. The students with the most growth were the students that had the higher score on their notebook. This further indicated that students who are able to internalize and reflect on the lesson understand it better.

Multimodal writing, in comparison, occurs when the students present their knowledge to an audience that is not the teacher. This use of writing, is therefore, a good way to deepen the students’ understanding of the content as it forces the students to focus on taking the information and presenting it to a particular individual or group (McDermott, 2010; McDermott & Kuhn, 2012). The audience of this writing can vary in nature such
as a class of elementary school students or a travel agency. Through this type of writing the students will bridge their new and previous knowledge. Multimodal writing alongside adequate feedback will result in a higher grade on the unit exam scores as seen in the case study, conducted by McDermott (2010), where three out of four classes in biology or chemistry increased in their unit exam scores in one assessment area.

Writing also has positive impacts on student’s long-term memory. Writing helps students understand the content especially when writing occurs quickly after learning. Students that write consistently about their learning have better comprehension (Floyd, McGrew, & Evans, 2008). A psychology professor, at the University of Georgia, investigated the effects of in-class writing on honors and nonhonors students. The control group was another nonhonors group that did not involve in-class writing. All of the others methods were the same and the results indicated that the students who had the writing assignments did better, regardless of their achievement level (Stewart, 2010).

Original writing by the student and their critiquing of others’ written text are two ways in which to develop problem-solving skills (Dlugokienski & Sampson, 2008). Peer editing, the text through the use of a rubric provides feedback to the writer. This also requires the editor to isolate limitations within their partners writing (Wilson, 2008). The comments by peers and the teacher improve the quality of the writing, and direct students to articulate more clearly what they have learned. The ability for students to correctly articulate their learning is a problem-solving skill and writing is a means to develop that skill (Ryan, Rillero, Clelland, & Zambo, 1996). This also gives the students the ability to be more confident in their claims (Roberson & Lankford, 2010; Mason, 1996).
A group of teachers noticed that students, in high school science, had difficulty answering the main problem posed in the lab without analysis questions. They found that the students have a difficult time, not with writing, but with data analysis. Answering data analysis questions is related to the student’s problem solving skills. The teachers gave group one no directions on how to interpret and explain the data. Group two received a rubric to aid in the data analysis, while the other group participated in a classroom discussion with a model, and a rubric. The group with more teacher direction increased their scores in their writing of the data analysis. Therefore, problem-solving skills can be used by the students, however, modeling is needed to increase student understanding of how to analyze and explain the data (McDermott, 2010).

The students’ awareness of their own learning is the process of metacognition. Metacognition and writing are linked because the students must be aware of their own learning in order to write (Prain & Hand, 1996). In action research conducted with 12 fourth and fifth graders over a 9 month period, the teacher looked at the influence of writing in modifying and solidifying students understanding of environmental science concepts. The students were engaged in discussions with their peers on a topic followed by writing to solidify their learning. A preunit assessment was given in the form of writing and 11 of the students wrote reflectively while one wrote an expository text. After the whole class discussion only five choose to write reflectively. Reflective writing is writing that involves the students communicating their previous and current ideas and the process by which they arrived at their understanding. This way of thinking and communication parallels the scientific community. The researchers further stated that the objective is not for fast change in their thinking but their deeper understanding of the
concepts. The students realized that the writing led to better debates and discussions in the future as it allowed them to analyze their own thoughts and lack of understanding (Mason, 1998). Reflective writing in the science classroom can also be conducted after a science laboratory activity to increase student understanding (Roberson & Lankford, 2010; Knipper & Duggan, 2008).

Furthermore, students taking ownership of their learning impacts the depth of their writing. In classrooms where students are actively constructing their own learning, the students are most often writing (Knipper & Duggan, 2006). A college professor investigated the effect that students, in two physics classes, views on the subject matter had on the way in which students wrote. The students that had a higher motivation and outlook on the subject were more likely to have statements in their reflections that used previous knowledge rather than writing notes from the textbook. Therefore, student motivation plays a role in the style of writing that the students produce (Huang & Kalman, 2012).

A doctorate candidate at the University of Erzincan, in Turkey, investigated the effects of expository verses reflective writing on student motivation (Sagirli, 2010). The students in the sample were university freshmen in the mathematics department between two classes. One classroom was given the assignment to write letters to a close friend that was in an accident and could not be in the class for the lectures. It was their job to provide all of the important points of the lesson. This was an expository type of writing assignment. The other classroom was given the task of keeping a notebook about the class so that when they graduate they can use it to study for the exam. These students are to include how they learned it, where they lacked understanding, which subjects they
understand better, and their emotions and ideas about the topics discussed. This type of writing was reflective in nature as the students were required to express to the reader their views and thoughts. The scientists conducted interviews and determined that the students experienced motivation in both types of writing. The students also expressed that they, “understood the concepts better”. The students also noted that they were more interested in the lectures and had higher motivation.

The last subquestion dealt with teacher motivation. According to Nixon, Saunders and Fishback (2012), the main reasons why teachers do not use writing in the science classroom are student resistance and lesson planning. An online survey was conducted by a professor to 127 students taught in education courses over the past 10 years. Seventy-five percent of the science teachers stated that the reflection stage of the lesson is very important to the student’s long-term memory. The implementation of this reflection was easy according to the responding teachers. The five most common reflective strategies used by teachers were study guides, compare/contrast charts, exit cards, Venn diagrams, and journal writing. The top five most beneficial reflective strategies were series-of-events chain, compare/contrast chart, study guide, Venn diagram, and agree/disagree whole class discussion. Extra lesson planning and organization are required; however, most teachers agreed that choosing a few strategies is best for both the teacher and the student. On the other hand, from the students’ perspective, writing-to-learn is often “more difficult” and “less appealing” (Mason, 1998).

According to Knipper and Duggan (2006), however, the time and energy that is required to create and assess lessons that involve writing as a means to learn requires no more time than traditional lessons. Two ways to counteract the time restraints are to ask
for planning times and remember that the time required will decrease each year. To lessen the effect of not knowing how to teach writing, the research suggests teaming up with a writing teacher to develop lessons. The evaluation should only focus on one item at a time. A well established rubric and student checklist is an easy way to assess the students’ performance on the writing assignment (Roberson & Lankford, 2010; Knipper & Duggan, 2006). The teacher can begin the semester with a framed paragraph that the students fill in. This helps the students determine the most important pieces of information and provide a base for their future writing (Knipper and Duggan, 2006).

There is a direct relationship between students learning and students writing in the classroom. The modes of writing may vary; however, the results remain consistent in that students that are engaged in writing are internalizing their learning, which will increase the student’s long and short-term retention. Overall, writing has a positive impact on students learning and performance.

METHODOLOGY

Project Treatment

The capstone project consisted of three units of eighth-grade science. One nontreatment unit was followed by two treatment units conducted during the spring 2014 semester from February to May. The Nontreatment Unit was populations and ecosystems, whereas the two treatment units were landforms and lifeforms followed by natural resources. Students reflected on their learning, during the Nontreatment Unit, through sample test questions and through discussions with others. In the treatment units, the students reflected through writing in participation logs, student indicator logs, and
other writing activities. The research methodology for this project received an exemption by Montana State University’s Internal Review Board, and compliance for working with human subjects was maintained.

The main topic investigated during this action research was the effect of reflective writing on students learning, retention, and the teacher, thus, reflective writing was used in the treatment units. During the Nontreatment Unit the students wrote teacher directed notes, answered lab analysis questions or homework questions, which were expository in nature. In addition, the variety and depth of their writing was minimal in the Nontreatment Unit. In the treatment unit, however, the students completed a variety of writing prior to, during, and after the lesson.

One way students incorporated reflective writing during the treatment unit was completing their participation logs each day, typically during the last five minutes of class. During this time the students reflected on the lesson and answered the essential question. They also described their muddiest point (the content they did not understand) and recorded their comments made in class in their ISN. Some days the students did not complete the participation log, in lieu, of another evaluative assignment. The layout of the participation log was set up so that the students went back and answered their muddiest point at any time during the week. On the participation log, there is a location to write their daily homework and a section for the parents to sign. The participation log is in Appendix A. The participation log was taken home at the end of the each treatment unit and the students were required to write a unit essay essence. I also wrote comments/questions that encouraged the students to reflect on their learning. Therefore,
the participation log was one way student made the connection between prior knowledge and the content covered that day.

During the treatment units, the students were given student indicator sheets to complete as a study guide to submit with their test. The indicator sheet used in Treatment Unit 1 is located in Appendix B. The student indicator sheets had columns for student objectives, page number and activity name, and an explanation. The students were encouraged to complete this nightly and it was collected on the day of the test. The student objectives were written in, “I can” statements, and were given to the students. In the explanation section they were to prove to the teacher that they mastered the objective by using an explanation that involved a reflection of the activity. On the other hand, a study guide was given prior to the Nontreatment Unit assessment; however, it did not have questions to answer but the concepts that the students needed to know for the test. The study guide is in Appendix C.

In addition, the students were also involved in writing reflections after laboratory activities in the treatment unit. The students were required to describe what occurred in the laboratory activity and explain what they learned with three sets of data. This allowed me to determine the students understanding of the content. The rubrics, used to assess the reflections, are found in Appendix D. This was different from the Nontreatment Unit because a lab summary was not assigned as a teacher-led discussion occurred, through call and response and four corners activities.

I used the five E lesson plan format, which includes Engagement, Exploration, Explanation, Elaboration, and Evaluation. In the engagement section the students participate in a quick activity that activates their thinking about the content that will be
covered that day. During the exploration section of the lesson they will conduct either a hands-on experiment or worksheet that increases their content depth. This will also aid in their connection with the content and can be used in their reflective writing assignment. The explanation phase is where the teacher ensures that the students have learned the information correctly. If students are interested in the content then the next phase of the 5E lesson plan is elaboration where students go much deeper. The final and most important part of the lesson is the evaluation portion. This allows the teacher to assess what the students have learned.

The topic for the Nontreatment Unit was populations and ecosystems. The following is an example nontreatment lesson. One day we discussed the importance of the different animal relationships (amensalism, commensalism, coexistence and cooperation, competition, parasitism, and mutualism). When the students entered the classroom these animal relationships were listed on the board. The students were given time to have a conversation about the words with their table partners. At the end of time we discussed the meaning of the words and how they were related to each other. During the exploration phase the students were given cut out pictures of different animals and used the previous words to match up the animals. This provided the students an opportunity to practice using the new vocabulary words and I was able to see the students who needed additional instruction on the vocabulary. After every group completed matching the pairs, we entered the explanation phase, which was where we discussed the correct answers. The students noticed there were a variety of answers that were correct based on the definition. The pictures were displayed on the SMART Board for the students to view during the discussion. Next, the students were placed in their biome
groups and were given the task to determine which animals are found in their biome. This multimodal type of writing took the remainder of the time and the expectations are in Appendix E. For homework, the students completed the assignment by using a Google Docs. The students were also required to determine the interactions between the animals. The group presentations were posted online for their classmates to view. At the end of the class, the students answered the essential question on a sticky note and submitted it to their teacher as they exited the classroom. The essential question that day was, “Explain the symbiotic relationships between animals.”

During the first treatment unit, the students were introduced to various landforms and life forms. One lesson taught had the essential question, “Explain relative age dating laws and principles.” Therefore, during this lesson the students were introduced to the concepts of dikes, faults, inclusion, intrusions, original horizontality, relative age dating, sills, and superposition. When the students entered the classroom, they had a clip-art picture of a chicken and an egg. The question was posed, “Which came first, the chicken or the egg?” The reason why this was chosen, as the engagement piece, was because of its humorous nature and they were familiar with the question. After we had a quick discussion, I had the students hypothesize about the term, relative age dating. After discussion was made, I had them think about how the engagement photo might relate to the lesson’s main topic “relative age dating”.

During the exploration portion of the lesson, the students received a double sided sheet that had pictures of various Earth’s layers. Beside each picture there was a question that helped the students think about the law or principle. For instance, the first picture asked the students describe the direction in which the layers were deposited. The
students were able to look at the picture and see that it was deposited in horizontal layers. Another layered picture had a textbox that said that a dike was a magmatic body that was linked to the magma chamber and has the possibility to make it to the surface of the Earth. From this they listed the order that the layers were deposited. The goal was to have the students make the connection that in order for the magma to be there it has to “eat” its way through the layers that it is seen in. While the students completed this assignment I walked around spot checking and posing other questions. The worksheet is in Appendix F. Therefore, this was a way that students participated in reflective writing.

As the groups completed the worksheet they received the answer sheet and were asked to take a pen and mark through the errors they made and to correct it. I was not having them complete the corrections for a grade but in order for them to see their errors and make new connections. As expected, different partnerships completed the task at different times therefore upon completion they wrote a detailed essence paragraph that explained what they had learned in the activity and how their misconceptions changed. The next step of the lesson was the extension portion where they created their own relative age dating picture. They included in the picture all of the vocabulary words that were covered and attached the answer sheet. Some groups did not complete this step prior to leaving therefore they were assigned to complete the activity outside of class. The students also wrote a fictitious story about their pictures that included the vocabulary words for the day. Before the students left they filled out their participation log and submitted it to the teacher upon exiting.

The second treatment unit was Natural Resources which investigated the various natural resources, conservation, and the impact of humans on the environment. At the
start of the unit the students completed a Know, Want to learn, and Learned (KWL) chart in their science notebook. It was encouraged that each day the students revisited the KWL page and adds a new item with a date so they could see their learning progress. The first lesson discussed, was the concept of reduce, reuse, recycling and stewardship. The original orientation of the 5E’s were shifted to fit the lesson, thus, after the engagement was completed the teacher explained the concepts. The explanation phase occurred when the teacher led the class through a discussion on the meaning of these words. The students then took time to complete the learned portion of the chart using reflective explanations. After this the students watched the original video, The Lorax (1972). In conclusion of the video, the teacher asked for a written summary using guiding questions. These guiding questions are in Appendix G. They also went back to the KWL chart to add more information. At the conclusion of the reflection, the students exited the classroom to pick up trash and recyclables on campus. When they entered the classroom, the students wrote on a sticky note what they learned in the lesson and place it on the door as they exited. In addition, there was a large sheet of paper where they wrote what they collected while they were out. This change of answering the essential question was to relieve the writing redundancy, have them express their thoughts concisely within time restraints. The students went back the following class period and answered the essential question on their participation log so that they would have this when they wrote their essay.

Data Collection Instruments

The students involved in this capstone project were eighth-grade science students at Wake County Young Men’s Leadership Academy. There were currently 150 middle
school students and another 150 students were dual enrolled in high school and St. Augustine College, with the opportunity to earn an Associate’s degree upon graduation.

The students were chosen because of their interest, my knowledge of the content, and the goal to increase their overall performance. There were a total of 26 students involved in this action research. I was their fourth teacher this year, as I started teaching them in January. The school caters towards first generation college students and underrepresented students on the college campus. It is a single gender, public middle and high school, that is focused on developing leadership skills in students. Fifty percent of the students are classified as first generation college students. The unemployment rate in Wake County North Carolina in 2013 was 6.7%. The school is located in Raleigh, which is the second largest city in the state. Therefore, the school is classified as urban and has a diverse student body. There were 14 minority students in the capstone project: eight African American, and six Asian. Of the 28 students in the capstone project, 6 were classified as Academically and Intellectually Gifted. Academically and Intellectual Gifted students are classified based on their Intelligence Quotient. Two students were classified as behavior problem students based on their social performance in the classroom. Also, two students have Attention Deficient Hyperactive Disorder, and one student has consistently scored a level one on their State End of Grade Test since 3rd grade. End of Grade tests are given in science in grades, third, fifth, and eighth, while Final Exams are given in the subsequent years. The EOG assesses the students’ attainment of the content.

Data that were collected in this capstone project helped answer the questions posed. These data were collected through colleague observations, reflective journaling,
teacher survey, student interview, survey and concept mapping, student assessment, and capstone project targeted assessments. Table 1, shows the data triangulation matrix, which provides a basis for how these data was collected and which question it answered.

Table 1:  
*Data Triangulation Matrix*

<table>
<thead>
<tr>
<th>Focus Questions</th>
<th>Data Source 1</th>
<th>Data Source 2</th>
<th>Data Source 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Question:</strong> What is the effect of student’s written reflections have on their understanding of Earth science concepts?</td>
<td>Preunit and postunit capstone project target assessments</td>
<td>Preunit and postunit student concept interview with concept mapping</td>
<td>Pretreatment and posttreatment student surveys</td>
</tr>
<tr>
<td><strong>Subquestions:</strong> What are the effects of student written reflections on their ability to develop and transfer Earth Science concepts?</td>
<td>Preunit and postunit assessments</td>
<td>Preunit and postunit Student concept map</td>
<td>Preunit and postunit interviews.</td>
</tr>
<tr>
<td>What are the effects of student written reflections on students’ long-term memory?</td>
<td>Postunit and Delayed capstone project targeted assessments</td>
<td>Postunit and Delayed Student concept Interviews-with concept mapping</td>
<td>Postunit and Delayed Student Surveys</td>
</tr>
<tr>
<td>What are the effects of student written reflections on problem solving skills?</td>
<td>Preunit and postunit capstone project target assessments</td>
<td>Preunit and postunit Student concept interview with concept mapping</td>
<td>Pretreatment and posttreatment student surveys</td>
</tr>
<tr>
<td>What are the effects of student written reflections on students’ motivation?</td>
<td>Pretreatment and posttreatment Student survey</td>
<td>Pretreatment and posttreatment Student Interview</td>
<td>Instructor weekly reflection journaling</td>
</tr>
<tr>
<td>What are the effects of students’ written reflections on my teaching (motivation, change in lesson plan)?</td>
<td>Pretreatment and posttreatment Teacher survey</td>
<td>Instructor weekly reflection journaling with prompts</td>
<td>Non-treatment and treatment colleague observations</td>
</tr>
</tbody>
</table>
The preunit assessment contained content specific items and the big ideas. The assessment helped the teacher obtain information about students’ problem solving skills, short-term memory, the linkage between different parts of the science lessons, and overall understanding of the concepts. The postunit and the delayed assessments asked the same questions for consistency and validity of the test. The assessment for the Nontreatment, Treatment Unit 1, and Treatment Unit 2 are found in Appendix H, I, and J, respectively. The students also took preunit, postunit, and delayed capstone project target assessments. These assessments asked five content specific questions. Like the unit assessments these questions remained the same throughout the capstone project. These data sources served to answer the primary question. The questions are in Appendix K.

In order to compare results from different units, the percent change from preunit and postunit assessment score was calculated according to the following formula: 
\[
\frac{(Y_2 - Y_1)}{Y_1} \times 100.
\]
The symbol \(Y_1\) is the preunit assessment score, whereas \(Y_2\) is the postunit assessment score. Due to varying preunit scores, a normalized gain was also calculated to compare the change in understanding between units. The normalized gain was calculated as follows: \(\frac{\text{postscore} - \text{prescore}}{(100 - \text{prescore})}\). This formula was created by Hake in his study of class average gains in various physics classes (1998).

Furthermore, students were interviewed preunit and postunit which allowed the teacher to observe if they understood the content. The interview also questioned their perspective of the writing assignments. Every interview was given to the same eight students of varying academic level. The interview included three high and middle-achieving students each, two low-achieving students and a behavior problem student. The questions used, are in Appendix L. Each unit had open ended content specific
questions which the students answered during the preunit, postunit, and delayed interview. These questions were analyzed as a data source for the third subquestion, which investigated the effect of reflective writing on problem solving skills. These content specific questions are in Appendix M. The students also participated in a pretreatment and posttreatment student interview. This allowed me to see how students’ motivation and perception of writing changed throughout the course of the capstone project. This is in Appendix N.

Students’ constructed concept maps at the beginning and end of the units to assess the amount of new knowledge that was gained. The depth of their understanding was also visible. Therefore, the concept map looked at the students’ ability to develop and transfer content knowledge, long-term learning, and students’ metacognition. The RubiStar modified concept map rubric is in Appendix O (2014).

In order to determine the effect that writing in the classroom has on my motivation and lesson development, I took a pretreatment and posttreatment survey. The questions investigated my motivation to teach science, teach and incorporate writing, and my perspective on the effects of writing. This was conducted prior to and after the project to see how these views changed. This also allowed enough transition time for the new way of teaching and learning. The survey is in Appendix P.

Furthermore, I also completed a weekly reflection journal with six Likert scale questions followed by an area to explain these answers. The first four questions focused on the effect that reflective writing had on my motivation, teaching style, attitude, and planning. The last two questions focused on the impact of reflective writing on students’
motivation and problem solving skills. The instructor’s weekly reflection journaling questions are in Appendix Q.

One time, during each unit, a colleague observed my teaching. They focused on the students’ understanding of the writing assignment, content, and their interest. The colleague also observed my ability to explain the writing assignment, my explanation of the linkage between the different parts of the classroom, and my teaching motivation. The survey is located in Appendix R.

The students also completed a pretreatment and posttreatment survey. This survey asks the students questions about their enjoyment of the science class overall followed by questions about the individual parts of the classroom such as laboratory, solving of science problems, writing, and the process in which students answer questions. The questions also asked to include the effect of specific writing activities (in ISN, answering essential question, completing participation logs and student indicator sheets, and after laboratory activities) on their understanding and retention of the content. The survey also investigated their enjoyment of these activities. A question on the survey was open-ended and investigated the student perceived effect that writing has on their ability to solve problems. This document, in Appendix S, helped answer the subquestions, what are the effects of student written reflections on problems solving and student motivation. This survey was given to students on the first day of class prior to any instruction in order to get a clear understanding of their previous thoughts. On the last day of the project the students took the same student survey. In addition, I was interested in how the students viewed reflective writings effect on long-term memory within each unit. Therefore, the students completed postunit and delayed student surveys. This survey is in Appendix T.
The project was conducted during the 2014 spring semester from March to May. The three units covered were populations and ecosystems, landforms and lifeforms, and natural resources. The Nontreatment Unit and the treatment units were both two weeks each. The delayed assessments were given two weeks after the postunit assessment to determine long-term memory. All of the units were similar in content difficulty and expectations. A more detailed time frame is seen in Appendix U.

DATA AND ANALYSIS

Data from assessments, interviews, journaling, observations, and surveys were collected to investigate the effect that student written reflections have on their understanding of middle school science concepts. The primary focus question investigated the effect of student’s written reflections on their understanding of Earth science concepts. The three data sources collected were preunit and postunit capstone target assessments, preunit and postunit student concept interview with concept mapping, and pretreatment and posttreatment student surveys.

A capstone project target assessment was given to my students’, preunit and postunit, to assess their learning. A normalized gain was used to compare the effectiveness of writing in the classroom because the preunit scores were not consistent throughout the project. According to these data collected from the preunit and postunit capstone project target assessments, and displayed in Table 2, there was an increase in the normalized gain in all student achievement levels. The low-achieving students’ had the highest normalized gain in the entire project, 0.825 (in Treatment Unit 2). The student groups from smallest to largest overall change in normalized gain were: middle, low, high, all, and AIG. The normalized gains indicated that writing in the middle school
classroom positively affected students understanding of science concepts overall with the exception of middle and high-achieving students in Treatment Unit 1.

Table 2

*Preunit and Postunit Capstone Project Target Assessment Results by Student Achievement Level (N=28)*

<table>
<thead>
<tr>
<th>Assessment Scores</th>
<th>All (N=28)</th>
<th>High (n=17)</th>
<th>Middle (n=7)</th>
<th>Low (n=4)</th>
<th>Academically and Intellectually Gifted (n=6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preunit</td>
<td>35</td>
<td>40</td>
<td>25</td>
<td>28</td>
<td>38</td>
</tr>
<tr>
<td>Postunit</td>
<td>61.5</td>
<td>60</td>
<td>54</td>
<td>60</td>
<td>58</td>
</tr>
<tr>
<td>% Change</td>
<td>76</td>
<td>50</td>
<td>116</td>
<td>160</td>
<td>52</td>
</tr>
<tr>
<td>Normalized Gain</td>
<td>0.30</td>
<td>0.33</td>
<td>0.38</td>
<td>0.44</td>
<td>0.32</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assessment Scores</th>
<th>All (N=28)</th>
<th>High (n=17)</th>
<th>Middle (n=7)</th>
<th>Low (n=4)</th>
<th>Academically and Intellectually Gifted (n=6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preunit</td>
<td>46.5</td>
<td>57</td>
<td>36</td>
<td>45</td>
<td>50</td>
</tr>
<tr>
<td>Postunit</td>
<td>65</td>
<td>87</td>
<td>57</td>
<td>55</td>
<td>70</td>
</tr>
<tr>
<td>% Change</td>
<td>40</td>
<td>53</td>
<td>58</td>
<td>22</td>
<td>40</td>
</tr>
<tr>
<td>Normalized Gain</td>
<td>0.35</td>
<td>0.697</td>
<td>0.33</td>
<td>0.18</td>
<td>0.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assessment Scores</th>
<th>All (N=28)</th>
<th>High (n=17)</th>
<th>Middle (n=7)</th>
<th>Low (n=4)</th>
<th>Academically and Intellectually Gifted (n=6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preunit</td>
<td>68</td>
<td>90</td>
<td>59</td>
<td>60</td>
<td>73</td>
</tr>
<tr>
<td>Postunit</td>
<td>93</td>
<td>98</td>
<td>88</td>
<td>93</td>
<td>95</td>
</tr>
<tr>
<td>% Change</td>
<td>37</td>
<td>8.9</td>
<td>49</td>
<td>55</td>
<td>23</td>
</tr>
<tr>
<td>Normalized Gain</td>
<td>0.78</td>
<td>0.8</td>
<td>0.71</td>
<td>0.825</td>
<td>0.82</td>
</tr>
</tbody>
</table>

*Note.* Maximum raw score is 100.

Another data source used to answer the focus question were preunit and postunit student concept interview with concept mapping. The normalized gain for the preunit and postunit student concept interview with concept mapping by student achievement level is displayed in Table 3.
Table 3
Normalized Gain per Unit by Student Achievement Level Using Preunit and Postunit Student Concept Interview with Concept Mapping. (N=8)

<table>
<thead>
<tr>
<th>Student Achievement Level</th>
<th>High Achieving (n=3)</th>
<th>Middle Achieving (n=3)</th>
<th>Low Achieving (n=2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonintervention Unit Normalized Gain</td>
<td>-0.04</td>
<td>0.15</td>
<td>-1.25</td>
</tr>
<tr>
<td>Intervention Unit 1 Normalized Gain</td>
<td>0.35</td>
<td>0.25</td>
<td>0.3</td>
</tr>
<tr>
<td>Intervention Unit 2 Normalized Gain</td>
<td>0.5</td>
<td>0.54</td>
<td>0.33</td>
</tr>
</tbody>
</table>

In Table 3, the lowest achievement level had the largest increase in normalized gain (1.58). During the Nontreatment Unit the normalized gain was negative for both the high and low-achievement groups which meant that the students scored lower on the postunit concept map. This occurred because the students did not make the correct number of additional connections between the vocabulary words. The low-achieving group had the largest change in normalized gain throughout the project, which corresponds with the normalized gain change on preunit and postunit capstone project target assessments.

The third data source, used to determine the effect of writing on students understanding of 8th grade science concepts, were pretreatment and posttreatment student surveys in Table 4. The treatment survey asked the students to rate their liking of the class and writing. Four of the questions dealt with the students’ perception of how writing affects their understanding of science concepts. The questions were: rate lab summaries helpfulness in learning the material, the helpfulness of analysis questions, and the usefulness of reading and editing in understanding, and overall how writing helps in understanding the material.
Table 4
Student Survey Average Score with percent change for Pretreatment and Posttreatment Likert Ratings in Perception of Writing Assignments Effect on Their Understanding of Science Concepts (N=28)

<table>
<thead>
<tr>
<th>Student Perception</th>
<th>High Achievers (n=17)</th>
<th>Middle Achiever (n=7)</th>
<th>Low Achiever (n=4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab summary</td>
<td>3.3</td>
<td>3</td>
<td>2.6</td>
</tr>
<tr>
<td>Percent Change</td>
<td>+3.7%</td>
<td>0%</td>
<td>-12.4%</td>
</tr>
<tr>
<td>Analysis Questions</td>
<td>3.5</td>
<td>2.5</td>
<td>2.6</td>
</tr>
<tr>
<td>Percent Change</td>
<td>-5.26%</td>
<td>-20%</td>
<td>+12.78%</td>
</tr>
<tr>
<td>Peer Reading and Editing</td>
<td>2.8</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Percent Change</td>
<td>+4.7%</td>
<td>+16%</td>
<td>0%</td>
</tr>
<tr>
<td>Overall writing</td>
<td>3.5</td>
<td>3.5</td>
<td>1.3</td>
</tr>
<tr>
<td>Percent Change</td>
<td>+3.4%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Note. Likert Scale 5 = Strongly Agree and 1 = Strongly Disagree

The low-achieving groups had the lowest scores in lab summaries, peer reading and editing, and overall writing. This suggests that even though low-achieving students had the highest normalized gain on the preunit and postunit assessments and largest growth in concept interviews they do not perceive writing to be helpful. This is also captured in a low-achieving students’ statement, “Writing is too much work and I don’t think it helps me understand.” The high-achieving students scored the highest in perception while having the highest normalized gain change between the preunit and postunit capstone target assessments. These data indicated that these students are able to see the effect of writing on their learning. A high-achieving student shared during an interview that, “I do it [reflective writing] because it is required, and I would not do it if I didn’t have too. But in all honesty it does help me to better answer the questions.” While interviewing the students during the Nontreatment Unit a middle-achieving student stated, “I think writing helps me understand the content that we are learning.”

The largest positive percentage change, 16, occurred in the middle-achievers view toward peer reading and editing while the largest negative change, 20, occurred in their
perception of answering analysis questions. When averaging the four perceptions of writing it was determined that the high-achieving group had the largest likert score average. Likewise, this group experienced the most normalized gain growth on the capstone project target assessment the second highest growth on the student concept interview. Therefore, for the high-achieving students there was a connection between students’ perceived benefit of writing and their actual benefit. Analyzing the three data sources indicated that even though the low-achieving students increased on the capstone target assessments and interview they still did not see the benefit of reflective writing on their understanding.

The first subquestion investigated the effect of student written reflections on their ability to develop and transfer Earth science concepts. The data collected were obtained from preunit and postunit assessments, preunit and postunit student concept mapping, and preunit and postunit interviews. The most ideal situation for comparison of knowledge is to have equal value preassessment scores. To account for higher preunit scores in the second intervention unit, the normalized gain of the average postunit scores were calculated, and are also included in Table 5.

Table 5
Average Preunit and Postunit Assessment Scores with Percent Change, and Normalized Gain by Academic Groups (N=28)

<table>
<thead>
<tr>
<th>Assessment Scores</th>
<th>Student Achievement Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All (N=28)</td>
</tr>
<tr>
<td>Preunit</td>
<td>38</td>
</tr>
<tr>
<td>Postunit</td>
<td>94</td>
</tr>
<tr>
<td>% Change</td>
<td>147</td>
</tr>
<tr>
<td>Normalized Gain</td>
<td>0.90</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assessment Scores</th>
<th>Student Achievement Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment Unit 1</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th></th>
<th>All (N=28)</th>
<th>High (n=17)</th>
<th>Middle (n=7)</th>
<th>Low (n=4)</th>
<th>AIG (n=6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preunit</td>
<td>31</td>
<td>35</td>
<td>24</td>
<td>29</td>
<td>42</td>
</tr>
<tr>
<td>Postunit</td>
<td>77</td>
<td>89</td>
<td>56</td>
<td>69</td>
<td>85</td>
</tr>
<tr>
<td>% Change</td>
<td>148.3</td>
<td>154</td>
<td>133</td>
<td>138</td>
<td>102</td>
</tr>
<tr>
<td>Normalized Gain</td>
<td>0.66</td>
<td>0.83</td>
<td>.42</td>
<td>0.56</td>
<td>.74</td>
</tr>
</tbody>
</table>

Treatment Unit 2

<table>
<thead>
<tr>
<th>Assessment Scores</th>
<th>All (N=28)</th>
<th>High (n=17)</th>
<th>Middle (n=7)</th>
<th>Low (n=4)</th>
<th>AIG (n=6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preunit</td>
<td>67</td>
<td>75</td>
<td>63</td>
<td>44</td>
<td>82</td>
</tr>
<tr>
<td>Postunit</td>
<td>96</td>
<td>96</td>
<td>92</td>
<td>93</td>
<td>95</td>
</tr>
<tr>
<td>% Change</td>
<td>41.8</td>
<td>28</td>
<td>46</td>
<td>111</td>
<td>16</td>
</tr>
<tr>
<td>Normalized Gain</td>
<td>0.85</td>
<td>0.84</td>
<td>.78</td>
<td>.875</td>
<td>.72</td>
</tr>
</tbody>
</table>

Note: Maximum raw score is 100. AIG is academically gifted students.

The normalized gain decreased in each student achievement level except the low-achieving group during Treatment Unit 2. The normalized gain decreased in most groups from the Nontreatment Unit to Treatment Unit 1 then increased in Treatment Unit 2, but still below the Nontreatment Unit. There were two exceptions to this pattern as the AIG students’ normalized gain decreased from 0.90 to 0.72. The other exception is that the low-achieving students decreased during Treatment Unit 1, from 0.78 to 0.56, then increased to 0.874 which is higher than original. The largest percent change occurred during Nontreatment Unit in the low-achieving group. These patterns indicate that reflective writing does not help student’s ability to develop and transfer Earth science concepts. An AIG student stated, “I am spending more time on the writing then I am with trying to understand the material in the first place. I didn’t do good on the landforms and life-forms test because the unit essence essay took up a lot of my study time.” From this I understand that this student was more concerned with the writing assignment that was due prior to the test. Even though the writing assignment was intended to prepare them for the test this student saw it as a hindrance.
The writing took place during labs and projects and after teacher directed instruction in their ISN. Therefore, the preunit and postunit assessment had questions that were from the three main portions of the classroom (labs, projects, and teacher directed instruction). The number of questions answered correctly from each portion of the classroom was calculated and the normalized gains, in each type of writing, are displayed in Table 6.

**Table 6**

*Preunit and Postunit Assessment Normalized Gain According to Question Type for Each Unit by Achievement Level (N=28)*

<table>
<thead>
<tr>
<th>Nontreatment Unit</th>
<th></th>
<th>Student Achievement Level</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Question Type</td>
<td>All (N=28)</td>
<td>High (n=17)</td>
<td>Middle (n=7)</td>
<td>Low (n=4)</td>
</tr>
<tr>
<td></td>
<td>Projects</td>
<td>0.55</td>
<td>0.53</td>
<td>0.25</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>Labs</td>
<td>0.81</td>
<td>0.37</td>
<td>0.5</td>
<td>0.57</td>
</tr>
<tr>
<td></td>
<td>Teacher Directed Instruction</td>
<td>0.65</td>
<td>1.0</td>
<td>0.5</td>
<td>0.25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Unit 1</th>
<th></th>
<th>Student Achievement Level</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Question Type</td>
<td>All (N=28)</td>
<td>High (n=17)</td>
<td>Middle (n=7)</td>
<td>Low (n=4)</td>
</tr>
<tr>
<td></td>
<td>Projects</td>
<td>0.47</td>
<td>-0.18</td>
<td>0.14</td>
<td>-1.0</td>
</tr>
<tr>
<td></td>
<td>Labs</td>
<td>0.53</td>
<td>0.61</td>
<td>-0.14</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Teacher Directed Instruction</td>
<td>0.36</td>
<td>0.64</td>
<td>-0.083</td>
<td>-1.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Unit 2</th>
<th></th>
<th>Student Achievement Level</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Question Type</td>
<td>All (N=28)</td>
<td>High (n=17)</td>
<td>Middle (n=7)</td>
<td>Low (n=4)</td>
</tr>
<tr>
<td></td>
<td>Projects</td>
<td>0.72</td>
<td>0.77</td>
<td>0.50</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>Labs</td>
<td>0.66</td>
<td>0.43</td>
<td>0.80</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Teacher Directed Instruction</td>
<td>0.74</td>
<td>0.81</td>
<td>0.71</td>
<td>0.64</td>
</tr>
</tbody>
</table>

From Table 6, the normalized gain in Treatment Unit 1 is lower than in the Nontreatment Unit in all three achievement levels and types of writing. The differences between the Nontreatment and Treatment Unit 1 could be because the students had to get used to the
writing assignments. All student achievement levels increased when comparing the Nontreatment to Treatment Unit 2 with the exception of the high achieving students. The largest increase occurred with the low-achieving students in questions from teacher directed instruction.

The next source of data used to investigate the effect that writing has on student ability to develop and transfer science content was through grading word webs. Figure 1 contains the word web data according to student achievement level.

![Word Web Score Change](image)

*Figure 1.* Change in preunit and postunit word web score in each unit for each student achievement level. *Note:* Maximum Score is 100. All (*N*=28), High (*n*=17), Middle (*n*=7), Low (*n*=4)

During the units the low-achieving students had the largest increase in their word web score with an increase of 1.75. The class average also increased throughout the units. The middle-achieving students decreased by 2.0 which were more than the other levels. The concept maps were analyzed by the students and teacher to compare the amount of new connections made by the type of classroom writing. Figure 2 shows this information.
Figure 2. New connections per type of classroom activity (N=28).

Overall, the students made more new connections during the treatment units as a result of the reflective writing that occurred. The number of new connections the students made increased in the projects and teacher directed instruction, 0.5 and 1.0 respectively. The project content connections on the word webs increased which corresponds to the largest change in normalized gain in the preunit and postunit assessments. A middle-achieving student stated that projects “make me think about it [content] and how to present it to others so that they will learn.” This student is able to see that multimodal writing is helping him learn as it internalizes the content and must present it in an acceptable way so that his peers will also understand. In addition, when comparing these two data sources, the students experienced a decrease in normalized gain and word web connections for content covered during labs.

Based on the student interview the students had a higher normalized gain, in the treatment units when reflective writing was involved, as displayed in Table 7. The exception to this was the high and low-achieving students during Treatment Unit 2. The
low-achieving students had the highest normalized gain (0.80), which occurred during Treatment Unit 1.

Table 7
Preunit and Postunit Student Depth of Understanding Interview Score Based on Teacher Using Likert Scale with Percent Change and Normalized Gain (N=28)

<table>
<thead>
<tr>
<th>Nontreatment Unit</th>
<th>Data Type</th>
<th>All (N=28)</th>
<th>High (n=17)</th>
<th>Middle (n=7)</th>
<th>Low (n=4)</th>
<th>AIG (n=6)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preunit</td>
<td>3.375</td>
<td>3.3</td>
<td>3.3</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>Postunit</td>
<td>3.625</td>
<td>3.6</td>
<td>3.6</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>% Change</td>
<td>7.4</td>
<td>9.1</td>
<td>9.1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Normalized Gain</td>
<td>0.15</td>
<td>0.17</td>
<td>0.17</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Unit 1</th>
<th>Data Type</th>
<th>All (N=28)</th>
<th>High (n=17)</th>
<th>Middle (n=7)</th>
<th>Low (n=4)</th>
<th>AIG (n=6)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preunit</td>
<td>2.75</td>
<td>2.67</td>
<td>3.0</td>
<td>2.5</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>Postunit</td>
<td>3.75</td>
<td>3.3</td>
<td>3.6</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>% Change</td>
<td>36</td>
<td>19</td>
<td>16</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Normalized Gain</td>
<td>0.44</td>
<td>0.27</td>
<td>0.3</td>
<td>0.80</td>
<td>0.75</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Unit 2</th>
<th>Data Type</th>
<th>All (N=28)</th>
<th>High (n=17)</th>
<th>Middle (n=7)</th>
<th>Low (n=4)</th>
<th>AIG (n=6)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Preunit</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>Postunit</td>
<td>3.375</td>
<td>3.3</td>
<td>3.3</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>% Change</td>
<td>12.5</td>
<td>10</td>
<td>10</td>
<td>16.6</td>
<td>16.6</td>
</tr>
<tr>
<td></td>
<td>Normalized Gain</td>
<td>0.19</td>
<td>0.15</td>
<td>0.15</td>
<td>0.25</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Note: Max raw score is 5.0. Likert Scale 5 = Strongly Agree 1 = Strongly Disagree AIG stands for Academically and Intellectually Gifted

The three data sources indicate that there is a disconnection between what the students can explain orally and their performance on assessments. This is seen in an increase in interview and word web scores throughout the capstone project and a decrease in the written assessments. The low-achieving students performed better on the interview and concept map then the written assessments. This group, however, was the only group that grew in their preunit and postunit assessments. Therefore, these data indicated that
writing does improve low-achieving students ability to develop and transfer 8th grade science concepts. These data indicated, however, that there is an amount of time that the students need to get accustomed to the new way of learning, as seen in the decrease in normalized gain, from the preunit and postunit assessment during Treatment Unit 1.

The next capstone project subquestion investigated the effects that student written reflections have on students’ long-term memory. This question was answered through analyzing postunit and delayed assessments, postunit and delayed student concept interviews with concept mapping, and postunit and delayed student surveys. Table 8 contains information in regards to the postunit and delayed assessments.

Table 8
*Average Postunit and Delayed Unit Assessment Scores, Percent Change and Normalized Gain (N=28)*

<table>
<thead>
<tr>
<th>Nontreatment Unit</th>
<th>Assessment Scores</th>
<th>% Change</th>
<th>Normalized Gain Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Postunit</td>
<td>Delay</td>
<td></td>
</tr>
<tr>
<td>All (N=28)</td>
<td>94</td>
<td>76</td>
<td>-19 %</td>
</tr>
<tr>
<td>High (n=17)</td>
<td>99</td>
<td>87</td>
<td>-12 %</td>
</tr>
<tr>
<td>Middle (n=7)</td>
<td>90</td>
<td>70</td>
<td>-22 %</td>
</tr>
<tr>
<td>Low (n=4)</td>
<td>81</td>
<td>33</td>
<td>-66.7 %</td>
</tr>
<tr>
<td>Treatment Unit 1</td>
<td>Assessment Scores</td>
<td>% Change</td>
<td>Normalized Gain Delay</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>Delay</td>
<td></td>
</tr>
<tr>
<td>All (N=28)</td>
<td>78</td>
<td>91</td>
<td>+16.7 %</td>
</tr>
<tr>
<td>High (n=17)</td>
<td>89</td>
<td>96</td>
<td>+7.9 %</td>
</tr>
<tr>
<td>Middle (n=7)</td>
<td>56</td>
<td>83</td>
<td>+48 %</td>
</tr>
<tr>
<td>Low (n=4)</td>
<td>69</td>
<td>81</td>
<td>+17.4 %</td>
</tr>
<tr>
<td>Treatment Unit 2</td>
<td>Assessment Scores</td>
<td>% Change</td>
<td>Normalized Gain Delay</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>Delay</td>
<td></td>
</tr>
<tr>
<td>All (N=28)</td>
<td>94</td>
<td>93</td>
<td>-1 %</td>
</tr>
<tr>
<td>High (n=17)</td>
<td>96</td>
<td>94</td>
<td>-2 %</td>
</tr>
<tr>
<td>Middle (n=7)</td>
<td>92</td>
<td>94</td>
<td>+2 %</td>
</tr>
<tr>
<td>Low (n=4)</td>
<td>93</td>
<td>87</td>
<td>-6.5 %</td>
</tr>
</tbody>
</table>

*Note:* Maximum Score is 100.

The students did not forget as much content during the treatment units as seen from the more positive change and the higher normalized gain. In Treatment Unit 1, the percent
change results were positive, which showed that the students earned higher grades on their delayed assessment then during their postunit assessment. The class average change was a positive 16.7 percent. This could be a result of the students being required to make revisions on their unit test. During the second treatment unit the students did forget one percent of the information, however, it was far below the amount lost during the Nontreatment Unit. Furthermore, since reflective writing was involved during both units the case can be made that writing does improve long-term memory of concepts. The high-achieving students had the largest change in normalized gain (11.5), which indicates that reflective writing helped this group the most.

Another source of data used to investigate the effect of writing on students’ long-term memory was student concept interviews with concept mapping. These data are in Table 9. The largest change in normalized gain, 0.55, occurred in the low-achieving group which indicates that writing has a more positive effect on this group than the others. The highest normalized gain, 0.94, was the high achievers, during Treatment Unit 1, which parallels with the postunit and delayed unit assessment scores. Overall, the normalized gain increased for all achievement levels which indicated that reflective writing increased students’ long-term memory.

Table 9

<table>
<thead>
<tr>
<th>Achievement Level</th>
<th>Nontreatment Unit</th>
<th>Treatment Unit 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>High (n=3)</td>
<td>.74</td>
<td>.94</td>
</tr>
<tr>
<td>Middle (n=3)</td>
<td>.57</td>
<td></td>
</tr>
<tr>
<td>Low (n=2)</td>
<td>.22</td>
<td></td>
</tr>
</tbody>
</table>

*Student Concept Interview Normalized Gain by Achievement Level for Postunit and Delayed Unit Related to Long-Term Memory (N=8)*
Middle \((n=3)\) & .78  
Low \((n=2)\) & .73

<table>
<thead>
<tr>
<th>Achievement Level</th>
<th>Normalized Gain Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>High ((n=3))</td>
<td>.76</td>
</tr>
<tr>
<td>Middle ((n=3))</td>
<td>.84</td>
</tr>
<tr>
<td>Low ((n=2))</td>
<td>.77</td>
</tr>
</tbody>
</table>

The third data source was preunit and delayed student surveys. Table 10 includes the students’ perception of writing on their understanding of the content. The pattern in Table 10 is that the normalized gain for the perception of understanding for high-achieving group increases while the other two groups decrease. The high-achieving groups increase in their perception of the effect of writing corresponds to their increase in normalized gain for the postunit and delayed assessments. The group that decreased the most is the low-achieving students and does not correspond with the concept interviews or assessments. This pattern is also seen in the pretreatment and posttreatment survey.

**Table 10**  
*Student Perception of the Effect of Writing on Understanding Content Using Likert Scale on Postunit and Delayed Student Surveys \((N=28)\)*

<table>
<thead>
<tr>
<th>Nontreatment Unit</th>
<th>Survey Scores</th>
<th>Normalized Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achievement Level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High ((n=17))</td>
<td></td>
<td>.06</td>
</tr>
<tr>
<td>Middle ((n=7))</td>
<td></td>
<td>.23</td>
</tr>
<tr>
<td>Low ((n=4))</td>
<td></td>
<td>.43</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Unit 1</th>
<th>Survey Scores</th>
<th>Normalized Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achievement Level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High ((n=17))</td>
<td></td>
<td>.12</td>
</tr>
<tr>
<td>Middle ((n=7))</td>
<td></td>
<td>.13</td>
</tr>
<tr>
<td>Low ((n=4))</td>
<td></td>
<td>.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Unit 2</th>
<th>Survey Scores</th>
<th>Normalized Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achievement Level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High ((n=17))</td>
<td></td>
<td>.19</td>
</tr>
<tr>
<td>Middle ((n=7))</td>
<td></td>
<td>.07</td>
</tr>
<tr>
<td>Low ((n=4))</td>
<td></td>
<td>0.0</td>
</tr>
</tbody>
</table>
From the postunit and delayed capstone project targeted assessments and the student concept interviews there was an increase in the normalized gain in all student achievement levels. The low-achieving group had the highest change in normalized gain on the concept interviews, while the high-achieving group had the highest change on the assessments. This indicates that both groups increased in their knowledge, however, each group expressed their knowledge in different ways. In addition, every student achievement level increased as evidenced by the postunit and delayed assessments and the interview. This indicates that every student increased as a result of reflective writing. These data from the postunit and delayed student surveys indicated that only the high-achieving students were aware of the positive impact that writing had on their learning.

The third subquestion, in the capstone project, concerned the effects of student written reflections on problem solving skills. The three data sources used were preunit and postunit assessments, preunit and postunit student concept interview with concept mapping, and pretreatment and posttreatment student surveys. The assessments were created to include high-level thinking questions and the assessment results to the high level thinking questions are in Table 11.

<table>
<thead>
<tr>
<th>Table 11</th>
<th>Normalized Gain for Preunit and Postunit Average Assessment Scores for Problem Solving Skill Questions (N=28)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-treatment Unit</td>
</tr>
<tr>
<td></td>
<td>Student Achievement Level</td>
</tr>
<tr>
<td>All (N=28)</td>
<td></td>
</tr>
<tr>
<td>High (n=17)</td>
<td></td>
</tr>
<tr>
<td>Middle (n=7)</td>
<td></td>
</tr>
<tr>
<td>Low (n=4)</td>
<td></td>
</tr>
<tr>
<td>Treatment Unit 1</td>
<td></td>
</tr>
<tr>
<td>Student Achievement Level</td>
<td></td>
</tr>
<tr>
<td>All (N=28)</td>
<td></td>
</tr>
<tr>
<td>High (n=17)</td>
<td></td>
</tr>
<tr>
<td>Middle (n=7)</td>
<td></td>
</tr>
<tr>
<td>Low (n=4)</td>
<td></td>
</tr>
</tbody>
</table>
These data show that after the last treatment unit the scores of both the high-achieving and the middle-achieving groups increased, 0.25 and 0.65 respectively. The middle-achieving group was the only group that consistently increased throughout the units. There were two occasions when the normalized gain delay reached one: during Treatment Unit 1 with the low-achieving group and during Treatment Unit 2 with the high-achieving group. Therefore, these data indicate that reflective writing has the potential to help all student levels with their problem solving skills. More data are required to conclude reflective writings effect on assessments for low-achieving student because of their fluctuation.

The students participated in pretreatment and posttreatment surveys that investigated how writing effected their perception of solving problems. The normalized gain is in Table 12. According to these data there was minimal change that occurred in the students’ perception of the difficulty of solving problems. All student groups, except low-achieving students, increased in their normalized gain in their perception of their possession of strong problem solving skills. This means that they perceived that their problem solving skills had improved. The middle-achieving group had the highest
normalized gain in enjoyment of solving problems, 0.25, and their perception of problem solving skills, 0.50. A middle-achieving student shared with me one day during class that he really enjoyed solving problems because it makes the content seem important and “useful”. The low-achieving students did not experience any change in their enjoyment, perception of challenge, or possessing strong problem solving skills.

Table 12

<table>
<thead>
<tr>
<th>Student Type</th>
<th>Enjoy Solving Problems</th>
<th>Problems are Challenging</th>
<th>Strong Problem Solving Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>All (N=28)</td>
<td>0.125</td>
<td>0.02</td>
<td>0.13</td>
</tr>
<tr>
<td>High (n=17)</td>
<td>0.133</td>
<td>0.02</td>
<td>0.16</td>
</tr>
<tr>
<td>Middle (n=7)</td>
<td>0.25</td>
<td>0.0</td>
<td>0.50</td>
</tr>
<tr>
<td>Low (n=4)</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

The third data source was the preunit and postunit student concept interview with concept mapping where each student answered three to four real world problems. The teacher scored their responses based on a rubric in Appendix P. Real-world problem were asked because 37.5% of the students interviewed, in the pretreatment, said that they were motivated by real world issues. Therefore, in order to relate to my students and hopefully increase their enthusiasm these types of questions were asked.

Table 13

<table>
<thead>
<tr>
<th>Nontreatment Unit</th>
<th>Interview Scores</th>
<th>Student Achievement Level</th>
<th>Normalized Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>All (N=8)</td>
<td></td>
<td></td>
<td>0.37</td>
</tr>
<tr>
<td>High (n=3)</td>
<td></td>
<td></td>
<td>0.36</td>
</tr>
<tr>
<td>Middle (n=3)</td>
<td></td>
<td></td>
<td>0.35</td>
</tr>
<tr>
<td>Low (n=2)</td>
<td></td>
<td></td>
<td>0.39</td>
</tr>
<tr>
<td>Treatment Unit 1</td>
<td>Interview Scores</td>
<td>Student Achievement Level</td>
<td>Normalized Gain</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student Achievement Level</td>
<td>Normalized</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td>------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All (N=8)</td>
<td>0.36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High (n=3)</td>
<td>0.46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle (n=3)</td>
<td>0.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low (n=2)</td>
<td>0.30</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Only the high-achieving students had continued growth while only the low achieving students continued to decline. The middle-achieving student’s ability to solve problems decreased; however, they had the most growth in their perception of their problem solving skills. These data from the student survey and the interview scores showed that the high-achieving students were more aware of the difficulty of the problems. On the other hand, they had the highest normalized gain growth on the preunit and postunit interview and assessment throughout the capstone project.

I also investigated the effects of student written reflections on the students’ motivation. Student motivation was assessed using a pretreatment and posttreatment student survey, pretreatment and posttreatment student interview, and the instructors’ weekly reflection journaling. The survey provided information about the student’s enjoyment of writing and peer reading and editing, as displayed in Table 14.

**Table 14**

*Pretreatment and Posttreatment Student Survey Scores Showing Student Motivation in Various Parts of Science Class using the Likert Scale (N=26)*

<table>
<thead>
<tr>
<th>Portion of Science Class</th>
<th>Pretreatment Score</th>
<th>Posttreatment Score</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enjoy writing</td>
<td>2.57</td>
<td>2.52</td>
<td>-1.9%</td>
</tr>
<tr>
<td>Enjoy reading and editing others work</td>
<td>3.04</td>
<td>3.19</td>
<td>4.9%</td>
</tr>
</tbody>
</table>
The students experienced a 1.9 percent decrease in their enjoyment in writing during the capstone project and an increase in editing and reading peers work. Since the enjoyment of reading and editing others work was the only portion of the science class that the students’ enjoyment increased, I investigated how each achievement student level was different. The results are displayed in Figure 3.

Figure 3. Students Percent Change in Enjoyment in Writing Based on the Pretreatment and Posttreatment Student Survey, (N=28)

Figure 3 illustrates that all achievement groups increased their viewpoint on reading and editing each others’ work. The largest growth, at 14 percent, occurred with the middle-achieving group. One student stated in his posttreatment interview that reading others’ essence essays helped him figure out what he needed to do better in his own essay.

The students completed a pretreatment and posttreatment interview that collected data about reflective writings ability to motivate them and their view on writings helpfulness in learning the material. The quantitative data are located in table 15.

<table>
<thead>
<tr>
<th>Question</th>
<th>Student Achievement Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretreatment and Posttreatment Student Interview Score on Perception of Writing using the Likert Scale (N=28)</td>
<td></td>
</tr>
<tr>
<td>Writings Helpfulness</td>
<td>Assessment Type</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Pretreatment</td>
<td>3.125</td>
</tr>
<tr>
<td>Posttreatment</td>
<td>3.0</td>
</tr>
<tr>
<td>Percent Change</td>
<td>- 4.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Explain how writing affects your motivation</th>
<th>Assessment Type</th>
<th>Pretreatment</th>
<th>Posttreatment</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2.6</td>
<td>3.0</td>
<td>- 3.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.5</td>
<td>3.0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.67</td>
<td>2.67</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.0</td>
<td>1.5</td>
<td>- 25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.5</td>
<td>2.0</td>
<td>- 20</td>
</tr>
</tbody>
</table>

*Note:* Likert Scale 5 = writing was helpful and 1 = writing was not helpful

Table 15 shows that the high-achieving students’ perceived the helpfulness of writing to be positive based on the increase in normalized gain data. A high-achieving student stated during the posttreatment interview, “I didn’t feel like the writing helped me understand the material as much as it helped me be able to talk about it better and to do better on the test.” This student increased his Likert scale score from a two to a three because he viewed that it helped him on the test. Another high-achieving student shared with me that it helped him see the connections between the different parts of his learning.

The middle-achieving students had the largest decrease in their perception of the helpfulness of writings, 17.5 percent, which is consistent with their low normalized gain on the student interview. According to the Likert scale score, all student achievement levels remained the same or decreased on reflective writings ability to motivate them.

The low-achieving students experienced a 25 percent decrease in motivation which is the greatest loss.

Student motivation data taken from the teachers’ journal is in Figure 5.
Figure 4. Teacher Perception of Students’ Attitude and Motivation Each Week

Note: Likert Score 5 = strongly enjoyed writing and 1 = strongly did not enjoy writing

There was an increase in Treatment Unit 1 only and could be a result of the new ways of learning being implemented into the classroom. The decrease, in the second treatment unit, is a result of the students not liking the writing assignments. During Treatment Unit 2 I wrote in my journal that as I realized that some students “enjoyed the writing aspect of the classroom while others despised it.”

These data from both the interview and survey indicated that the students did not feel that reflective writing motivated them. These data directly related to the students enjoyment of writing. Therefore, even though there was an increase in students’ enjoyment of peer editing it was not enough to change the students overall view of reflective writing taking place in the classroom. I also observed little change in the students’ motivation, as a result of reflective writing assignments, throughout the capstone project. However, I did notice an increase in students’ motivation during week three, which was the start of Treatment Unit 1.

The last subquestion, under investigation, was the effect that writing has on my motivation to teach, lesson plans, and overall enjoyment. The first data source was my
weekly journal which investigated the impacts of writing on me. These data changed throughout the capstone experience, as seen in Table 16.

Table 16

<table>
<thead>
<tr>
<th>Unit</th>
<th>Writing Impacts my attitude toward teaching</th>
<th>Writing impacts my lesson plan construction</th>
<th>Writing impacts Lesson Plan time</th>
<th>Writing impacts students motivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nontreatment Unit</td>
<td>4.0</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Treatment Unit #1</td>
<td>4.5</td>
<td>4.5</td>
<td>4</td>
<td>3.5</td>
</tr>
<tr>
<td>Treatment Unit #2</td>
<td>5.0</td>
<td>4.5</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

*Note: Likert Scale 5 = Strongly Agree and 1 = Strongly Disagree*

These data expressed that as the capstone project continued the writing did have an impact on my attitude toward teaching. For example, I scored a 5.0 during the last treatment unit which indicates that the use of writing influenced the teacher’s attitude toward teaching. The journal entry during Treatment Unit 2 is characteristic of my viewpoint, “I struggle with finding ways to introduce writing in the classroom that are meaningful and that these boys will relate too. Right now my attitude towards introducing new writing is affecting my attitude towards teaching. This makes me discouraged and a little stressed.” From the pretreatment and posttreatment teacher survey my perception of my ability to teach writing increased by one point on the Likert scale, from a 2 to a 3.

Writing also influenced the way in which I plan my lessons, as indicated by an increase of a 0.5 point on the weekly teaching journal. This was due to me simplifying the lesson plan construction and spending more time finding new ways to have the
students write that the students enjoyed. In addition, I felt that lesson planning time
increased to create writing activities that were tailored to the individual student and their
writing interests. The teachers’ viewpoint toward student motivation changed throughout
the project because during Treatment Unit 1 the students were more motivated to
participate in the writing assignments. Over time the students felt that the writing
assignments were “mundane and boring”. This corresponded to the change in the
pretreatment and posttreatment teacher survey of the ability of writing to motivate
students from a 3 to a 2.

A colleague observed me once per unit and these data are displayed in Table 17.

Table 17
Non-treatment and Treatment Colleague Observations on Teacher’s Teaching Ability and
Motivation using Likert Ratings

<table>
<thead>
<tr>
<th>Question</th>
<th>Nontreatment Unit Score</th>
<th>Treatment Unit 1 Score</th>
<th>Treatment Unit 2 Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher appears confident in explaining writing procedures and expectations.</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Teacher clearly explains the linkages between various parts of the lesson.</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Teacher clearly explains linkage of today’s lesson with previous lessons.</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Teacher appears to be motivated to teach the lesson.</td>
<td>4</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

Note: Likert Scale 5 = Strongly Agree and 1 = Strongly Disagree

The colleague observation scored me 1 point higher on the Likert scale in three of the
four categories. This contradicts the previous data discussed from the other two sources.
The colleague rated my ability to explain the expectations for the writing assignment
higher in the treatment units than in the Nontreatment Unit. This could be because I was
more aware of what I was going to say during the treatment units. The colleague also saw an increase in the explanation of the linkages between different parts of the lesson and between different lessons. This could be because of the increase in lesson planning time. Furthermore, I appeared to be more motivated to teach the lessons during the treatment unit. During Treatment Unit 1 the colleague wrote, “The teacher is smiling, making jokes, and making the content [is] fun for the students while still ensuring that they learn.” During treatment unit 2 the colleague wrote, “The students were learning about renewable energy sources and the teacher was having individual group conferences. All the students were on task and sharing their thoughts on the topic and the teacher seemed to enjoy teaching.”

These data from the three sources indicated that writing does impact my motivation. It affected my attitude towards teaching, in that, I was constantly thinking about how to incorporate reflective writing in each lesson. Because I am more conscious of how to incorporate writing into the classroom the colleague is able to observe improvements in my attitude and in my delivery of the lesson. My perception of my ability to motivate students decreases throughout the capstone project yet data from my colleague contradicted this. This could be the result of my continuous presence in the classroom and conducting the students’ interview and survey data.

INTERPRETATION AND CONCLUSION

This project focused on the effect that student reflective writing has on their understanding of 8th grade science concepts. From the preunit and postunit capstone project target assessment data and the preunit and postunit student concept interview with concept mapping, all student achievement levels increased, in their understanding. This
indicates that writing has a positive impact on all students in the classroom. Data from
the pretreatment and posttreatment student survey revealed that low-achieving students
had the lowest perception that writing was affecting them, indicating that there is
disconnect between students perception of writings influence and their actual influence.
The high-achieving students increase the most in their understanding of the content based
on their assessment normalized gains. They were also more aware of the impact of
writing on their understanding based on their survey data.

The first subquestion considered the effects of student writing on their ability to
develop and transfer 8th-grade concepts. The preunit and postunit student concept map
was the most helpful in determining that all students were able to increase their depth of
knowledge from writing. The low-achieving students experienced the greatest change in
their normalized gain in the preunit and postunit student concept map and the preunit and
postunit interviews. These students also experienced an increase in their normalized gain
on their assessments. Therefore, writing appears to positively impact low-achieving
students ability to develop and transfer 8th grade science concepts. The pretreatment and
posttreatment student survey data indicated that the lab summaries and analysis questions
were helpful to their learning. The concept maps provides evidence that the number of
linkages between vocabulary words increases as well as the word web score.

Another question under investigation was the effect of writing on long-term
memory. All students increased in their normalized scores in the postunit and delayed
capstone project targeted assessments and the postunit and delayed student concept
interviews. From these data sources the case can be made that reflective writing helps
student’s long-term memory. Most students earned higher on Treatment Unit 1 delayed
assessments than their postunit assessments. This information is puzzling as I would assume that the students would lose concepts covered during previous lessons. This could be for a number of reasons. The rough draft of the students essence essay was due the day prior to the test, however, their final product was due the day after the test. Therefore, after the students conducted peer edits in class they took it home to complete and bring back. This means that the students were engaged in their learning past the unit time. Another reason is because the students had in their possession the postunit test. Another data source used in the capstone project was the postunit and delayed student surveys. These data showed a decrease in student’s perception of the effect of writing on understanding content.

The third subquestion, that I investigated, was the effect of student written reflections on problem-solving skills. The three data sources used were preunit and postunit capstone project target assessments, preunit and postunit student concept interview with concept mapping, and pretreatment and posttreatment student surveys. Writing helped middle-achieving student’s problem solving skills by increasing their preunit and postunit average assessment scores the most. In addition, these students also had the highest overall change in their perception of their problem solving skills. This was not triangulated by the pretreatment and posttreatment student survey as this group’s normalized gain fluctuated throughout the three units. There were not patterns that could be gathered between the other three data sources that linked to the other two achievement levels.

Next, I investigated student motivation. The students decreased in regards to enjoying writing whereas students did enjoy editing peers written work. When I looked
at all of the student’s enjoyment of writing, I noticed that there was a decrease while students enjoyed peer editing. Upon further investigation, I noticed that the low and middle-achieving students enjoyed peer editing the most. The low-achieving student, according to the pretreatment and posttreatment student survey scores, had the largest decrease in writings affect on motivation. This extreme percentage decrease (20) is the reason why the overall class percent change was negative. I noted in my teaching journal while I thought that the students enjoyed correcting others and “playing teaching”. One of my notes says that they “enjoy the power that it gives them.” As mentioned in the data and analysis section one student shared with me that it helped him know how to make his writing better. This provides validity to the articles read about the impact of editing others work. Some of the students stated that the writing assignments were mundane and overtime they became boring. Therefore, during the first treatment the students were more receptive and had a higher motivation to complete the writing assignments.

The final subquestion investigated writing effect on my motivation. Writing did impact my view towards teaching, lesson plan construction, lesson planning time, and my perception of writing on students’ motivation. My motivation did decrease slightly over the course of the capstone process. This was because of the disinterest of the students during the second treatment unit to complete the writing assignments. The teacher perception of overall ability to teach decreased as well as their attitude toward teaching. The reasons are numerous for this. The ability to teach decreased mainly because the teacher was struggling with how to make the writing assignments fun and engaging for the students. According to the posttreatment colleague observation data, I increased a
point in his view toward teaching writing. This is mostly due to the fact that I had obtained experience on how to teach the writing aspect of the class.

A limitation of this capstone project was the fact that the low-achieving students scored low in their perceived affect of writing on learning could be a result of the students not receiving their interview grade back for them to see. Therefore, since the low-achieving students were only seeing the assessments, it could have skewed their viewpoint on the effect that writing was having on their learning. In addition, the students started this capstone project at the end of the semester. Therefore, the students were required to complete the assignments in addition to studying for their final exam. This caused the teacher to modify the amount of reflective writing that occurred during Treatment Unit 2. Even with these limitations, I feel this capstone project gives me, the school, and other teachers in single-gender environments crucial information in regards to the effect of writing on students learning, motivation, and teacher motivation.

There are a few things that I would change if I were to complete this capstone project again. The major thing that I would change about the capstone project is the amount of time that I collected student data. The class was on an alternating day schedule therefore, I only saw the students every other day. This meant that extensive amounts of information had to be covered each day, in addition, to completing the capstone project. Increasing the time collecting data would eliminate the stresses of the teacher and students and the new way of teaching. Also towards the end of the capstone project began to study for their EOG’s which meant that the amount of time spent on reflective writing was reduced. I also felt like the word web was not adequate time spent in the class because the students did not take it seriously. This assignment could be
completed at home and used as a cheat sheet on summative assessments. This would eliminate the time spent in the classroom on word webs while also encouraging the students to complete it.

When collecting data, I noticed that there were a few items that I would change. I would collect these sources of data electronically. This would eliminate excess paper, help to organize the data and expedite the analysis. More specifically, I would rearrange the colleague observation form so that all the teacher and students questions would be separated. This would allow my colleague to more easily complete the sheet. Another data source that I would change is the pretreatment and posttreatment student survey. I would change the number of questions that the students are asked while providing them the opportunity to explain themselves. This would have allowed me to collect more qualitative data.

VALUE

This project has value to me as an educator, at an all boy’s public school, because it provides me with data to know what to do differently next semester. It has provided me the opportunity to see that writing does improve students’ understanding, long-term memory, and problem solving skills. This is important to me as one of the goals of the project is to increase the end-of-grade test scores for the school. Another reason why I choose this topic was because our school was interested in learning how writing within the common core helps student achievement. From these data I determined that writing impacts student learning more on the long-term than in the short-term. It does however have a negative impact on the students’ motivation in the classroom. From knowing this I will change the way in which I have students write in the classroom. Next year, I will
be teaching high school science with the same students and I plan on implementing some of the same techniques in the future classroom. Since the majority of the students felt that the writing was mundane I will be sure to mix up the writing assignments. One way to do this is through having student choose what writing format that they would like to use. The students could select any type of multimodal writing as long as specific expectations are met. This would also provide the students with individualized assignments.

There were some limitations of this action research due to the small sample size. The sample size was 28 students with 8 students being interviewed on a regular basis. In future studies, a paired T-test could be conducted to determine significance of results. Also, I did not quantify the changes of their normalized gain as low, middle, or high. If this classification was conducted, then I would be able to clearly view the effect of reflective writing on the students and me. In addition, the students only met every other day for two weeks per unit, therefore the students did not have enough time to process the information before the unit was over. If I were to conduct this action research again, I would increase the amount of time in each unit to four weeks which would be the equivalent to a traditional school schedule. I would also like to use more than two intervention units as this would provide more data to interpret for trends. The type of students involved in this study is very unique. The findings may not overlap into other classrooms.

I am interested in investigating how I can conduct multiple types of summative assessments. From the data, it was concluded that the low-achieving students had higher gains on their interviews, therefore, this group might benefit from having oral tests. We
have access to IPAD’s and, therefore, they could record their answers orally and I would use those to grade them. There are applications that can be downloaded that produce text from the students voices. Instead of listening to their answers, I could read their response. I could also conduct small summative assessments orally to these low-achieving students that covered the same material as the high-achieving students. This could be completed because of the small number of students that are classified as low-achieving.

School wide, we are planning on implementing more writing in the classroom regardless of the content. Next year, I will be the science department chair, thus, I am planning on meeting with the other science teachers in the school to scaffold basic writing techniques and activities in each grade (6-12). I would like to incorporate reflective writing in terms of peer editing, lab summaries, and unit essence essays into each grade level. These would be beneficial to the students in their future endeavors. It would also help them to be 21st century students and have the basis to be a good employee from their ability to write and solve problems.

From this capstone project, these data provides teachers elsewhere a view on how writing impacts boys learning of 8th grade science concepts. Teaching all boys, is a very different environment, which lends itself to specific ways of teaching. From this capstone project, I have learned that the students in an all boys eight grade classroom do not enjoy writing and generally perceive that the writing provides little help. This capstone project provides teachers that work in single gender schools with data that increase writing has a strong relationship with the increased long-term memory of concepts with minimal short-term learning. Using at least three data sources for each
question under investigation provided greater validity to the project. I am curious to investigate how these results would differ in a traditional school or in another early college that was not single-gendered.

I am pleased that I have participated in this capstone project. It has provided me the opportunity to investigate how reflective writing affects many aspects of my students and me as a professional. Participating in the Masters of Science in Science Education provided me with the opportunity to think like a scientists as I created data sources, conducted the capstone project, and analyzed data. From this experience, I now have the mindset that three data sources are ideal when analyzing data. I also am aware of the differences between peer-reviewed journal writing and writing for a periodical. In the future, when I read the monthly subscription, I will be more likely to search and read the methodology of their project. Reading the methodology will allow me to see if the lesson would be reproducible in my classroom. In addition, I have discovered first-hand the importance of critical friends in the development of the paper.

Overall, I have learned that increasing writing assignments in the classroom increases the workload at the beginning of a unit, and also increases the amount of time needed to grade the assignments appropriately. However, after reflecting upon the capstone project, I feel that each type of writing used by the students was beneficial. A further study could investigate which writing type used in this class was the best. The preunit and postunit data was beneficial for me as it helped me determine which concepts students’ were missing and which portion of the class the students struggled with (lab, direct instruction, projects, etc). Knowing this information in the future, I will be able to cater my instruction in the classroom to meet the needs and desires of the students.
REFERENCES CITED


Reinhart, S., (2000). Never say anything a kids can say!. *Mathematics Teaching In Middle School, 5*(8), 54-57  


APPENDICES
APPENDIX A

PARTICIPATION LOG
<table>
<thead>
<tr>
<th>Day</th>
<th>Essential Question:</th>
<th>Essential Question answer:</th>
<th>My Comments:</th>
<th>Muddiest Point:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Tuesday</td>
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<td>Wednesday</td>
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<td>Thursday</td>
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<tr>
<td>Friday</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX B

STUDENT INDICATOR SHEET
<table>
<thead>
<tr>
<th>UNIT LANDFORMS</th>
<th>NC Essential Standards</th>
<th>Student Objectives</th>
<th>Page Number &amp; Activity</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNIT LANDFORMS</td>
<td>8.E.2.1 Infer the age of the Earth and relative age of rocks and fossils from index fossils and ordering of rock layers (relative dating and radioactive dating).</td>
<td>I can define an eon.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I can define an era.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I can define a period.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I can define an epoch.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I can contrast the time scale divisions.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I can list the time scale divisions from largest to smallest.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I can contrast the eras.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I can explain how the biology changes between the eras.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I can define the word fossil.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I can explain how a mold fossil forms.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I can provide an example of a mold fossil.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I can explain how a cast fossil forms.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I can provide an example of a cast fossil.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>I can explain how a petrified fossil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>forms.</td>
<td></td>
<td></td>
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<tr>
<td>---</td>
<td>--------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>I can provide an example of a petrified fossil.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX C

NONTREATMENT STUDY GUIDE
Populations and Ecosystems:

**Vocabulary Words:**
Be able to define each and provide an example

1) Symbiotic Relationships
   - a) Competition
   - b) Commensalism
   - c) Amensalism
   - d) Coexistence
   - e) Cooperation
   - f) Parasitism
   - g) Mutualism
2) Limiting Factors
3) Adaptations versus Mutations
4) Exponential Growth
5) Carrying Capacity
6) Ecosystem, Community, Populations, Biosphere, Biodiversity, Biome, Habitat
7) Emigration versus Immigration
8) Niche
9) Matter, Energy
10) Nitrogen cycle, Carbon cycle, Oxygen cycle

**Things to think about:**
1) How do humans impact the three chemical cycles?
2) What are some examples of relationships in a biome?
APPENDIX D

LAB REFLECTION RUBRIC
Lab Reflection Rubric

<table>
<thead>
<tr>
<th>Part of Lab</th>
<th>Score 3</th>
<th>Score 2</th>
<th>Score 1</th>
<th>Extra Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>The students clearly restate the original problem or their hypothesis in their own words.</td>
<td>The student restates the original problem or their hypothesis in their own words. It needs work</td>
<td>The student copies the original problem or hypothesis.</td>
<td></td>
</tr>
<tr>
<td>Data</td>
<td>Student uses three sources of data to answer the original problem or hypothesis. Each source of data is unique and student explains how it answers the problem.</td>
<td>Student uses two sources of data to answer the original problem or hypothesis. Each source of data is unique and student explains how it answers the problem.</td>
<td>Student uses one source of data to answer the original problem or hypothesis. Each source of data is unique and student explains how it answers the problem.</td>
<td></td>
</tr>
<tr>
<td>Understanding</td>
<td>Student thoroughly answers the original problem or hypothesis by explaining the process and results.</td>
<td>Student answers the original problem or hypothesis by explaining the process and results.</td>
<td>Student answers the original problem or hypothesis.</td>
<td></td>
</tr>
<tr>
<td>Conclusion</td>
<td>The student answers thoroughly answers the question, “So What?”</td>
<td>The student answers the question, “So What?” There answer lacks deep understanding.</td>
<td>The student needs more work in relating the results to the real world and themselves.</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX E

POPULATIONS AND ECOSYSTEMS PROJECT
Biome Project

Citations: (30 points)

1) All pictures must have the URL directly beneath the picture. It can be extremely small 8 font if needed. (10 points)

2) All sources must be cited in MLA format. (20 points)

3) Writing taken directly from sources (cut and pasted) will result in a penalty of 50 points.

Layout: (15 points)

- Each slide needs at least two picture but no more than three (3 points)
- Writing on the ppt needs to be written in a professional manner (4 points)
  - Writing does not need to appear as if you are talking to the audience.
  - If there is copious amounts of words on the slide I will not read it and content points will be deducted.
- The text must be black in color (3 points)
- The background on the slides must be white only (3 points)
- Do not add transitions. (2 points)

Slide #1: Title Pages (4 points)

Student Names

Biome Name

Block

Picture of your Biome location in the world

Slide #2: Location (6 points)

1) Where is it located in the world – provide another picture.

2) Provide the longitude and latitude for the area.
3) What countries are found in?
4) If it can be found in the United State specify where.

APPENDIX E (continued)

Slide #3: Climate (6 points)
1) Average Summer Temperature
2) Average Winter Temperature
3) Average Rainfall and/or Snowfall

Slide #4: Animals (6 points)
1) List 3-5 animals found in your biome
2) Choose one animal to research more about. Do not choose a typical animal such as a black bear.
   a) Height
   b) Weight
   c) Lifespan
   d) Diet
   e) Find map of its habitat
   f) How many are found in an area?

Slide #5: Plants (6 points)
1) List 3-5 plants found in your biome
2) Choose one plant to research more about. Choose a plant that you do not know a large amount about.
a) Height

b) Lifespan

c) Find map of its habitat

d) What is its benefit to Humans?

APPENDIX E (continued)

Slide #6: Hydrology (6 points)

1) List a river basin in the area.

2) Provide information about the river basin
   a) Picture of its location.
   b) Length of the River or largeness of the body of water.
   c) What is its use to humans?

3) Provide three popular bodies of water in the biome.

Slide #7: Citations (6 points)

1) Must be in MLA Format.

2) Must be in alphabetical order.

3) Must be from three different credible sources.

4) The pictures can only be taken from public domains (Wikipedia and such) and should NOT be included in this page as they are placed on each slide directly underneath the picture.
APPENDIX F

LANDFORM AND LIFE-FORM EXAMPLE WORKSHEET
Relative Age Dating Worksheet

Purpose: The purpose of this activity is to introduce you to the different principles used to calculate the relative age of the layers.

Procedures: Look layers of sedimentary rock in the first textbox. Answer the questions or write what you notice occurring in the second textbox.

1. Describe the direction that the layers are deposited. This is how the layers are deposited normally.

2. Describe what you are seeing and how it is different from the way in which layers are deposited normally.

3. Which layer came first? Explain how you know this. This is the principle of superposition.
Faults are divisions in the earth where the earth shifts. Which came first the fault or the layers of earth? Explain your answer. This is the principle of cross cutting relationships.

Use this picture to explain the principle of cross cutting relationships.

Magma Chambers use the same cross-cutting principle as faults. Therefore, arrange layers and in order in which they occurred from oldest to youngest.
APPENDIX G

LORAX REFLECTIVE WRITING QUESTIONS
Questions ___ - ___ are to be answered as you watch the video.

Questions ___ - ___ are to be answered after the video.

**During Video:**

1) What effects did the manufacturing of Thneeds have on the trees?

2) What effects did the manufacturing of Thneeds have on the animals?

3) What effects did the manufacturing of Thneeds have on the rivers?

4) What effects did the manufacturing of Thneeds have on the atmosphere?

**After Video:**

1) Who was the Onceler?

2) Have you ever been an Onceler?

3) What occurred because of the Oncelers actions?

4) What could the Onceler have done to fix his mistake?

5) The Onceler stated in the video that if he had not done it then surely someone else would. What does this mean? Is this justifiable?
APPENDIX H

PREUNIT, POSTUNIT, AND DELAYED ASSESSMENT FOR NONTREATMENT UNIT
Participation in this research is voluntary and participation or nonparticipation will not affect a student's grades or class standing in any way.

Contrast abiotic and biotic factors in an ecosystem and provide examples for each.

________________________________________________________________________

Explain how abiotic factors affect populations in an ecosystem.

________________________________________________________________________

Explain how biotic factors, especially humans, are affecting the ecosystem.

Part 2: Food Web Creation
1. Select a specific biome and write it in the section below.
2. Include a combination of ten different animals and plants found in a specific biome.
3. Give examples of all five relationships that could be found in the food web. Explain the relationship between each set of animals.

<table>
<thead>
<tr>
<th>Type of Symbiotic Relationship</th>
<th>Animals Involved from the biome food web created</th>
<th>Explain the relationship between the animals</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

Part 3: Cycle Interaction
Use three different colors to draw three different circles to create a Triple Venn Diagram. From these you will compare and contrast the Carbon, Nitrogen, and Oxygen Cycle.
APPENDIX I

PREUNIT, POSTUNIT, AND DELAYED ASSESSMENT FOR TREATMENT UNIT 1
Participation in this research is voluntary and participation or nonparticipation will not affect a student’s grades or class standing in any way.

Part 1: Geological Time Scale

Contrast eon versus era.

________________________________________________________________________

________________________________________________________________________

Arrange the parts of the time scale from smallest to largest.

________________________________________________________________________

Part 2: Relative and Absolute Dating

Contrast relative versus absolute dating.

________________________________________________________________________

________________________________________________________________________

Create a set of at least 6 sedimentary layers. Include in the set an inclusion, intrusion and a fault. Label them - layers, inclusion, intrusion, and fault, with letters.

List the order from oldest to youngest.
Part 3: Plant and Animal Changes

Explain in detail how plants have changed over time.

________________________________________________________________________
________________________________________________________________________

APPENDIX I Continued

Explain in detail how animals have changed over time.

________________________________________________________________________
________________________________________________________________________

Fossil Types:

<table>
<thead>
<tr>
<th>Provide the names of each type of fossil</th>
<th>Explain the type of fossil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

Evolution:

Contrast Microevolution and Macroevolution

________________________________________________________________________
________________________________________________________________________

Contrast Adaptation and Mutation

________________________________________________________________________
Explain how scientists use embryology to prove evolution.

Explain how scientists use phenotypes to prove evolution.
APPENDIX J

PREUNIT, POSTUNIT, AND DELAYED ASSESSMENT FOR TREATMENT UNIT 2
Preunit, Postunit, and Delayed Assessment for Treatment Unit 2

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

Contrast renewable and nonrenewable resources.

Provide one example of a nonrenewable natural resource.

Provide one example of a renewable natural resource.

List three renewable energy sources.

What is a risk associated with one of the sources you listed above.

List three nonrenewable energy sources.

What is a risk associated with one of the sources you listed above.

Contrast reduce, reuse, and recycle.

How are humans impacting the soil negatively?

How are humans impacting the soil positively?

How are humans impacting the air negatively?

How are humans impacting the air positively?

What is global warming?
What is acid rain and how do humans cause this?
APPENDIX K

PREUNIT, POSTUNIT, AND DELAYED CAPSTONE PROJECT TARGET ASSESSMENTS
Participation in this research is voluntary and participation or nonparticipation will not affect a student’s grades or class standing in any way.

1) This is a multi-step question; therefore make sure that you complete all of the steps.
   a) Draw a picture below of a food web and explain what is occurring.
   b) Draw a picture below of a food chain and explain what is occurring.

2) Contrast abiotic and biotic factors and provide an example of each.

3) Contrast radioactive dating and Absolute Dating.

4) Contrast renewable energy and nonrenewable energy. Provide an example of each type of energy.
5) Explain how humans are impacting the soil and air.
APPENDIX L

STUDENT PREUNIT AND POSTUNIT INTERVIEW QUESTIONS
Preunit and Postunit Student Interview Questions with concept mapping

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

1) How many connections did you make originally? (Preunit only) How many new connection did you make (Postunit only)
2) Read to me one connection and explain what you mean.

3) On a scale of 1 to 5, how deep do you think that connection was?
4) Explain your answer.

5) On a scale of 1 to 5, how deep do you think the other connections are?
6) Explain your answer.

7) On a scale of 1 to 5, how helpful was the writing assignment in learning the material?
8) On a scale of 1 to 5, how helpful was writing in motivating you to learn about the topic?
9) On a scale of 1 to 5, how important was previous writing in helping you develop these connections?
10) Explain your answer.

11) Provide an example of how you used writing in the past while studying these topics.

12) What typically motivates you to learn about science?
APPENDIX M

STUDENT PROBLEM SOLVING INTERVIEW QUESTIONS
Populations and Ecosystem:
1) Scientist say that the carbon cycle is being affected by humans. Provide evidence to prove or disprove this statement.

2) Currently in Yellowstone there is a disagreement between naturalists with their policy on wolves and farmers that are located outside the boundary. Explain each person’s side of the argument. Write a detailed compromise that each party would agree too

3) Explain the limiting factors and carrying capacity of the Yellowstone wolf issue.

4) Create a food web and explain the niche of each animal. Explain in detail what would occur if the animal became extinct in the area.

Landforms and Life-Forms:
1) A Paleontologist went on a dig in Montana over the summer and he found a dinosaur bone in the side of a cliff. Explain how the scientist can determine the age of the bone.

2) Which fossil type would a Paleontologist most likely choose to determine the age of the animal or plant?

3) Explain how humans can adapt and mutate throughout their life and how our daily life can impact these. Assume that you are a doctor trying to explain this to your patient.

4) A geologist walks into an area with a cross-section. It has two faults. Explain the relative age of the cross-section using the proper vocabulary words.

Natural Resources:
1) You are a farmer in Montana and you just had a power company install windmill on you land. Explain the negatives and positives that could occur as a result.

2) What types of renewable energy could North Carolina start building and using? Explain where each could be found.

3) You are a geologist and you are presenting to a group of farmers about the importance of soil conservation. What information would you share with them?
4) This winter North Carolina had the most snow in the past few years, why then do scientists say global warming is occurring?
APPENDIX N

PRETREATMENT AND POSTTREATMENT STUDENT INTERVIEW
Pretreatment and Posttreatment Student Interview

1) Explain a writing assignment that was most interesting for you to complete in a previous science class [this science class].

2) On a scale of 1 to 5, how helpful is writing assignment in learning the material?
3) Explain your answer.

4) On a scale of 1 to 5, how helpful is writing in motivating you to learn about the topic?
5) Explain your answer.

6) What typically motivates you to learn about a topic in science?

7) How has your viewpoint towards writing in science changed over the course of the past three units?
APPENDIX O

PREUNIT AND POSTUNIT WORD WEB RUBRIC
## Preunit Word Web Rubric

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content/Facts</strong></td>
<td>Facts were accurate for all events reported on the word web.</td>
<td>Facts were accurate for almost all events reported on the word web.</td>
<td>Facts were accurate for most (~75%) of the events reported on the word web.</td>
<td>Facts were often inaccurate for events reported on the word web.</td>
</tr>
<tr>
<td><strong>Readability</strong></td>
<td>The overall appearance of the word web is pleasing and easy to read.</td>
<td>The overall appearance of the word web is somewhat pleasing and easy to read.</td>
<td>The word web is relatively readable.</td>
<td>The word web is difficult to read.</td>
</tr>
<tr>
<td><strong>Title</strong></td>
<td>The word web has a creative title that accurately describes the material and is easy to locate.</td>
<td>The word web has an effective title that accurately describes the material and is easy to locate.</td>
<td>The word web has a title that is easy to locate.</td>
<td>The title is missing or difficult to locate.</td>
</tr>
<tr>
<td><strong>Linkages</strong></td>
<td>The student made and explained at least 7 connections between the vocabulary words and the main title.</td>
<td>The student made and explained at least 5 connections between the vocabulary words and the main title.</td>
<td>The student made and explained at least 3 connections between the vocabulary words and the main title.</td>
<td>The student made and explained less than 3 connections.</td>
</tr>
<tr>
<td><strong>Learning of Content</strong></td>
<td>The student accurately described 75% (or more) of the vocabulary connections on the word web.</td>
<td>The student accurately described 50 - 75% of the vocabulary connections on the word web.</td>
<td>The student accurately described 25 - 50% of the vocabulary connections on the word web.</td>
<td>The student accurately described less than 25% of the vocabulary connections on the word web.</td>
</tr>
<tr>
<td><strong>Fonts and Colors</strong></td>
<td>The use of font styles and colors always helps the viewer understand the flow of the word web.</td>
<td>The use of font styles and colors most of the time helps the viewer understand the flow of the word web.</td>
<td>The use of font styles and colors is consistent, but is not used effectively to organize.</td>
<td>The use of font styles and colors is not consistent OR detracts the reader from the organization of the word web.</td>
</tr>
</tbody>
</table>
## Postunit Word Web Rubric

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content/Facts</strong></td>
<td>Facts were accurate for all events reported on the word web.</td>
<td>Facts were accurate for almost all events reported on the word web.</td>
<td>Facts were accurate for most (~75%) of the events reported on the word web.</td>
<td>Facts were often inaccurate for events reported on the word web.</td>
</tr>
<tr>
<td><strong>Depth of Knowledge</strong></td>
<td>All the connections have a strong explanation.</td>
<td>Most connections have a strong explanation. Or All connections have a moderate explanation.</td>
<td>Some connections have a strong explanation.</td>
<td>Few connections have a strong explanation.</td>
</tr>
<tr>
<td><strong>Depth of Connections</strong></td>
<td>More information is added to every connection and new connections are made.</td>
<td>More information is added to every connection OR new connections are made.</td>
<td>The new additions express minimal depth of learning.</td>
<td>There are either no additional connections or the connections do not express depth of learning.</td>
</tr>
<tr>
<td><strong>Readability</strong></td>
<td>The overall appearance of the word web is pleasing and easy to read.</td>
<td>The overall appearance of the word web is somewhat pleasing and easy to read.</td>
<td>The word web is relatively readable.</td>
<td>The word web is difficult to read.</td>
</tr>
<tr>
<td><strong>Title</strong></td>
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<td>The word web has an effective title that accurately describes the material and is easy to locate.</td>
<td>The word web has a title that is easy to locate.</td>
<td>The title is missing or difficult to locate.</td>
</tr>
<tr>
<td><strong>Linkages</strong></td>
<td>The student made and explained at least 12 connections between the vocabulary words and the main title.</td>
<td>The student made and explained at least 10 connections between the vocabulary words and the main title.</td>
<td>The student made and explained at least 8 connections between the vocabulary words and the main title.</td>
<td>The student made and explained less than 5 connections.</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Learning of Content</strong></td>
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<td>The student accurately described less than 25% of the vocabulary connections on the word web.</td>
</tr>
<tr>
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</tbody>
</table>
APPENDIX P

TEACHER PRETREATMENT AND POSTTREATMENT SURVEY
Pretreatment and Posttreatment Teacher Survey

*Use the Likert Scale to rank the effect of student writing on various aspects of your teaching.*

*This survey is to be completed prior to and after the treatment.*

1 = Strongly Disagree  2 = Disagree  3 = Indifferent  4 = Agree  5 = Strongly Agree

1) My attitude toward my teaching ability is positive.  1  2  3  4  5
2) Explain.

3) My attitude toward teaching is positive.  1  2  3  4  5
4) Explain.

5) My attitude toward teaching my students through writing is positive.  1  2  3  4  5
6) Explain.

7) I am confident in my lesson planning.  1  2  3  4  5
8) Explain.

9) I have adequate amounts of planning time.  1  2  3  4  5
10) Explain.

11) I feel confident in my ability to motivate students.  1  2  3  4  5
12) Explain.

13) I feel confident in my ability to teach problem solving skills.  1  2  3  4  5
14) Explain.

15) What influence does student motivation have on my attitude towards teaching?

16) What influence does incorporating writing have on my attitude toward teaching?
APPENDIX Q

INSTRUCTOR WEEKLY REFLECTION JOURNAL PROMPTS
Instructor Weekly Reflection Journal Prompts

Use the Likert Scale to rank the effect of student writing on various aspects of your teaching.

To be completed each week with explanations of each rating expected.

1 = Strongly Disagree       2 = Disagree       3 = Indifferent       4 = Agree       5 = Strongly Agree

1) Student writing implementation has an impact on my teaching. 1 2 3 4 5
2) Explain your answer.

3) Student writing implementation has an impact on my attitude. 1 2 3 4 5
4) Explain your answer.

5) Student writing implementation impacts on lesson plan construction. 1 2 3 4 5
6) Explain your answer.

7) Student writing implementation impacts planning time requirements 1 2 3 4 5
8) Explain your answer.

9) Student writing has a positive impact on student’s motivation. 1 2 3 4 5
10) Explain your answer.

11) Student writing positively impacts student’s problem solving skills. 1 2 3 4 5
12) Explain your answer.
APPENDIX R

NONTREATMENT AND TREATMENT COLLEAGUE OBSERVATIONS
Nontreatment and Treatment Colleague Observations

*Use the Likert Scale to rank the effect of student writing on teacher’s performance.*

*This survey is to be completed during or immediately following an observation.*

1. What is the objective of the lesson?

2. How does the teacher incorporate writing into the lesson?

3. The teacher appears to be confident in explaining the writing procedures and expectations to the students. 1 2 3 4 5

4. The students appear to understand the expectations for the writing procedures. 1 2 3 4 5

5. The students appear to enjoy the writing aspect of the lesson. Explain 1 2 3 4 5

6. The teacher clearly explains the linkages between various parts of the lesson. 1 2 3 4 5

7. The teacher clearly explains the linkage of today’s lesson with previous lessons. 1 2 3 4 5

8. The teacher appears to be motivated to teach the lesson. Explain 1 2 3 4 5

9. The students are engaged in the lesson. 1 2 3 4 5

10. The students appear to be interested in the lesson. Explain 1 2 3 4 5

11. What suggestions do you have on how to incorporate writing in this science lesson?

12. What suggestions do you have on how to incorporate writing in further lessons?
APPENDIX S

PRETREATMENT AND POSTTREATMENT STUDENT SURVEY
Pretreatment and Posttreatment Student Survey

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

*Use the Likert Scale to rank the effect of student writing on various aspects of your teaching.*

*To be completed prior to and after the treatment.*

1 = Strongly Disagree  2 = Disagree  3 = Indifferent  4 = Agree  5 = Strongly Agree

1) I feel as if the knowledge learned in science is useful to my life.  1   2   3   4   5

2) I enjoy science class.  1   2   3   4   5

3) I enjoy completing laboratory activities in the classroom.  1   2   3   4   5

4) Understanding laboratory content is difficult.  1   2   3   4   5

5) Writing a summary (essence) of the lab helps me understand.  1   2   3   4   5

6) Answering the analysis questions after the lab helps me understand  1   2   3   4   5

7) I see the overlap between lab and other areas of the classroom (group work, homework, labs, readings, etc.)  1   2   3   4   5

8) I enjoy solving science problems in the classroom.  1   2   3   4   5

9) Solving science problems is challenging for me.  1   2   3   4   5

10) I have strong problem solving skills.  1   2   3   4   5

11) I enjoy writing in the science classroom.  1   2   3   4   5

12) I enjoy reading and editing my classmates writing.  1   2   3   4   5

13) Writing helps me understand the material.  1   2   3   4   5

14) Explain:

15) When answering a question I think about the individual lesson where the concept was taught.  1   2   3   4   5

16) Explain the strategies you use in the classroom to solve problems?
APPENDIX T

PREUNIT AND POSTUNIT STUDENT SURVEY
Preunit and Postunit Student Survey

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

Use the Likert Scale to rank the effect of student writing on various aspects of your teaching.

To be completed after each unit.

1 = Strongly Disagree  2 = Disagree  3 = Indifferent  4 = Agree  5 = Strongly Agree

1) Writing in my notebook helped me understand the material.  1  2  3  4  5
2) Writing in my notebook helped me to retain the materials.  1  2  3  4  5

3) Answering the EQ helped me understand the material.  1  2  3  4  5
4) Answering the EQ helped me to retain the material.  1  2  3  4  5

5) Answering the essential question kept me attentive in class.  1  2  3  4  5

6) The participation log helped me understand the material.  1  2  3  4  5
7) The participation log helped me to retain the material.  1  2  3  4  5

8) The student indicators helped me understand the material.  1  2  3  4  5
9) The student indicators helped me to retain the material.  1  2  3  4  5

10) Writing after a lab activity helped me understand the material.  1  2  3  4  5
11) Writing after a lab activity helped me to retain the material.  1  2  3  4  5

12) Writing in the class helped me with my problem solving skills.  1  2  3  4  5

Explain

13) I enjoy writing in my science notebook.  1  2  3  4  5
14) I enjoy answering the essential question.  1  2  3  4  5
15) I enjoy completing the participation logs.  1  2  3  4  5
16) I enjoy completing the student indicators.  1  2  3  4  5
17) I enjoy the other forms of writing in the class.  1  2  3  4  5
APPENDIX U

PROJECT TIMELINE
Start Project Implementation: March 17\textsuperscript{th}

March 17\textsuperscript{th}: Pretreatment Survey, Preunit Assessment, Pretreatment Interview, Capstone Assessment
March 19\textsuperscript{th}: Preunit word web (nontreatment), preunit interview (nontreatment), Human population change
March 21\textsuperscript{st}: “Oh Deer” lab, camouflage butterfly lab,
March 25\textsuperscript{th}: Symbiotic relationships,
March 27\textsuperscript{th}: Nitrogen, Carbon and Oxygen Cycle; Postunit word web (nontreatment), postunit interview (nontreatment), postunit assessment (nontreatment)
March 31\textsuperscript{st}: Preunit word web (treatment 1), preunit test (treatment 1), preunit interview (treatment 1); earth history notes
April 2\textsuperscript{nd}: Earth History notes and project assignment
April 4\textsuperscript{th}: Relative Age Dating
April 8\textsuperscript{th}: Evolution (adaptation versus mutation)
April 10\textsuperscript{th}: Absolute Dating, Postunit word web (treatment 1), postunit interview (treatment 1), postunit assessment (treatment 1); unit essence essay due
April 14\textsuperscript{th}: Preunit word web (treatment 2), preunit interview (treatment 2), delayed assessment (nontreatment),
April 16\textsuperscript{th}: preunit assessment,
April 21\textsuperscript{st}: Reduce, Reuse, Recycle
April 23\textsuperscript{rd}: Humans impact on soil, air, and hydrologic cycle
April 25\textsuperscript{th}: Postunit word web (Treatment 2), postunit interview (Treatment2), postunit assessment (Treatment 2)
April 29\textsuperscript{th}: Delayed assessment (treatment 1)
May 1st:
May 5\textsuperscript{th}:
May 7\textsuperscript{th}:
May 9\textsuperscript{th}: Posttreatment Survey, Posttreatment Interview, delayed assessment (treatment 2)

End Project Implementation: May 9\textsuperscript{th}, 2014