Re-Write to Get It Right
Using Peer Editing to Improve Student Lab Conclusions

By

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THESIS

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DAVIS

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2008

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Title: Re-Write to Get It Right: Using Peer Editing to Improve Student Lab Conclusions

Research Question(s):

How does peer editing of lab conclusions affect students' ability to come to logical conclusions using data?

Sub-questions:

* How does peer editing of lab conclusions affect students' conclusion writing ability?

* How does peer editing of lab conclusions affect students' attitude towards writing conclusions and data analysis?

Research Activities:

The purpose of this intervention was to investigate the effects of peer editing on students' ability to develop and write logical conclusions using data. This study occurred in an 11th grade Earth Science class composed of 27 suburban students and took place over the course of a month. The intervention began with the introduction of a rubric for writing conclusions and direct instruction on how to use this rubric to peer-edit a classmate's conclusion. Students then wrote conclusions, had classmates peer-edit their conclusions, and rewrote their conclusions for three different labs: one on minerals, one on rocks, and one on the carbon cycle. Data were gathered in the form of student-written conclusions in lab reports, attitude surveys on student attitudes toward conducting lab procedures, data analysis, and writing conclusions, and selected student quotations collected during observations while students peer-edited. Students' conclusion scores doubled from 4.58

to 8.83 out of 12 during the intervention. I concluded that having a clear rubric for conclusions and clear expectations led to the greatest increase in ability to formulate logical conclusions (from 4.58 to 9.15 out of 12). Peer editing also led to an increase in the ability to formulate logical conclusions (from 9.15 to 10 out of 12) but the increase was not as large as those resulting from the use of a rubric for conclusion writing. I also found that students did not enjoy writing logical conclusions using data, based on the fact that the percent of students who strongly disagreed with the statement "I enjoy writing conclusions for labs" went from 42% before the intervention to 61% after the intervention.

Grade: Secondary

Research Methods: Observation-Selective verbatim; Writing samples; Survey-Attitude

Curriculum Areas: Science; Science-Earth Science; Writing-Writing in the content areas

Instructional Approaches: Scientific method; Error analysis; Writing-Peer response/feedback; Writing-Rubrics; Writing-Self-evaluation; Direct Instruction

Introduction

Long thought to be the domain of English and social studies classes, writing is quickly becoming a valued and necessary skill for success in the sciences. While science is still focused around analyzing data and coming to logical conclusions from that data, without the writing skills to express oneself clearly in science, it is impossible to express that conclusion to others. As a science teacher, it is important that my students are able to express themselves well in writing so that they can share their thoughts and ideas with others.

Another vital component to science classes is the hands-on work students do conducting laboratory experiments and activities. For many students, this is their favorite part of science and the way that science differentiates itself from most other academic classes. Students often ask for more lab activities in class and complain about non-lab learning. Hands-on lab activities are especially important among English learning students and those who are less successful in traditional academic environments.

In my 11th grade Earth Science class, I have many students who have not thrived in traditional academic classrooms. I noticed early on that while many of my students were good at conducting the hands-on lab procedures, very few of them were successful at explaining what the end result of the lab was and what they could conclude from what they found. I did not want to lose the enthusiasm of the students for science, but I wanted to improve their ability to explain their logic and write a cohesive conclusion. I embarked on this intervention project to improve my students' conclusion writing and ability to come to logical conclusions from data gathered in the lab. I attempted to do this using the process of having students peer-edit each other's conclusions to give them the opportunity to interact and make coming to conclusions a community process and not an individual pursuit. I found it to be a very successful exercise.

Context

Community

Douglass is a suburban town in the northern San Francisco Bay Area[1]. The school is located at the edge of a residential neighborhood. Directly across the street are a church and a horse stable. Driving three minutes from the school can take you to either a suburban neighborhood constructed in the 1960's, a new housing development of single family homes constructed in the 1990's or to agricultural farmland. Most residents of the community own their own homes and median household income is $63,453 per year (hometownlocator.com). Many residents commute to the central Bay Area for work. The average commute time is 34.8 minutes and 70% of residents drive to work alone. Many students come from households where both parents work full time. The community is politically fairly liberal with 73% of the population identifying as democrat, 25% identifying as republican and 2% identifying as independent. The community strongly supports the school and is very present at sports games and extra-curricular events.

School

[1] All names and places are pseudonyms

Oeste High School itself has 1050 students and is set around a main walkway and quad area with old oak trees and grassy areas. Most classrooms are in six buildings clustered on the side of this walkway area. At the end of the walkway area are some portable classrooms and a student center. (In the map below, the 200 building is under construction and the classes are located in portables behind the under-construction 200 building and the office). The school was built in 1968 and has an earthy, natural look to it. The school has an open campus at lunch so sophomores, juniors, and seniors are able to leave campus during lunch time. Additionally, the school has a seven period day, but many students only take six classes so they either attend school from 7:25 am until 1:47 pm or from 8:22 am until 2:44 pm. There are very strict behavior policies at the school such as students losing half of a percentage off of their semester grade for each tardy to a class.

Oeste is a high performing suburban high school. It has an API rating for the 2005-2006 school year of 803 with a state ranking of 9 out of 10 overall and 5 out of 10 compared to similar schools. Oeste High School also met 12 out of 12 of its AYP growth standards. Forty-nine percent of graduates from Oeste attend four-year colleges and another 41 percent attend two-year colleges. The average SAT score is 1692. Oeste is a primarily Caucasian school with 78.92% of students White, 11.65% Hispanic, 5.77% Asian, 2.6% African American, and 1.06% other (Figure 1). It also has the reputation as the whiter and richer of the two high schools in town, although the other high school still has 65% of their students white and 22% Hispanic. Oeste also has an English learner population of 6.06%, 80% of which are Spanish speakers. Of the 54 students classified as ELs, 20% are advanced, 30% are early advanced, 28% are intermediate, 15% are early intermediate, and 7% are classified as beginning. Thirteen percent of the school is eligible for free or reduced lunch.

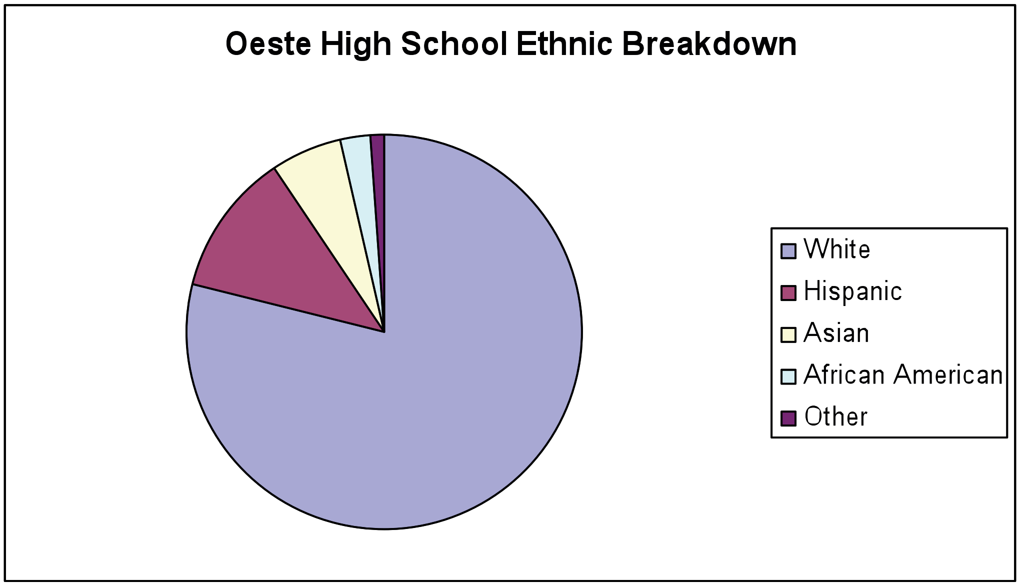


Figure 1. Oeste High ethnic breakdown

Classroom

As the students enter the class, most of them do so quietly and take their assigned seats. One or two say, "Good morning," to the teacher and one comes in and exclaims, "Yes! Another day in Earth Science!" The tardy bell rings and most students take their seats as one last student comes in the door late by five seconds. The class only has slightly more boys than girls in it, but the boys are much louder and thus it feels like there are far more of them. A group of five boys are talking across the classroom to each other as the teacher quiets the class and the students take out notebooks to begin their posted warm-up question. Most of the students are White, tan, and athletic-looking although there is a sprinkling of equally athletic-looking Hispanic faces throughout the class.

My focus class is the second of my three Earth science classes. It runs from 9:19 am until 10:11 am. I generally open class with a warm-up question that is either a review of what was covered the day before, or asks the students for their background knowledge of a topic to be covered that day. The class then proceeds with the lesson, which depending on the day could be a lab, an activity, a demonstration, taking notes, or student group work or presentations. Class ends with students practicing what we have learned or summarizing the lesson of the day.

My Earth Science class is composed of 17 boys and 10 girls. All of these students are 11th graders, except for two who are in 10th grade. My class has a similar ethnic breakdown to the school as a whole. Of my 27 students, 5 are Hispanic and 22 are Caucasian. While many of my other classes contain Asian and African American students, my target class does not. My target class is 18.5% Hispanic and 81.5% Caucasian. Although I have many English learners in my other classes, in my target class, there are no English learners. However, all of my Hispanic students speak Spanish at home. Of the 5 Hispanic students in the target class, 2 were initially fluent in English when tested, and 3 have been reclassified as fluent in English during their time in school.

The students in my Earth Science class are generally those students with an interest in science, but who have not had the most success academically in the past. Students have a very positive opinion of science, overall. Many of the students aspire to attend four year colleges, but have earned C's or below in their math or science courses. My students complete homework regularly and they test well, but they tend not to try hard on class-work, lab-work, or homework. They often rush to finish their work without thinking about what they are writing or doing. My students have very little experience doing inquiry-based scientific investigations. While all of my students have passed biology and almost all of them have also taken another science class before biology, these classes did not have students doing a lot of investigative work, so the students are unaccustomed to writing formal lab reports or investigating phenomena without having read about it first. Students have a lot of lab experience, but most of the labs they have conducted are labs that have been presented to them as worksheets with blanks to be filled in. Students excel at completing work, but struggle with critical thinking and justifying their answers using data. Students have scored well on standardized tests with 48 percent of students scoring proficient or advanced on the Biology STAR test and another 31 percent scoring at the basic level (Figure 2). Previous Earth Science classes at Oeste have had 60 percent of students score proficient or advanced with another 33 percent scoring at the basic level. In English, around half of my students scored proficient or advanced and half scored basic or below.

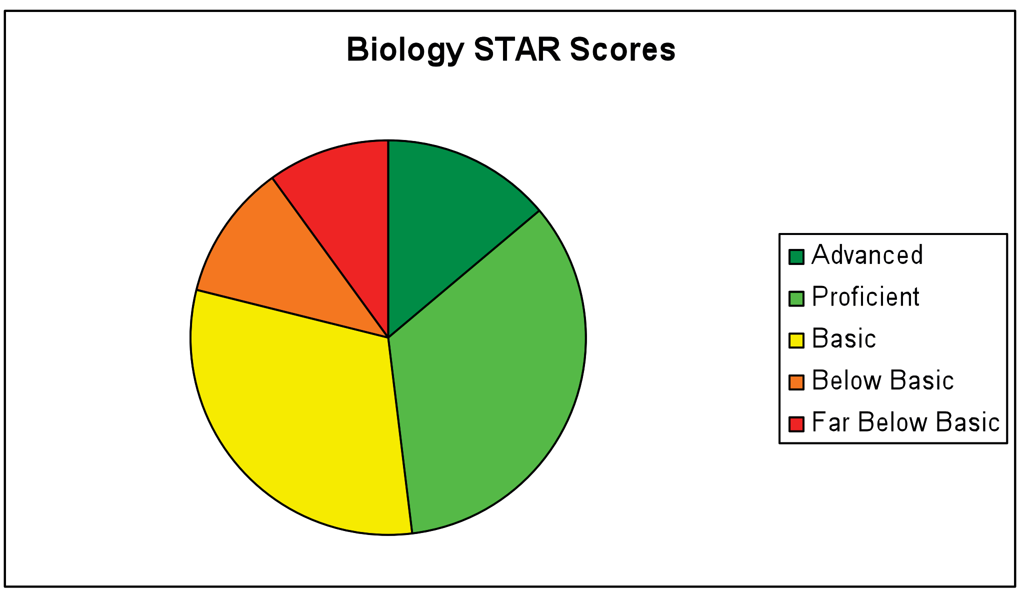


Figure 2. Biology STAR Scores

Purpose and Rationale

Preliminary Data

The goal of my intervention was to improve the conclusion writing of my students and to get students to use data as evidence to come to a conclusion. My decision to pursue peer editing of lab conclusions was based on both the data from my students and previous research literature. I noticed early in the year that, while most of my students had very good writing skills when writing me a note about their weekend or answering a question, their writing was stunted when trying to write about science. This was especially evident in their lab conclusions. Students conducted the labs we were doing in class with ease and seemed to be understanding what was going on, but when asked to write a conclusion for the lab, many of them were extremely terse and their conclusions were based more on words they had heard relating to the subject than on what they actually found in the lab. For example, when writing a conclusion for a lab on solar system formation, students would write things like, "It happens because of gravity," although the lab would not lead them to think gravity had anything to do with the formation of the solar system. Students were drawing their own conclusions based on prior knowledge and not from the evidence gathered in the lab.

Prior to beginning my study on September 13, 2007, my students wrote conclusions in class after completing a lab simulating the formation of the solar system. The lab was conducted the same day in class. Every student present in class completed a conclusion for a total of 27 conclusions. As a class, we came up with a problem question and hypothesis for the lab. I then demonstrated the lab, and students conducted the lab and answered three analysis questions about how the solar system was formed and what happened in the lab. Finally, I wrote the requirements for a good conclusion on the board and students wrote their conclusion. On the board, I wrote:

-What was your hypothesis? Was it correct?

- Answer to the problem question

-Possible experimental error

The conclusions the students submitted varied a lot in their depth. Seven of my students included all three requested elements in their conclusions. However, only one of those seven students wrote in paragraph form. The other students wrote short sentences or sentence fragments as if answering questions. Of the other 20 conclusions, two students failed to include any of the three aspects of the conclusion, six students failed to include two of the three aspects of the conclusion, and 12 students failed to include one aspect of the conclusion (Figure 3). Additionally, when answering the problem question, only two students gave evidence for their answer and related it to their answer. Another eight students gave evidence for an answer to the problem question, but they then did not use that evidence to answer the problem question (Figure 4). These students mostly wrote what happened in the lab without relating it to the solar system formation.

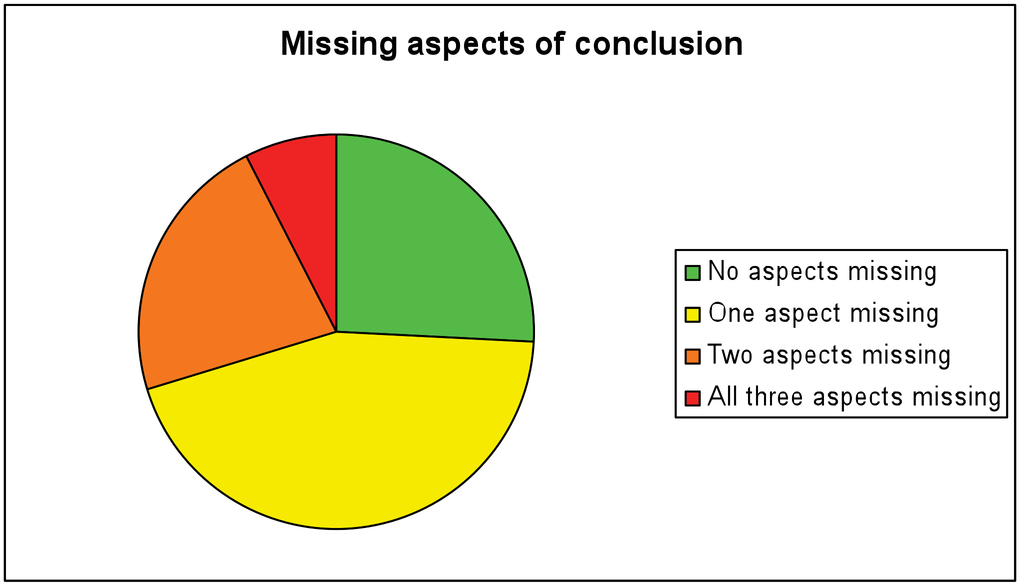


Figure 3. Missing aspects of conclusion

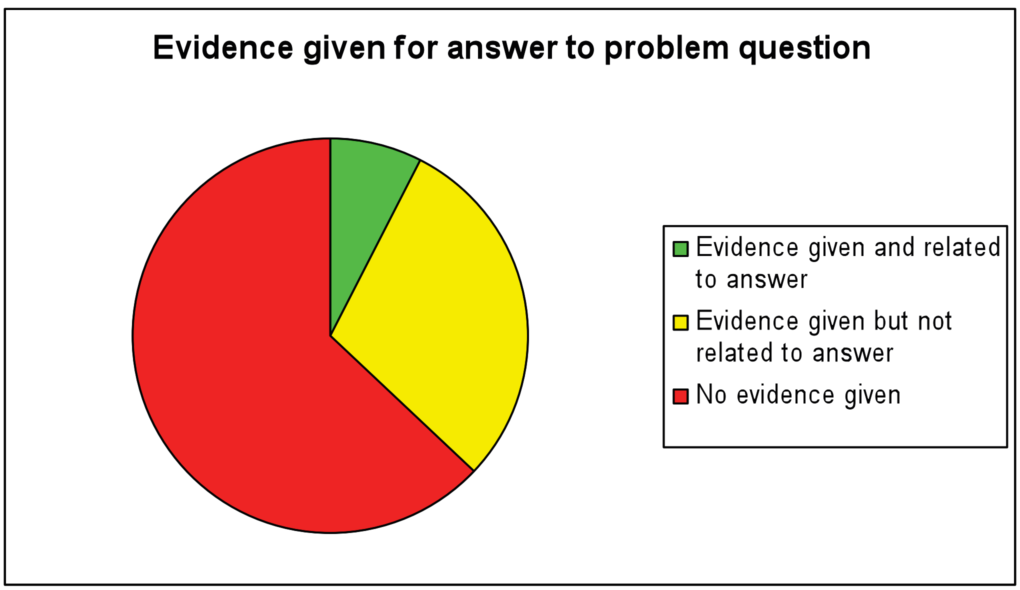


Figure 4. Evidence given for answer to problem question

In total, only 1 of the 27 conclusions submitted contained all three aspects and was written in proper paragraph form. Each aspect was neglected equally with ten students neglecting to include what their hypothesis was and whether it was correct, eleven students neglecting to relate what they saw to the problem question, eleven students neglecting to mention experimental error, and eleven conclusions written in incomplete sentences or not in paragraph format. Additionally, even the conclusions that had all aspects present often did an incomplete job of covering the aspect. For example, some conclusions stated that there was no experimental error, when in fact there were at least five things that could have been listed. The aspect that especially distressed me was that there were so few students who were giving evidence to support their answers to the problem question.

While students were writing their conclusions for the lab on September 13, 2007, I observed and took notes on the questions asked and comments made by students. I did this by writing down the questions that students asked me, or comments I heard students make. After I had asked students to write out a conclusion including the three listed parts of a conclusion, the first question was, "Is this busywork?" by one of the more intelligent and more disruptive students in the class. This question made me realize that this student did not see the value of writing a conclusion and saw it as just a time-filler for the end of the class period. After that, most students worked quietly and the only questions asked were questions about what parts the conclusion should contain. This question or a variation on it was asked by five different students. Each time, I pointed out that the parts required were listed on the board. That the questions asked were so general makes me believe that students did not know what was expected of them in writing a conclusion. Also, the lack of questions or comments makes me believe that students were not thinking in depth about the lab that they had just conducted when writing the conclusion, but were rather just trying to get something written down. I had no questions asking me to clarify what they did or found while conducting the lab.

Prior to the study, I also conducted a student survey about student attitudes about doing labs and writing conclusions. The survey was given to students at the very beginning of class on Tuesday, September 18, 2007. Every student in class completed the survey for a total of 25 surveys. To ensure anonymity and encourage honest answers, I did not ask students to write their names on the survey. I passed out the survey at the beginning of class and students answered it as a warm-up while sitting in their assigned seats. The survey asked students to respond on a Likert scale of 1 to 5, with 5 being highest and 1 being lowest. Answers of 1 or 2 were negative responses, 3 was a neutral response and 4 and 5 were positive responses. The survey was primarily based around student attitudes regarding lab work and writing lab reports.

In analyzing the survey data, I found that students overall have positive feelings about actually conducting the labs, but mostly negative and neutral feelings about writing the lab conclusions. On question 1, "How much do you enjoy performing the labs in class?" the mean answer was 4.04 out of 5, with no students having negative responses, seven students having neutral responses, and 18 students having positive responses (Figure 5).

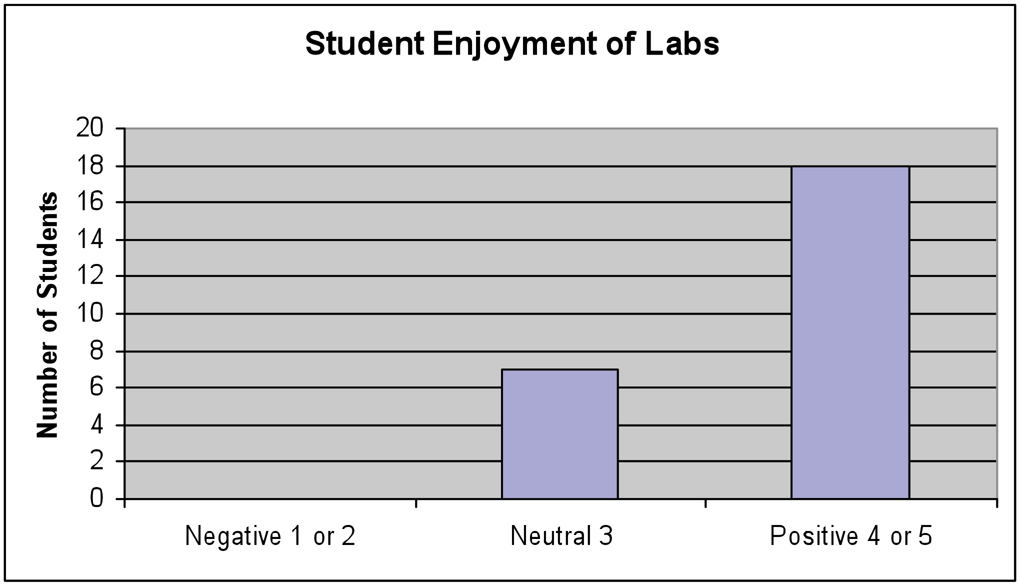


Figure 5. Student Enjoyment of Labs

Students also felt that they learned a lot from doing the labs. On question 5, “How much do you learn from doing the labs?” the mean answer was 4.12 out of 5. One student had a negative response, five students had a neutral response, and 19 students had a positive response (Figure 6).

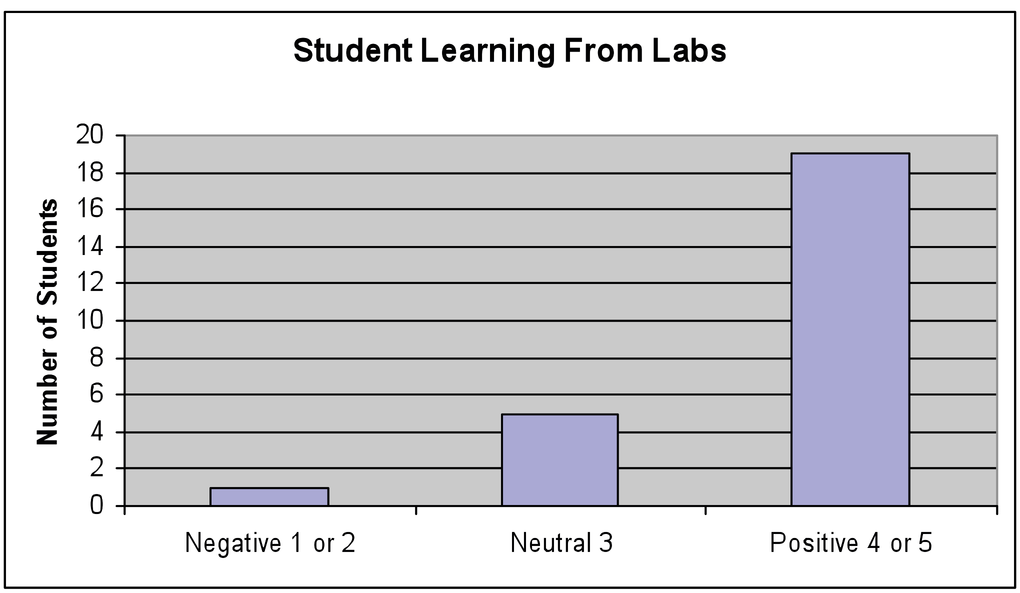


Figure 6. Student Learning from Labs

Students were not as positive about their lab conclusions. On question 4, "How much do you enjoy writing conclusions for the labs?" the mean answer was 2.08 out of 5. Eighteen students had negative responses, five students had neutral responses, and two students had positive responses (Figure 7)

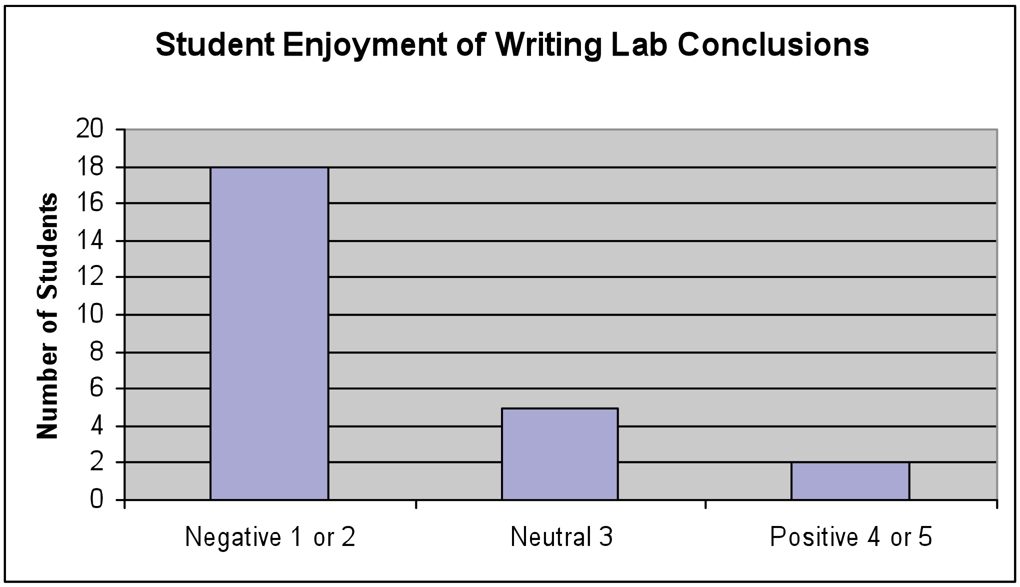


Figure 7. Student Enjoyment of Writing Lab Conclusions

Students had more mixed responses about the learning from writing the lab conclusions. On question 6, "How much do you think you learn from writing the lab conclusions?" the mean answer was 2.72 out of 5. Eight students had negative responses, eleven students had neutral responses, and six students had positive responses (Figure 8).

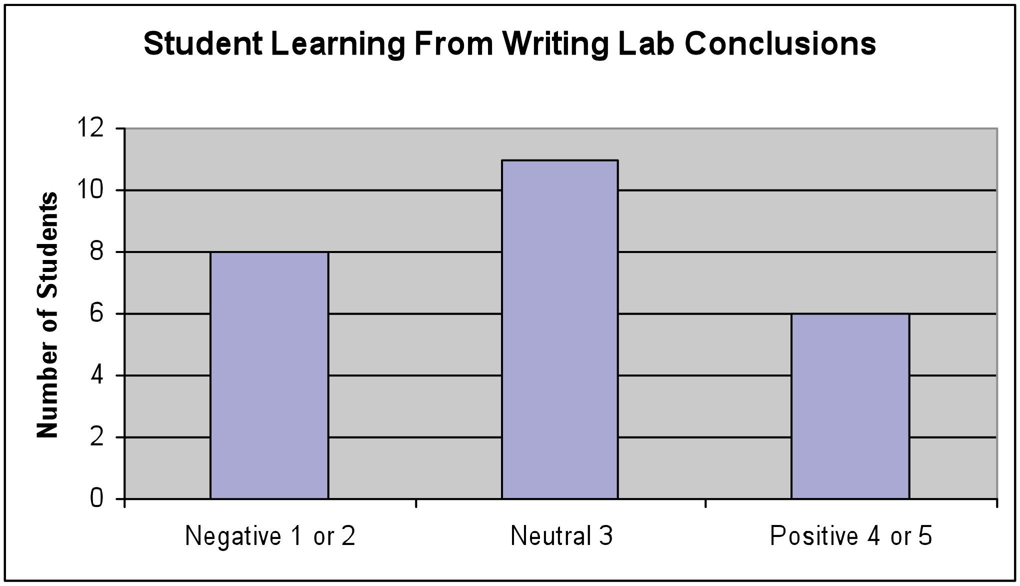


Figure 8. Student Learning from Writing Lab Conclusions

This data showed me that while most students enjoy and feel that they learn a lot from doing the lab, this does not carry over to writing the lab conclusions. Through my intervention, I hope to make conclusion writing a process that students can use as a learning tool to assist themselves in processing the data and knowledge they have gained by conducting the lab.

Relevant Research Literature

Academic and practitioner journals reporting educational research also informed my study. According to Yore (2004), increasing the quality of science writing could be very valuable for my students. In this study, scientists state that writing in science can lead to discovery and clarify areas that are less well understood for them. Yore also found that scientists did science writing in much the same way that they wrote when not writing about science. This provides some justification for my attempt to improve students' science writing. Since scientists believe that writing about science can lead to discovery and learning, then my students will hopefully increase their learning by improving their conclusion writing and results summaries. My students are struggling with both writing and discovering concepts so my intervention was an attempt to work on both of these issues.

Keys (1999) and Giannattasio (2005) showed that working to improve conclusion writing is a common struggle for students of all types. They report that it was an improvable skill and one that could lead to increased understanding. Giannattasio described a group peer-edit of a sample conclusion to teach students what to look for in a good conclusion on which I based the design of my intervention. The activity is a sample lab report that students read through and underline parts of the report that show conclusions, parts that show inferences, and parts that show predictions. This was adapted for my students as a conclusion that is written that shows appropriate result summaries, problem question answers, evidence for those answers, and possible sources of error or improvements. On this sample conclusion, it was important to show what each sentence addresses, just like it did in Giannattasio's activity. Keys was really effective in citing specific student work and quotes from the same students from before and after the intervention. By being able to read student work before and after the intervention, it was clearer how the conclusions improved. I used this same strategy of showing quotes from one student when analyzing my observational and achievement data.

Diaz (2004) confirmed that peer-editing is an effective strategy to improve conclusion writing as it makes students more aware of what is expected of them as they are required to interact with the rubric and find errors in another's work. Diaz only had students peer-edit once, but found it to be very useful as it made students really read the rubric they were using and thus came to a better understanding of what was expected of them. In their future lab reports, they were more aware of what was expected. This source informed my study by giving me justification to pursue peer editing as it seems to be effective in other classrooms. I similarly planned my intervention around using a rubric to peer-edit and have students compare the lab conclusions of their peers against the rubric being used. I adopted the idea of peer-editing for my intervention in the hope that students would both understand what is required of them and, by writing a complete conclusion, would do better in analyzing the data they have collected in the lab.

Bittel and Hernandez (2006) suggested a strategy that was very effective for English learners as well as mainstream students. In this intervention, students made a flipbook and wrote each part of the conclusion on a different page. Students used sentence starters to assist themselves getting started with the conclusions. This article gave me the idea that it would be useful to break the conclusion down into smaller pieces so students do not get overwhelmed by it. This strategy of breaking down the conclusion into parts would be helpful for English learners and would also be beneficial to all of my students who are fluent in English. It influenced how I constructed my rubric by parts to make things easier for my students to work on.

Finally, Merino and Scarcella (2005) gave me ideas about how to make the intervention accessible and useful to English learners by increasing both their content knowledge and their science literacy skills by combining the two of them. This article was mostly theoretical, but it advised integrating content and literacy to improve achievement in both. The article informed my study by telling me that working on writing and literacy in science among English learners is important. It also made me realize that using data-based labs would be beneficial as it would let students use data to discover new ideas and then write a conclusion using that data to support their idea thus improving their literacy and their content knowledge.

Research Question and Sub-Questions

The relevant research literature suggested that improving writing in science was valuable and peer editing could be a good way to improve that conclusion writing. My preliminary data showed me that my students were struggling with their conclusion writing and were not doing a good job letting the evidence they collected lead them to the appropriate conclusion. The combination of the relevant research literature and my preliminary data led me to the following research question:

How does peer editing of lab conclusions affect students' ability to come to logical conclusions using data?

I also asked these sub-questions:

- How does peer editing of lab conclusions affect students' conclusion writing ability?
- How does peer editing of lab conclusions affect students' attitude towards writing conclusions and data analysis?

Timeline of Instructional Intervention

Table 1. Timeline for the Intervention

WHAT	WHEN
Actions taken for the intervention	**Timeline**
Conduct Continental Drift Lab, write pre-intervention conclusions	Friday, Oct. 12, 2007
Collect pre-intervention attitude survey data	Friday, Nov. 2, 2007
Conduct direct instruction on peer editing and peer edit sample conclusion as a class	Tuesday, Nov. 6, 2007
Conduct Mineral Lab, write first draft conclusions (Observational notes)	Tuesday, Nov. 6, 2007
Peer-edit Mineral Lab conclusions, write final drafts (Observational notes)	Wednesday, Nov. 7, 2007
Conduct Rock Identification lab, write first draft conclusions (Observational notes)	Tuesday, Nov. 13, 2007
Peer-edit Rock Identification Lab conclusions, write final drafts (Observational notes)	Wednesday, Nov. 14, 2007
Conduct Carbon Cycle Lab	Wednesday, Nov. 28, 2007
Write first draft conclusions for Carbon Cycle Lab, peer-edit conclusions, write final drafts (Observational notes)	Thursday, Nov. 29, 2007
Conduct Oxygen in the Atmosphere Lab, write post-intervention conclusions	Wednesday, Dec. 12, 2007
Collect post-intervention attitude survey data	Thursday, Dec. 13, 2007

Description of Instructional Intervention

My intervention was designed to assist students with their ability to come to logical conclusions from looking at data from laboratory exercises. I expected in this intervention to see student conclusion scores rise and attitudes of students towards conclusion writing become more negative. I first gave students the rubric I used to grade their conclusions (Table 2). This rubric focuses heavily on what evidence from the data they are using and what overall conclusions this evidence leads them to. Then, students were given direct instruction on how to appropriately peer-edit each other's conclusions and were shown the importance of isolating each facet of the conclusion. To assist students with this, they looked at a sample conclusion and peer-edited it as a class, as was done in Giannattasio (2005).

Table 2. Rubric for scoring conclusions

CATEGORY	**0**	**1**	**2**	**3**
Evidence for answer to problem question	No Evidence given for answer to problem question	Writer mentions what they did in the lab	Writer mentions what they did in the lab and what data this led to.	Writer mentions what they did in the lab, what data this led to, and then connects data to their answer to the problem question.
Answer to Problem Question	No answer to problem question given	Writer answers another question, but not the problem question	Writer answers problem question incorrectly based on data	Writer comes to correct answer for problem question based on the data they gathered and the evidence they gave.
Hypothesis analysis	Hypothesis not mentioned	Writer states whether hypothesis was right or wrong.	Writer restates hypothesis and whether it was correct or not. "My hypothesis was ________ and it was right/wrong"	Writer restates hypothesis, states whether it was correct or not and states WHY it was correct or incorrect. "I had expected ________ to happen and I was correct/but I was incorrect because ________."
Experimental error	No experimental error mentioned	Claim that there was no experimental error	Writer mentions one thing that they did wrong or one thing wrong with the experiment	Writer mentions something they did wrong AND two or more things that are wrong with the design of the experiment.

The direct instruction component of the intervention began with handing out the rubric to all students at the beginning of class on November 6, 2007. I also handed out a conclusion that I had written for a lab the students conducted the week before. The students were told that in an effort to improve both their writing skills and the amount of knowledge they gain from doing labs, we would be focusing on improving their conclusion writing for the next month. They were told that in order to do this, we would be editing each other's work to make it as good as possible. Students were also told that they would be graded both on the quality of their conclusions, and on the quality of the written feedback that they gave to their fellow students through the process of editing. The sample conclusion was then put on the overhead, and as a class, we identified the evidence given for the answer to the problem question. We circled this part of the conclusion using a colored pencil and then scored it using the rubric on a scale of zero to three. We wrote this score next to the circled text. Students also wrote comments about how the writer could improve this aspect of the conclusion. This process was repeated for the answer to the problem question, the analysis of the hypothesis, and the discussion of experimental error. We then added the individual aspect scores to determine one total score for this conclusion. Students were told that this is the process that they would be doing every time they peer-edit a conclusion. The text of the sample conclusion I used (scored Evidence: 3/3, Problem question: 3/3, Hypothesis: 2/3, Error: 2/3, Total 10/12) is below:

> **Problem:** How does the viscosity (thickness) of a liquid affect how high it will pile up?
> **Hypothesis:** If we create two "volcanoes" of equal volume using ketchup and tomato paste, then I expect that viscosity will have no effect on how high it piles up.
> **Conclusion:** In this lab, we made two volcanoes using ketchup for one, and tomato paste for the other. We then measured the height of the volcanoes and took observations for both volcanoes. I found that the volcano with higher viscosity (tomato paste) had a height of 11 mm and looked clumpy and kind of like bird poop. The volcano with lower viscosity (ketchup) had a height of 5 mm and spread out really wide. It also had a depression/crater in the middle. This data showed me that the higher viscosity liquid piled up higher. The higher the viscosity of a liquid, the higher it will pile up and the lower the viscosity, the less high it will pile up. I had expected that the viscosity of the liquid would have no

> effect on how high it piled up, but I was wrong. It did have an effect. This lab may have been negatively affected because I accidentally put more ketchup in the volcano than the tomato paste volcano. This could mean that my height for the ketchup is a bit too high.

The next day, we conducted the Mineral Lab and students wrote a full conclusion for the lab. Students were allowed to use the rubric while writing their conclusion, although I did not require it. Students exchanged their labs with another student and each edited and scored the labs using the rubric in class that day. Students were reminded of the practice we did and the expectations for their editing. Students were required to circle the different aspects of the conclusion in different colors and grade each aspect separately. Unfortunately, very few students actually did circle the different aspects in different colors, choosing instead to do everything in pen or pencil. Some students did choose to take advantage of this visual learning technique, but most did not. They were also required to give ideas about how the writer could improve each aspect of the conclusion. Students exchanged labs back to the original writer the next day and were asked to rewrite their conclusion in class. For the first lab of the intervention, I asked every student to rewrite their conclusion based on the corrections made by their peer-editor, even if they got a perfect score. I noticed, however that those students who got a perfect 12 out of 12 from their peer-editor just chose not to rewrite the conclusions anyway. For the Rock Identification Lab, I told students that if they scored perfectly on their first draft that they did not have to write a second draft which led to almost all students choosing not to write a second draft, regardless of how they actually did on their first draft. For the Carbon Cycle Lab, I tried to address this issue of a lack of final drafts being written by requiring all students to rewrite their conclusion regardless of how well they did on the first draft in order to receive the points for the lab. This worked pretty well. While I still had seven students not rewrite it, four of them were absent for the peer-editing part of the lab so the lack of a rewrite was unavoidable. I then analyzed the students' initial conclusions, and the final draft conclusions. Each conclusion was scored using the rubric. This peer editing process was conducted for three different labs to ensure that the data is consistent for many different types of data and content areas within Earth Science (Table 3).

Table 3. Problem questions for labs during the intervention process

Conclusions that correspond with this lab (number of conclusion)	**Problem Question**
Pre-intervention Continental Drift Lab (1)	Why do we see the same fossils and the same types of rocks on opposite sides of the ocean?
During the intervention Mineral Lab (2, 3) Rock Identification Lab (4, 5) Carbon Cycle Lab (6, 7)	Are the following things minerals: graphite, zinc, ice, plastic, sugar, rubbing alcohol? What types of rocks will we observe? How many of each will there be? What effect do light and plants have on the amount of carbon dioxide (CO2) in the atmosphere?
Post-intervention Oxygen in the Atmosphere Lab (8)	What percentage of the Earth's atmosphere is oxygen?

At the end of the intervention, students chose one initial conclusion and one final conclusion to show their parents the change in their conclusion-writing ability. Students also showed their parents their scores on all five conclusions they had written so parents could see how much improvement they made during each stage of the intervention. Finally, I called the parents of five students who had made really significant improvements in their conclusions to let them know what great progress their students were showing and give them some positive feedback.

While I did not have any English Learners in my class, this intervention was especially designed for English Learners and diverse learners because English learners and IEP students usually have the most trouble identifying what the evidence is and what conclusion it would lead them to. This was also a very effective intervention for English learners because it led to an increase in both science content knowledge and literacy skills in reading and writing about science. English-learning students usually have a difficult time expressing their ideas about what the evidence is showing so the process of editing their thoughts would hopefully help them to clarify exactly what they saw and what it led them to conclude.

Results of the Intervention

Pre and Post-Intervention Achievement Data

I wanted to analyze the conclusions that the students wrote before, during, and after the intervention to see how their logical conclusion formation and conclusion writing had changed through the intervention. The conclusions written before and after the intervention were written after completing the lab procedures and with no other instructions from the teacher than to try their best and include all of the parts necessary for a good conclusion. The conclusions during the intervention were written as a first draft and then re-written after revisions as a final draft. The first draft students wrote of a conclusion was after completing the lab procedures and I urged students to use the rubric to make sure they included all necessary pieces of a conclusion although I did not require it. The final draft students wrote of a conclusion for the intervention labs was after exchanging papers with another student and undergoing the peer editing and scoring process. Students were encouraged to incorporate any suggested changes and improve pieces of the conclusions that did not receive perfect scores from their partner. I additionally told the editors to be as harsh as possible in their grading as it would allow for more improvement by the writer and thus lead to a higher score on the writer's final draft that I would be grading.

The pre-intervention conclusion for a lab on continental drift was written in class on October 12, 2007. The conclusion for the first intervention lab on the topic of identifying whether objects were minerals or not was written on November 6, 2007 and then rewritten on November 7, 2007. The conclusion for the second intervention lab on the topic of identifying whether rocks are igneous, metamorphic, or sedimentary was written on November 13, 2007 and then rewritten on November 14, 2007. The conclusion for the third intervention lab on the topic of what influence photosynthesis has on the amount of carbon is in the atmosphere was written and rewritten on November 29, 2007. Finally, the post-intervention conclusion on the topic of the percent of oxygen in the atmosphere was written on December 12, 2007 (see Timeline, p. 18). The pre-intervention and post-intervention conclusions were written only once and not peer-edited.

All students in class were asked to write every conclusion. For the first and second intervention conclusions, if students had been told by their editor that they had scored a perfect score, they were not required to rewrite their conclusion, however for the third intervention conclusion, all students were required to rewrite their conclusion regardless of their projected score on their first draft. This change was made because too many students were electing not to rewrite their conclusions after peer-editing.

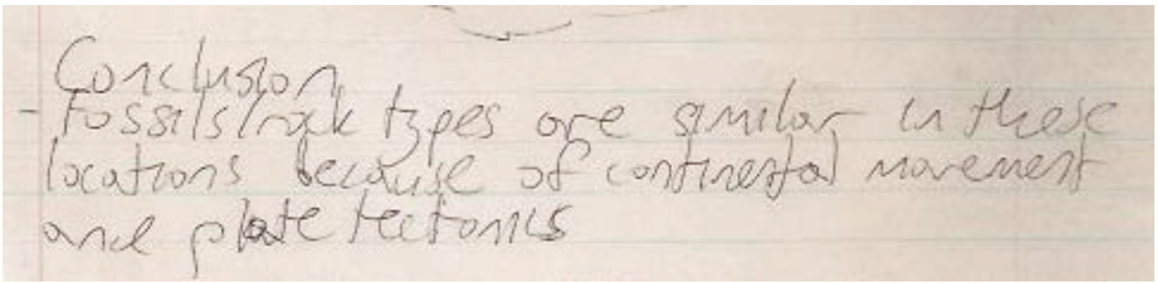
Students' conclusions were scored in four categories: (1) evidence for the answer to the problem question, (2) the answer to the problem question, (3) the analysis of the students' hypothesis, and (4) any experimental error that may have occurred. Each section was scored out of three possible points for a total score out of 12 possible points. Scores were analyzed as a total score and as scores on individual rubric elements (see rubric, Table 2). The mean was calculated for the whole class for each conclusion and for subgroups of students who started the intervention with different overall grades in the class. The grade subgroups were based on the students' grades as the intervention began and were separated into A students (90-100%), B students (80-89%), C students (70-79%), and D students (60-69%). There were no students with overall grades below 60%. The students' overall grade was determined by test scores, class work, and homework that were all completed before the intervention. There were five students in the A group, twelve in the B group, eight in the C group, and two in the D group. I also analyzed the overall score distribution for the pre-intervention and post-intervention conclusions so I could compare overall class achievement and individual achievement in both conclusions to each other. I had initially intended to analyze the subgroup of former English language learners and compare them to students who were English only speakers from birth, but I found no significant difference in their scores so I decided not to analyze these students as a subgroup.

During the intervention, and in my discussion of it below, conclusion number 1 is the pre-intervention conclusion on continental drift. Twenty four out of 27 students turned in this conclusion. Conclusion numbers 2 and 3 were the first and final drafts for the first intervention conclusion on the subject of identifying whether objects were minerals or not. Twenty seven out of 27 and 15 out of 27 students turned in these conclusions respectively. Conclusion numbers 4 and 5 are the first and final drafts for the second intervention conclusion on the subject of identifying whether rocks are igneous, metamorphic, or sedimentary. Twenty-four out of 27 and five out of 27 students turned in these conclusions respectively. Conclusion numbers 6 and 7 are the first and final drafts for the third intervention on the subject of what influence photosynthesis has on the amount of carbon in the atmosphere. Twenty-four out of 27 and 17 out of 27 students turned in these conclusions respectively. Conclusion number 8 is the post-intervention conclusion on the subject of the percent of oxygen in the atmosphere. Twenty-four out of 27 students turned in this conclusion (Table 4).

Table 4. Conclusions and number of students completing them

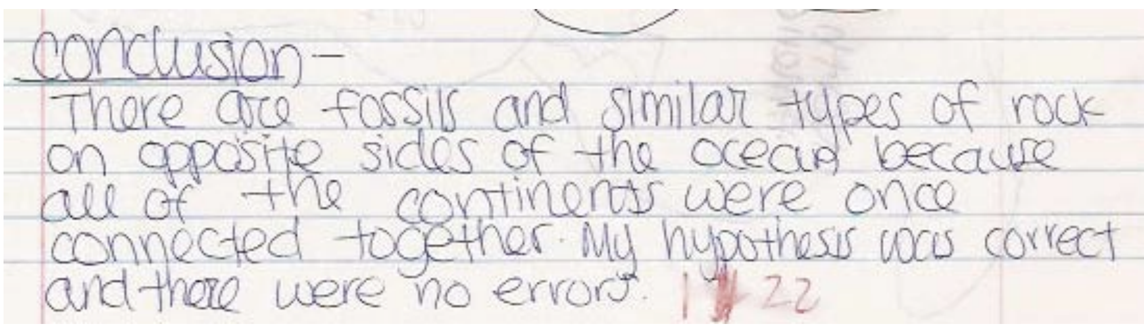
Stage	Conclusion Number	Conclusion Topic	Number of Students Completing the Conclusion (Out of 27)
Pre-intervention	1	Continental Drift Lab	24
During the intervention	2 3 4 5 6 7	Mineral Lab First Draft Mineral Lab Final Draft Rock Identification Lab First Draft Rock Identification Lab Final Draft Carbon Cycle Lab First Draft Carbon Cycle Lab Final Draft	27 15 24 5 24 17
Post-intervention	8	Percent of Oxygen in the Atmosphere Lab	24

Initially, in the pre-intervention conclusion from the continental drift lab, most students' conclusions were very terse and only one or two sentences. Many of the conclusions answered only the problem question and completely ignored the other aspects (Figure 9). Those conclusions that did address each aspect generally did not do so thoroughly (Figure 10). Twenty out of 24 conclusions scored 3 out of 3 on the answer to the problem question by correctly answering the problem question, but only one student scored 3 out of 3 on any other aspect of the conclusion. The high score on the conclusion for the class was eight out of 12 and the low score was two out of 12.



Conclusion
- Fossils/rock types are similar in these locations because of continental movement and plate tectonics

Figure 9. Pre-intervention conclusion answering only the problem question; Evidence: 0/3, Problem question: 3/3, Hypothesis: 0/3, Error: 0/3, Total 3/12



Conclusion-
There are fossils and similar types of rock on opposite sides of the ocean because all of the continents were once connected together. My hypothesis was correct and there were no errors.

Figure 10. Pre-intervention conclusion addressing hypothesis and error briefly; Evidence: 0/3, Problem question: 3/3, Hypothesis: 1/3, Error: 1/3, Total 5/12

I found that initially, before the intervention, students on average did very well at answering the problem question (2.83 out of 3), but very poorly at listing the evidence for their answer to the problem question (0.63 out of 3), analyzing their hypothesis (0.42 out of 3), and stating experimental error (0.71 out of 3) (Figure 11). These scores were pretty low and showed that although students were coming to good conclusions, they had lots of room for improvement in justifying those conclusions and discussing their hypotheses and experimental error. Before the intervention, students could accurately identify the one main point of the lab, but they could not or did not take the time to justify how they came to this one main point, or discuss it in any further depth. This relates to my research question as it shows that students demonstrated poor ability to give evidence for their conclusion although they are good at actually coming to a conclusion.

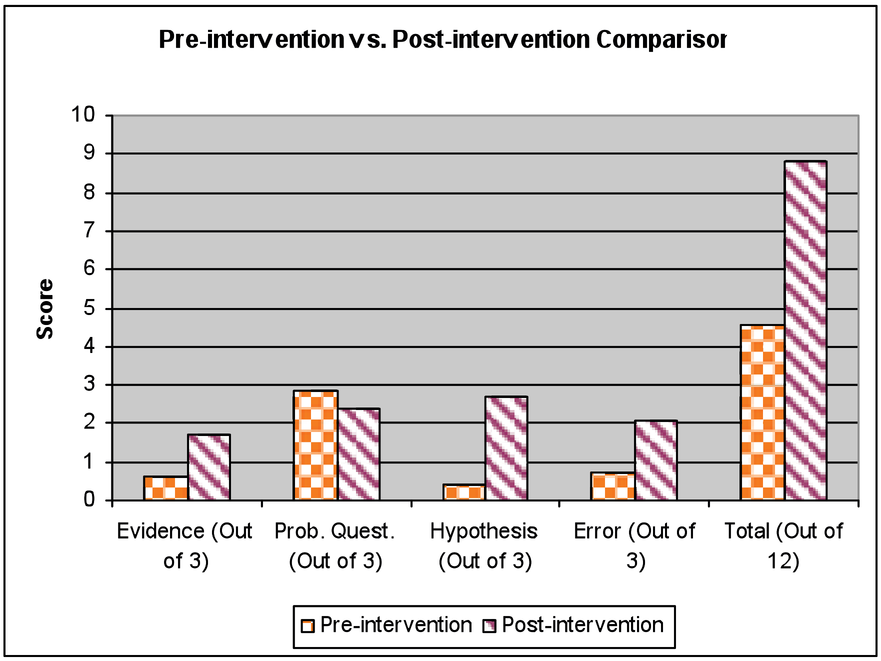


Figure 11. Non-peer-edited Pre-intervention Continental Drift Lab vs. Post-intervention Oxygen in Atmosphere Lab conclusion score comparison

Overall, there were big changes in student conclusions over the course of the entire intervention. After the intervention was complete, the analysis showed a significant increase from pre-intervention conclusions to post-intervention conclusions (Figure 11). In terms of overall scores, the average class score increased from 4.58 to 8.83 out of 12. This is nearly a doubling of the score and shows that while content knowledge remained relatively constant, ability to logically explain reason for coming to this knowledge increased substantially over the course of the intervention and was maintained after the intervention finished. An increase was seen in every category students were expected to cover except for their answer to the problem question, which is initially counter-intuitive due to their initial success at answering the problem question in the pre-intervention lab. This may be partially because of a difference in the pre-intervention and post-intervention labs. Students appeared confused in the post-intervention lab because the data they gathered did not necessarily correspond to their prior knowledge about the subject. In the post-intervention lab, students were asked to find the percent of oxygen in the atmosphere and while we had talked about the percentage being 21 percent, student results varied from 21 percent to 32 percent. I observed that some students therefore tried to fake their data to ensure that they arrived at the perfect 21 percent which caused some students to lose points on their answer to the problem question. It may also be because the pre-intervention scores on the answer to the problem question were so high because students had a lot of background knowledge on the topic of continental drift.

The increase in conclusion scores was seen in every student in the class with no students receiving a lower overall score on the post-intervention conclusion than they had received on the pre-intervention conclusion. The range of scores in the class stayed pretty similar between the pre-intervention conclusion and the post-intervention conclusion, but all of the scores shifted up by four points. Additionally, in the pre-intervention conclusion, the scores were skewed towards the lower end of the range, while in the post-intervention conclusion the scores looked more like a normal curve with a median and mode of 9 out of 12. In the pre-intervention conclusion, scores ranged from 2 to 8 out of 12, while in the post-intervention conclusion, scores ranged from 5 to 12 out of 12 (Figure 12, Figure 13). This relates to my research question because it shows that the peer-editing intervention led to an increase across the board by all students in their ability to write a good conclusion and to come to a logical conclusion using data gathered in the lab.

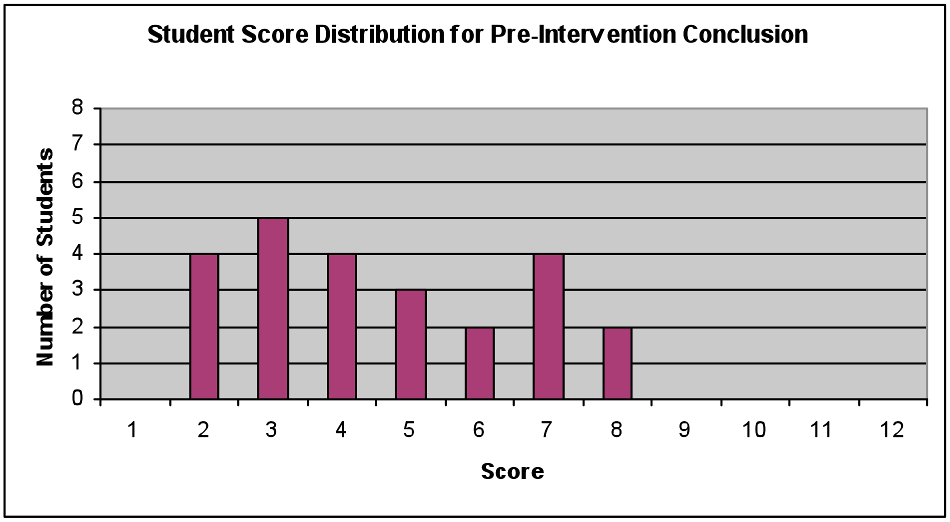


Figure 12. Student Score Distribution for Pre-intervention Conclusion

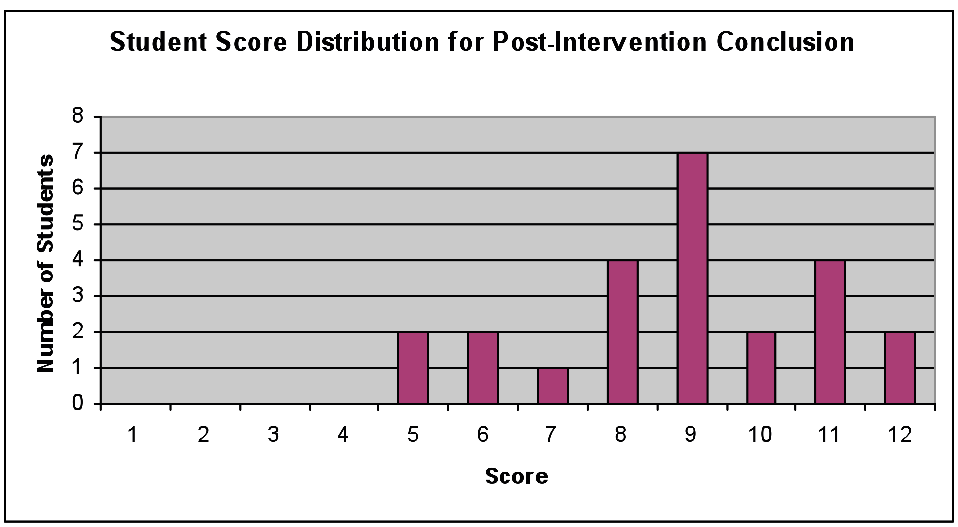


Figure 13. Student Score Distribution for Pre-intervention Conclusion

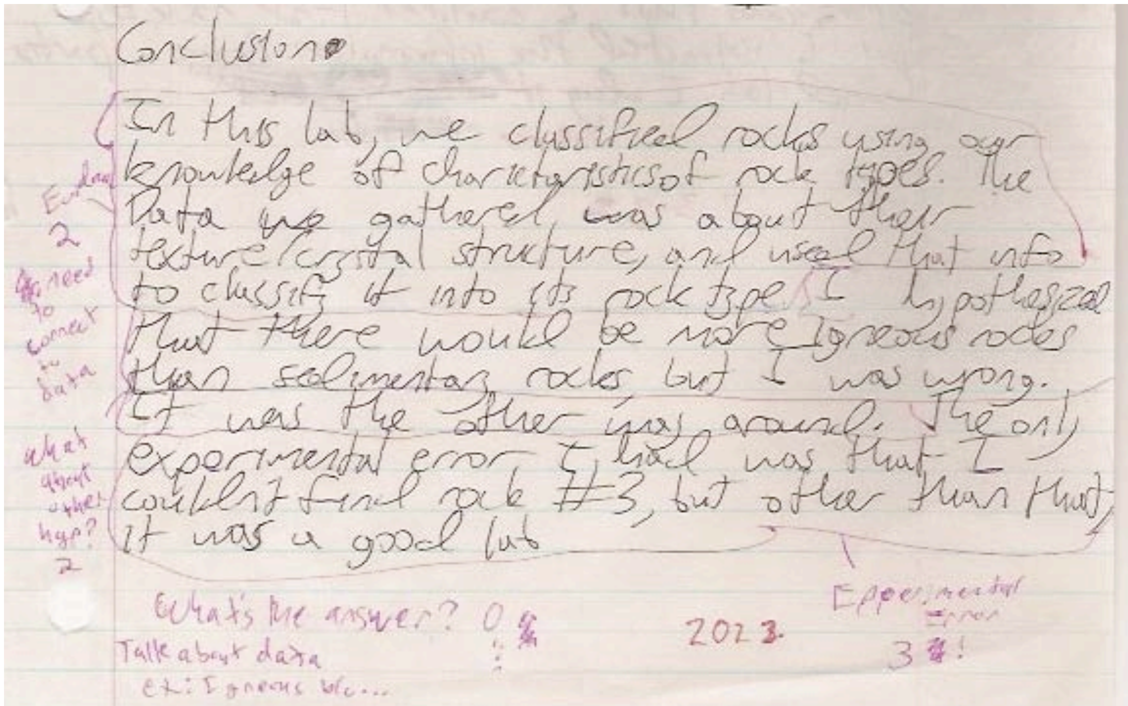
During Intervention Achievement Data

Significant progress was also seen in the scores throughout the intervention as well. For each lab that was conducted, the conclusion written after the peer editing process had an average score that was about one point higher than the first draft score. While one point does not seem extremely significant, it is significant that there was never a conclusion written after the peer-editing process that went down in score (Table 5). Every conclusion score after the peer-editing improved or stayed the same.

Table 5. Change in scores between first and final drafts as a result of peer-editing over the entire intervention (all three labs)

Change in total conclusion scores from first draft to final draft	Number of Conclusions
Increase	18
No Change	19
Decrease	0

For example, below is a sample first draft (Figure 14) and final draft conclusion (Figure 15) for the Rock Identification Lab (conclusions 4 and 5). The student initially scores six out of 12, then after peer editing, the score is raised to 10 out of 12.



Conclusion

In this lab, we classified rocks using our knowledge of characteristics of rock types. The Data we gathered was about their texture/crystal structure, and used that info to classify it into its rock type. I hypothesized that there would be more Igneous rocks than sedimentary rocks, but I was wrong. It was the other way around. The only experimental error I had was that I couldn't find rock #3, but other than that, it was a good lab

Evidence 2

need to connect to data

what about other hyp? 2

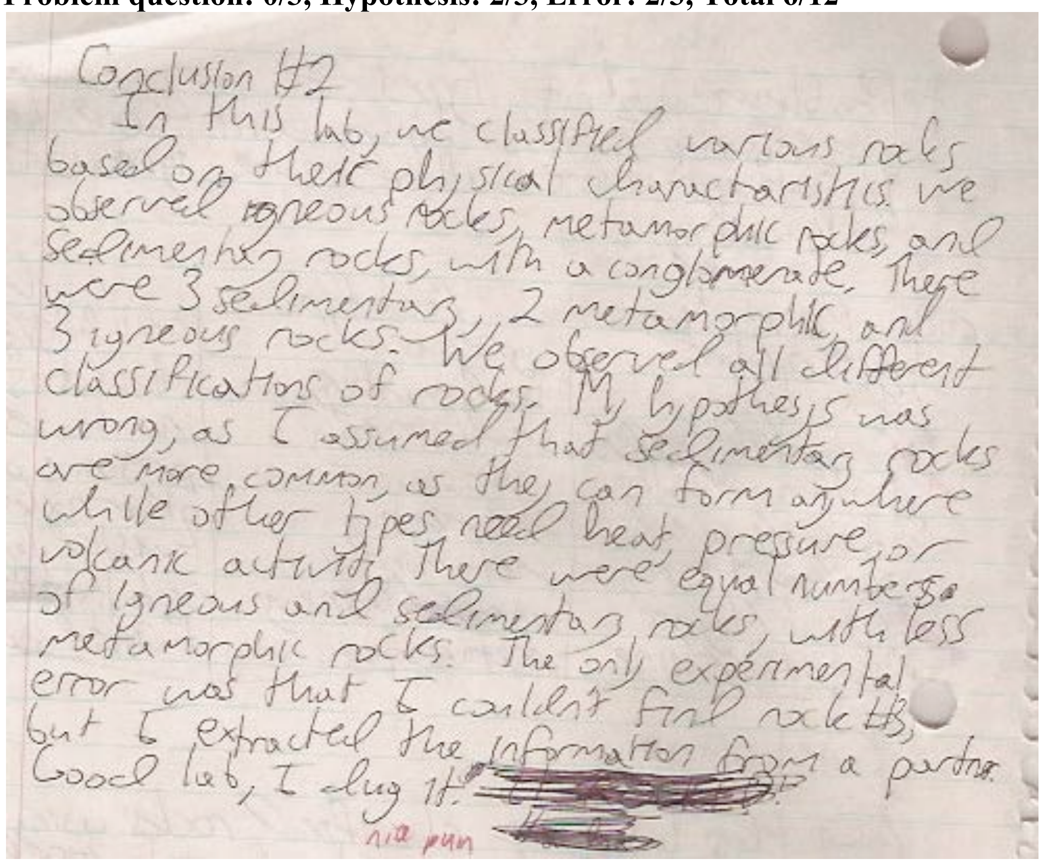
What's the answer? 0

Talk about data ex: Igneous were...

2023

Experimental error 3!

Figure 14. Example first draft conclusion with peer editing marks on it; Evidence: 2/3, Problem question: 0/3, Hypothesis: 2/3, Error: 2/3, Total 6/12



Conclusion #2

In this lab, we classified various rocks based on their physical characteristics. We observed igneous rocks, metamorphic rocks, and sedimentary rocks, with a conglomerate. There were 3 sedimentary, 2 metamorphic, and 3 igneous rocks. We observed all different classifications of rocks. My hypothesis was wrong, as I assumed that sedimentary rocks are more common, as they can form anywhere while other types need heat, pressure, or volcanic activity. There were equal numbers of igneous and sedimentary rocks, with less metamorphic rocks. The only experimental error was that I couldn't find rock #3, but I extracted the information from a partner. Good lab, I dug it.

nice pun

Figure 15. Example final draft conclusion after the peer editing comments have been taken into consideration; Evidence: 2/3, Problem question: 3/3, Hypothesis: 3/3, Error: 2/3, Total 10/12

The first draft average scores were very similar with average scores of 9.15, 8.88, and 8.75 points out of 12 for the Mineral Lab, Rock Identification Lab, and Carbon Cycle Lab respectively. The final draft average scores were also very similar with average scores of 10, 10.4, and 10 out of 12 for the Mineral Lab, Rock Identification Lab, and Carbon Cycle Lab respectively. For each intervention lab, the peer-edited final draft scores were higher than the first draft scores. The post-intervention conclusion class average score was closer to the first draft scores as the post-intervention class average score was 8.83 out of 12 while the pre-intervention class average score was substantially below any of the intervention class average scores at 4.48 out of 12 (Figure 16).

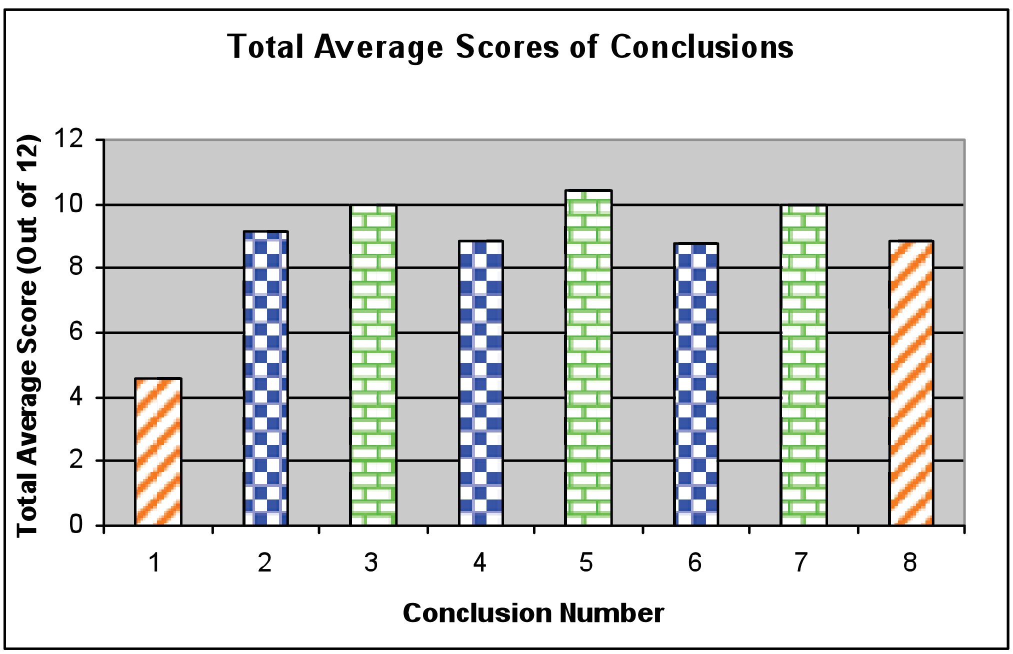


Figure 16. Total average scores of conclusions throughout the intervention (note: diagonal stripe pattern is non-peer-edited pre- and post-intervention conclusions, checkered pattern is first drafts of intervention conclusions, and brick pattern is final drafts of intervention conclusions)

The increase in conclusion scores after peer editing and the maintenance of this increase for each lab was likely the result of two factors. The first factor is that students were receiving feedback on their writing so that students could fix any errors they had made and improve their score immediately. The second factor is that by giving feedback, the editors were training themselves to find errors, so as they worked on their own writing they could find similar errors that they would have made and correct them for future labs. This second factor is much more difficult to measure, but based on student comments and questions throughout the intervention, I believe students were gaining proficiency through both getting their work edited and editing other students' work.

I also analyzed what percent of students were demonstrating proficiency for each conclusion by scoring a total score of 9 or higher (Figure 17), because the percent of proficient students varied much more between labs than the average score did. I chose 9 out of 12 as a level of proficiency because it meant that students were writing at least one section at the maximum three level and the other sections at least at a satisfactory two level or higher. Nine out of 12 is also 75 percent success which I felt was an acceptable rate for proficiency. For the pre-intervention conclusion, there were no students who achieved proficiency. For the post-intervention conclusion, 63 percent of students achieved proficiency. For the intervention conclusions, peer editing helped many students achieve proficiency as the percent of proficiency increased for each lab after the peer-editing process.

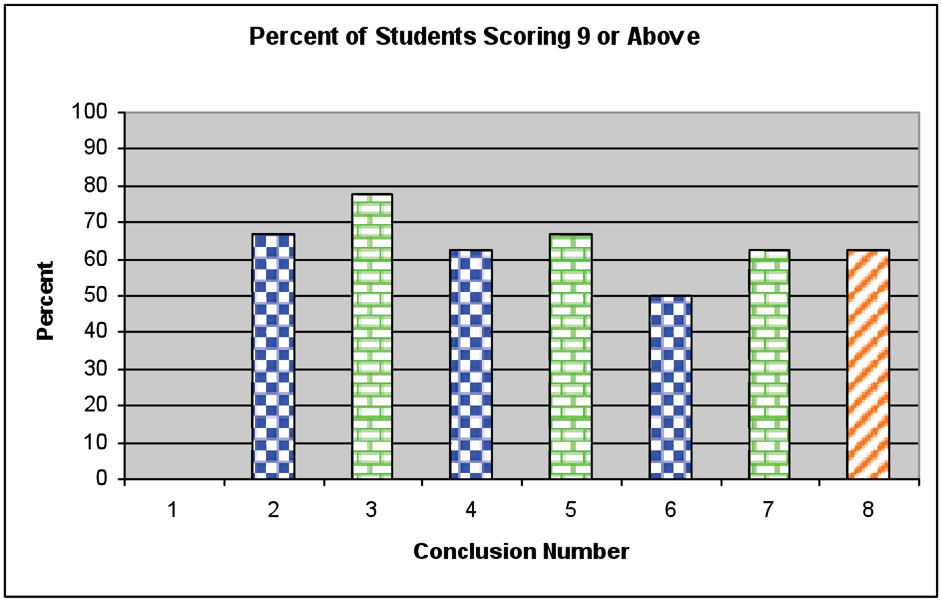


Figure 17. Percent of students proving proficiency by scoring 9 or above on each lab (note: diagonal stripe pattern is non-peer-edited pre- and post-intervention conclusions, checkered pattern is first drafts of intervention conclusions, and brick pattern is final drafts of intervention conclusions)

The proficiency scores were based on the percent of students who scored 9 or above on either their first draft, their edited final draft, or both. The percent of proficient students is not as high as it could have been for the final drafts because many students did not rewrite their conclusions after peer editing. This is especially true for conclusion number 5 since only 5 students rewrote their conclusions and only 1 of those students was not proficient before rewriting it. After the Rock Identification Lab, when so few students were rewriting their conclusions, I made rewriting absolutely mandatory, regardless of how good the first draft was. Thus, the numbers for conclusions 6 and 7 are more inclusive as almost all students rewrote their conclusions for that lab. That lab was, however, a more difficult lab for students to interpret so their conclusions were slightly lower and some students also did not put their full effort into their first draft. Since students knew that they were required to write a final draft, they only wrote a sentence or two for their first draft (Figure 18), took the low score, then “rewrote” their conclusion actually trying so they did not have to do so much work (Figure 19)

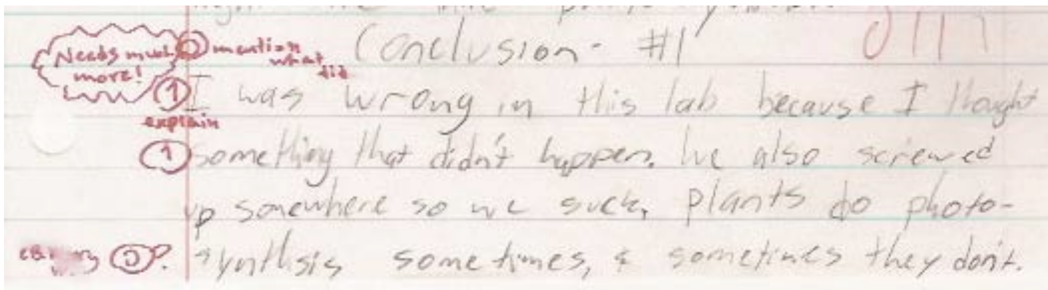
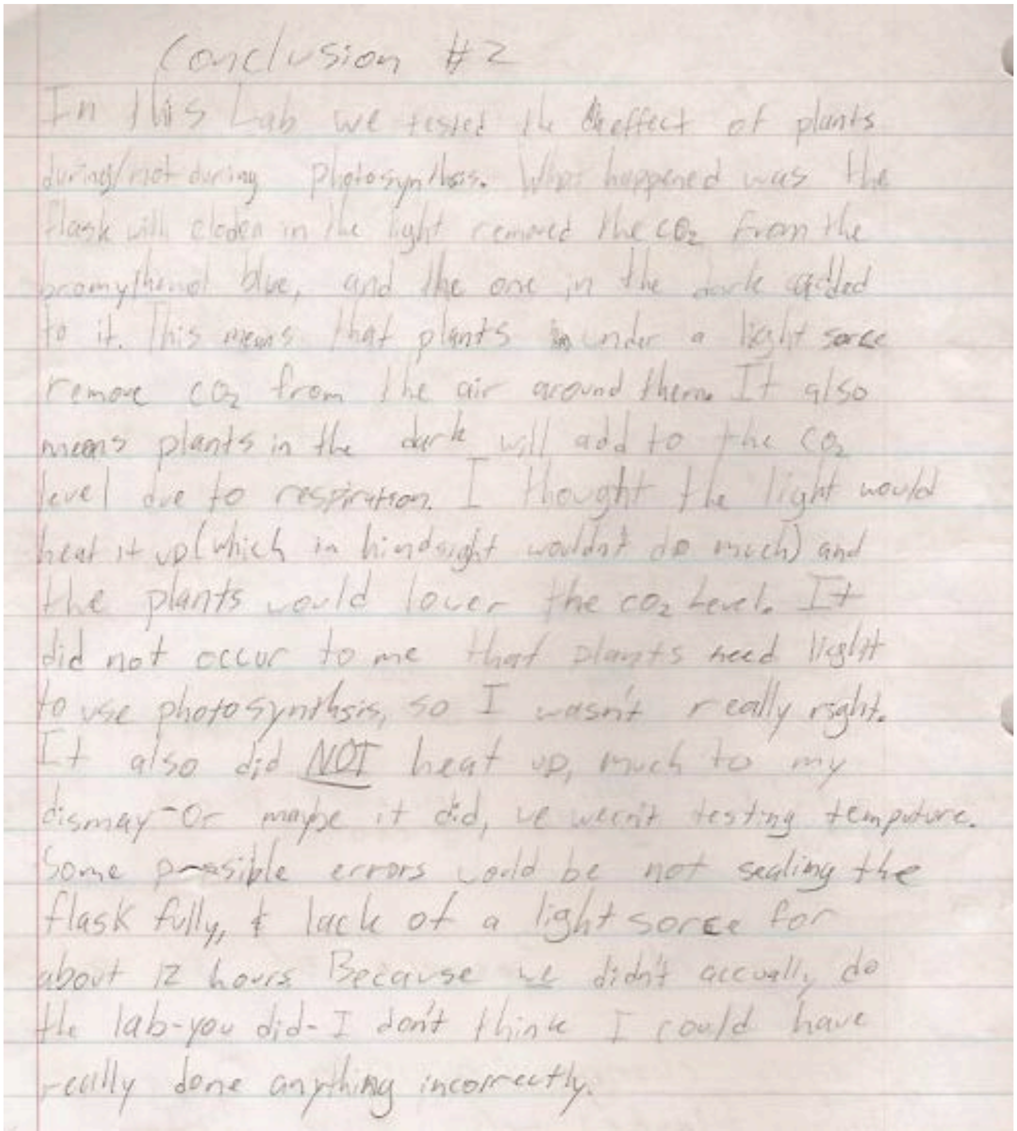


Figure 18. Example of initial conclusion written by a student who did not try; Evidence: 0/3, Problem question: 1/3, Hypothesis: 1/3, Error: 1/3, Total 3/12



Conclusion #2

In this Lab we tested the effect of plants during/not during photosynthesis. What happened was the flask with elodea in the light removed the CO_2 from the bromythenol blue, and the one in the dark added to it. This means that plants under a light sorce remove CO_2 from the air around them. It also means plants in the dark will add to the CO_2 level due to respiration. I thought the light would heat it up (which in hindsight wouldn't do much) and the plants would lower the CO_2 level. It did not occur to me that plants need light to use photosynthesis, so I wasn't really right. It also did NOT heat up, much to my dismay - Or maybe it did, we weren't testing tempature. Some possible errors would be not sealing the flask fully, & lack of a light sorce for about 12 hours. Because we didn't accually do the lab - you did - I don't think I could have really done anything incorrectly.

Figure 19. Example of second draft of student who did not initially try; Evidence: 3/3, Problem question: 3/3, Hypothesis: 3/3, Error: 3/3, Total 12/12

I wanted to see whether the peer-editing process was having a greater impact on my low-performing or high-performing students so average conclusion scores were also broken down into subgroups based on the grade students were earning in the class at the time the intervention started (Figure 20). Initially, in conclusions 1 through 4, there was a total score breakdown that correlated very well with the overall grades students were earning in the class. The A students were performing the highest with B, C, and D students trailing at regular intervals. However, in conclusions 5 through 8, the achievement gap narrowed and the scores began to become much more even. There was still a slight difference, but the average group scores did not have such great differences between them. The reason some conclusions have no data for certain grade groups is because no members of those groups turned in that particular conclusion (Figure 20). This occurs especially in the D group because there are only two students in that group and those students often do not turn in work or are absent. This comparison between groups of students with different grades corresponds with my research question as it shows that the peer-editing and rubric intervention was successful in reducing the achievement gap in student ability to make logical conclusions from the data. I believe this pattern is seen because low achieving students had the expectations made more clear to them during the intervention and the peer editing gives them an opportunity to correct their mistakes and learn from them.

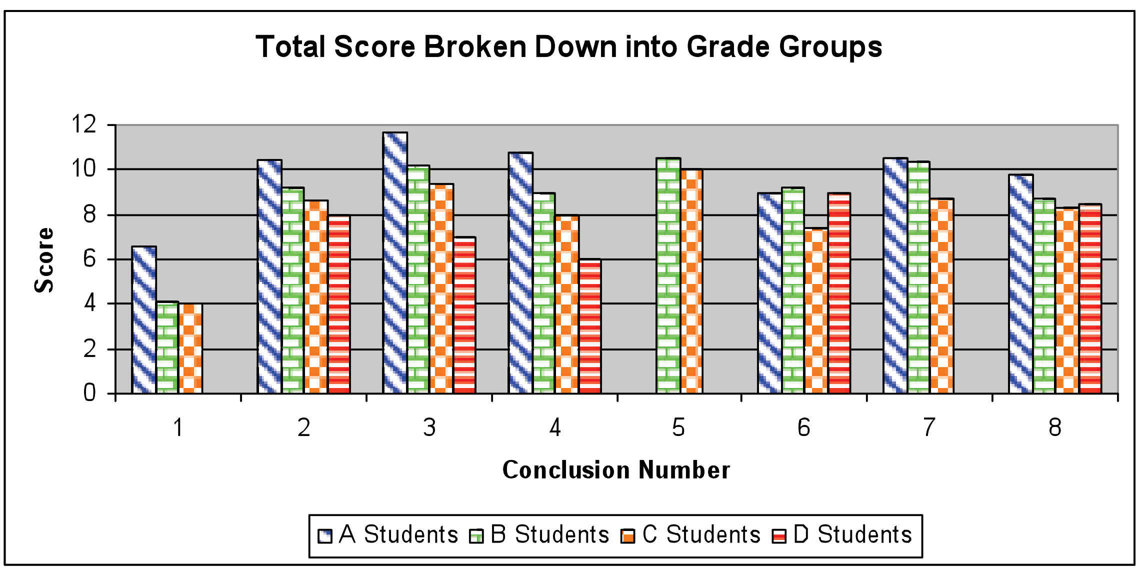


Figure 20. Total average scores broken down into grade groups

Along with looking at the overall scores on the conclusions, I wanted to look particularly at the scores on the section of the conclusion about the evidence given to justify the students' answer to the problem question. I wanted to look at this section in more depth because it corresponds especially to my research question as this is the section of the conclusion where students actually justify their logical conclusion using the data gathered in the lab. I found that students' demonstration of this logical thinking increased substantially during the intervention and that it had a carry-over effect to the post-intervention conclusion as well. The pre-intervention class average for the evidence section was only 0.63 out of 3 with no students scoring a perfect 3 and 14 students scoring a zero and not even addressing their data when answering the problem question (Figure 21). This increased to average scores of about 2 for all of the conclusions during the intervention with many students scoring 3s. For the post-intervention conclusion, the class average was 1.77 out of 3 with only 1 student scoring a 0 on that section and 7 students scoring perfect 3s. I believe this great increase in the scores on the evidence section is a result of the increased emphasis placed on the evidence section during the intervention. Having the rubric in front of students while they were writing reminded them to mention what data they were looking at that led them to their answer to the problem question. This is supported by the immediate increase as the intervention starts and the slight increase achieved after the peer editing process.

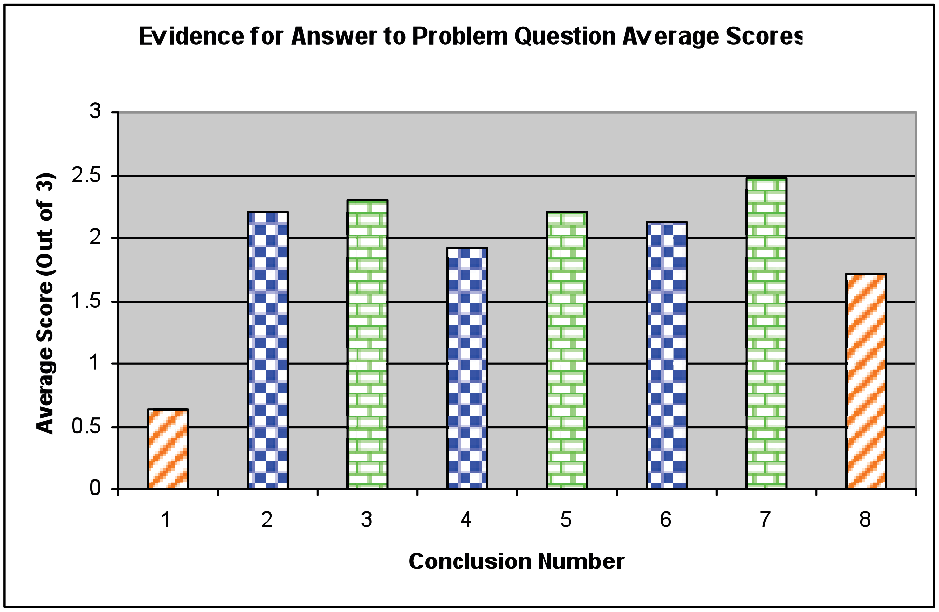


Figure 21. Average class scores for the section of conclusion on evidence for the answer to the problem question (note: diagonal stripe pattern is non-peer-edited pre- and post-intervention conclusions, checkered pattern is first drafts of intervention conclusions, and brick pattern is final drafts of intervention conclusions)

Attitude Data

I also conducted a student survey about student attitudes toward performing lab procedures, analyzing data, and writing conclusions. The survey was given to all students at the beginning of class as a warm-up for class that day. It was given to 26 students on November 5, 2007 for the pre-intervention survey and 23 students on December 13, 2007 for the post-intervention survey. The pre-intervention survey and the post-intervention survey were identical surveys. The survey asked students to respond on a scale of 1 to 4 as to whether they agreed or disagreed somewhat or strongly with statements about enjoying, being good at, and learning from conducting lab procedures, analyzing data they gathered in the lab, and writing conclusions for labs. Answers of 1 or 2 were disagreeing statements and negative responses, while 3's and 4's were statements of agreement or positive responses (Figure 22).

Name: ____________

Lab Survey

Please rate how strongly you agree or disagree with the following statements by circling the appropriate number. 4 – Agree Strongly, 3 – Agree Somewhat, 2 – Disagree Somewhat, 1 – Disagree Strongly

Conducting lab procedures is actually doing the lab. For example, making the volcanoes using the ketchup and tomato paste and measuring their heights.

Analyzing the data is looking at your observations and data and coming to the logical conclusion. For example, comparing the heights of the volcanoes and your observations and determining what the effect of the viscosity of the lava was.

Writing conclusions is the actual writing process where you put your ideas into writing to summarize the lab, answer the problem question, recap your hypothesis and suggest sources of error.

	Disagree Strongly	Disagree Somewhat	Agree Somewhat	Agree Strongly
1. I enjoy conducting lab procedures.	1	2	3	4
2. I am good at conducting lab procedures.	1	2	3	4
3. I learn a lot from conducting lab procedures.	1	2	3	4
4. I enjoy analyzing the data I collect in labs.	1	2	3	4
5. I am good at analyzing the data I collect in labs.	1	2	3	4
6. I learn a lot from analyzing the data I collect in labs.	1	2	3	4
7. I enjoy writing conclusions for labs.	1	2	3	4
8. I am good at writing conclusions for labs.	1	2	3	4
9. I learn a lot from writing conclusions for labs.	1	2	3	4

Figure 22. Example of Pre-Intervention Survey

Survey results were analyzed by determining what percent of students had positive opinions of the different topics and how that changed from before to after the intervention. I also analyzed the sections on analyzing data and writing conclusions to see if the percent of students who strongly disagreed and strongly agreed changed. I did not perform a detailed analysis of the questions on conducting lab procedures because my research question and intervention were not focused on conducting lab procedures.

I found that even before the intervention, most students agreed with and responded positively to statements about conducting the actual lab procedures (Figure 23). Over 70 percent of students said they enjoyed and learned from conducting lab procedures but only 60 percent of students thought that they were good at it. Data analysis showed that only 35 percent of students enjoyed analyzing data, but 54 percent thought they were good at it, and 60 percent claimed to learn from it. The most negative responses came about writing conclusions. A mere 15 percent of students enjoyed writing conclusions before the intervention with only 35 percent believing that they were good at writing conclusions, and 43 percent claiming to learn from the conclusion writing process (Figure 23).

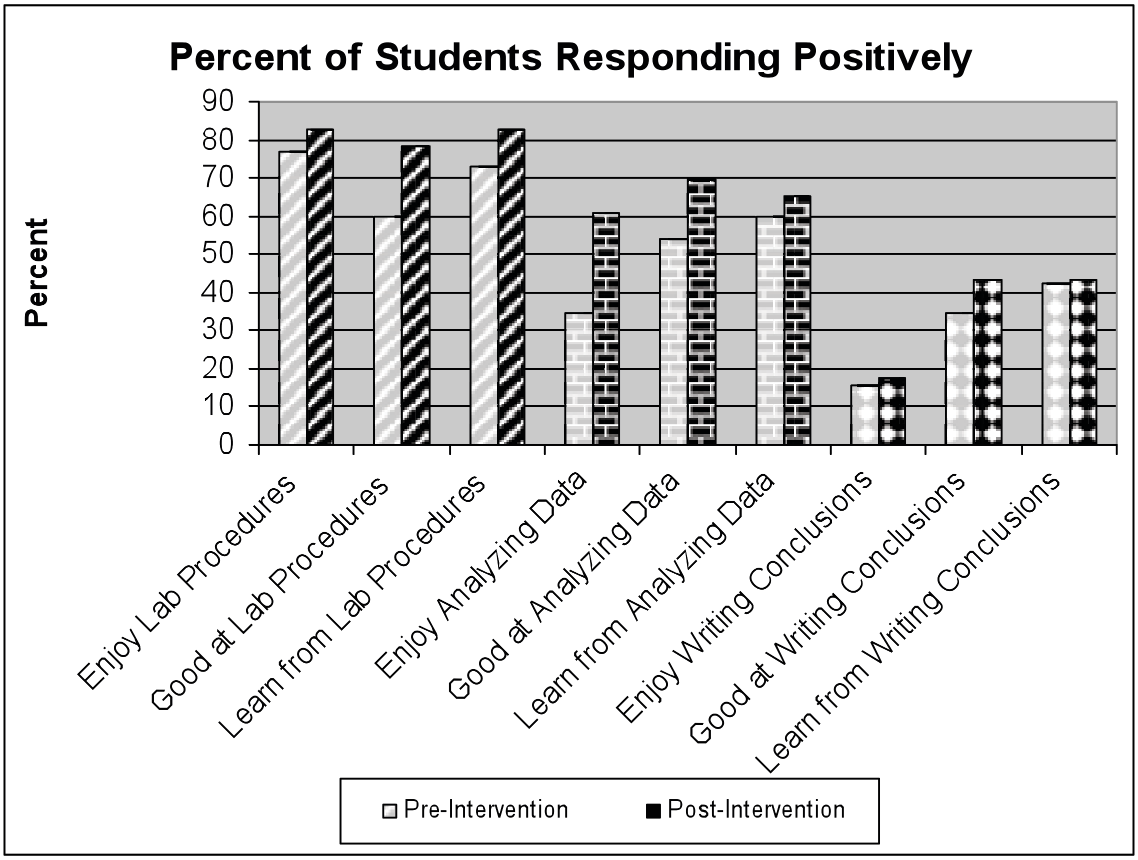


Figure 23. Percent of students responding positively to each question on the pre-intervention and post-intervention attitude surveys

These pre-intervention survey results show me that students did not enjoy, feel that they learn from, nor have confidence in their conclusion writing abilities. Students felt much better about their performance conducting labs and analyzing the data from labs, but when asked to summarize everything and write it as a lab conclusion, students did not feel good about their performance. Their attitudes about writing conclusions were predominantly negative while students were largely split equally in their attitudes about analyzing data.

After the intervention, I found that the number of positive responses increased for every single question on the survey (Figure 23). The greatest increase in agreement was about the enjoyment of analyzing data. Before the intervention, only 35 percent of students said that they enjoyed analyzing data, but after the intervention, that number jumped to 61 percent. There were also significant gains made in student attitudes about how good students felt they were at conducting lab procedures (from 60 percent to 78 percent) and how good they thought they were at analyzing data (from 54 percent to 70 percent). I had initially expected student attitudes regarding writing conclusions and analyzing data to fall significantly since they were being required to do much more work in these areas during the intervention, but the results showed that the percent of students responding positively to these areas actually increased. While the percent of students who felt they were good at and learned from writing conclusions remained below 45 percent and the percent of students who enjoyed writing conclusions remained below 20 percent, the fact that these percentages did not fall during the intervention can be seen as evidence that the intervention did not have a hugely negative effect on student attitudes towards writing conclusions. That agreement rose in every category shows that the intervention may have even led to a rise in positive student attitudes regarding conducting lab procedures and analyzing data. This relates to my research sub-questions as it shows that peer editing leads to an increase in positive students attitude towards data analysis.

When I analyzed each of the data analysis questions in detail, I found that positive student attitudes towards data analysis increased. For all three questions, after the intervention, no students disagreed strongly with the statements. For the enjoyment of data analysis, students who disagreed strongly went from 15 percent to 0 percent and students who disagreed somewhat went from 50 percent to 39 percent. This is a 26 percent increase in students who enjoy the data analysis process. All of that gain was seen in the category of agreeing somewhat with the statement. For how good students thought they were at data analysis, students who disagreed strongly went from 12 percent to 0 percent and students who disagreed somewhat went from 35 percent to 30 percent, again with all of the gain being found in the students who somewhat agreed. For the learning from data analysis, the percent of students who disagreed strongly went from 12 percent to 0 percent with the gain being split between students who disagreed somewhat and students who agreed somewhat (Figure 24, Figure 25, Figure 26).

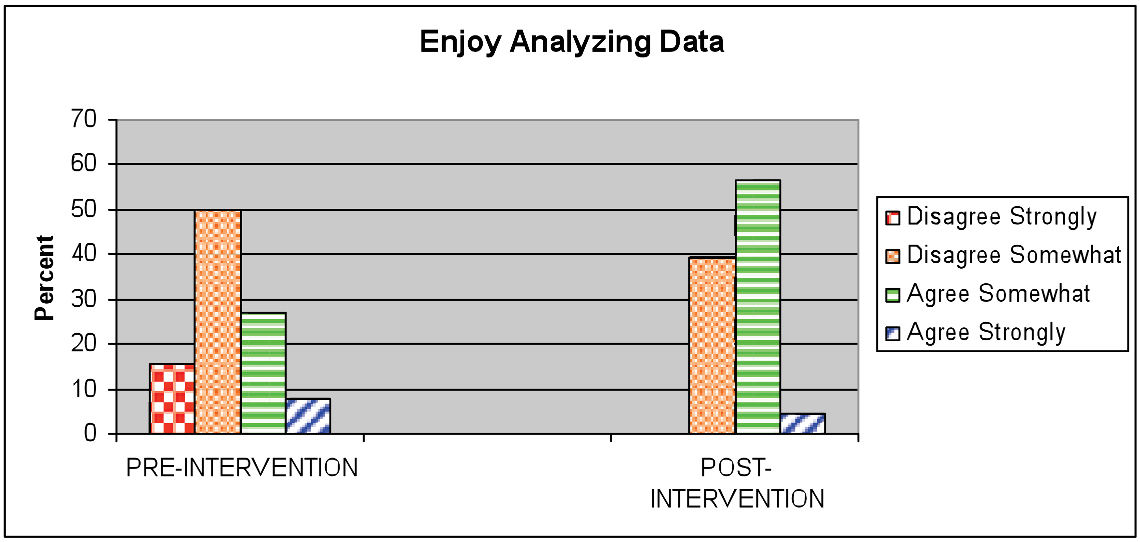


Figure 24. Enjoyment of data analysis attitudes from survey data split into percent of students who disagree strongly, disagree somewhat, agree somewhat, and agree strongly with the statements

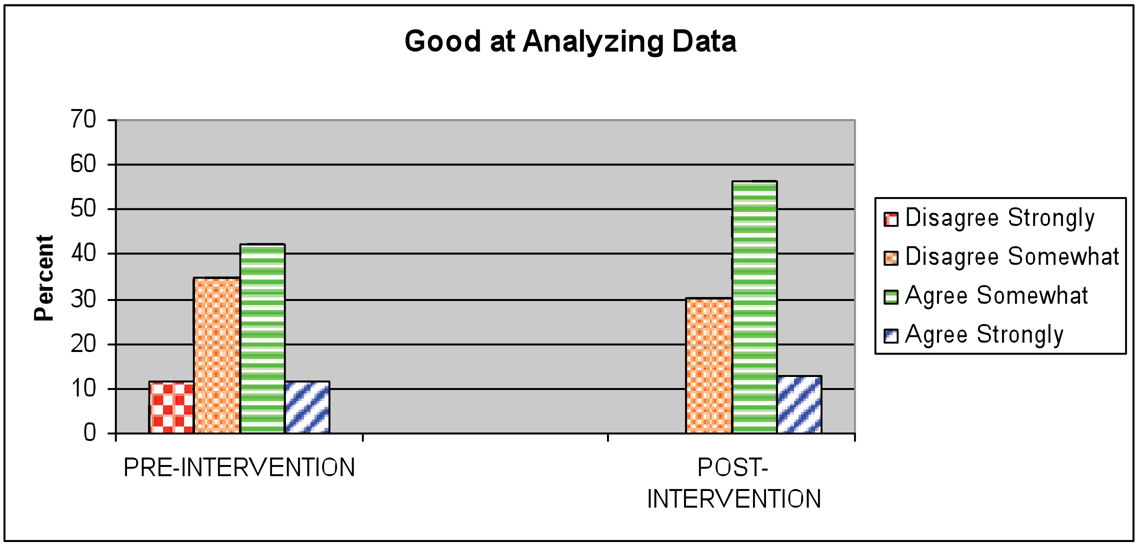


Figure 25. Good at data analysis attitudes from survey data split into percent of students who disagree strongly, disagree somewhat, agree somewhat, and agree strongly with the statements

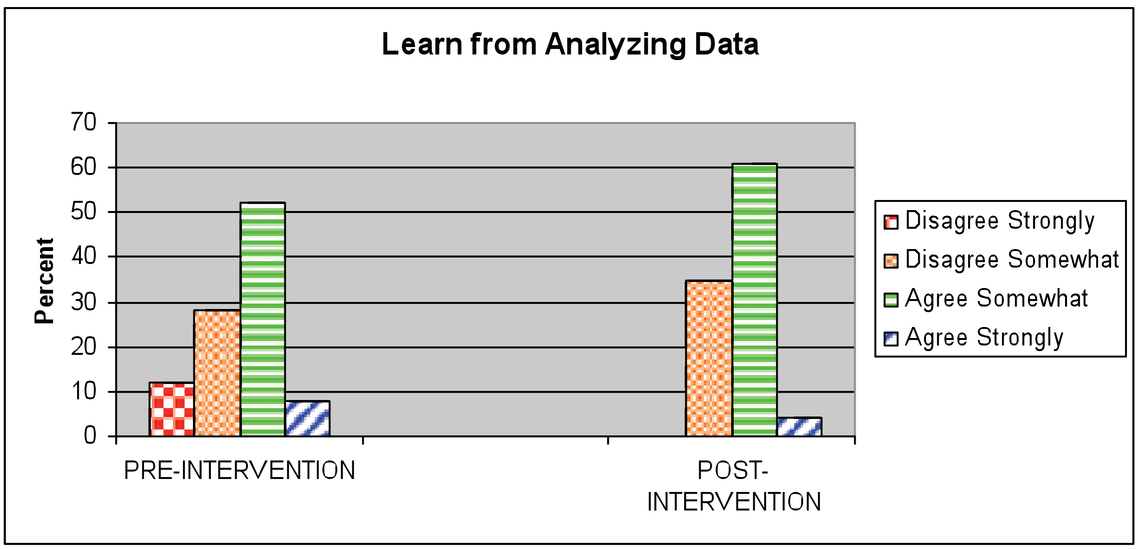


Figure 26. Learning from data analysis attitudes from survey data split into percent of students who disagree strongly, disagree somewhat, agree somewhat, and agree strongly with the statements

When I analyzed the questions on the subject of conclusion writing, I found that while the overall percentages of students agreeing and disagreeing with statements about conclusion writing did not change drastically, the amount that they agreed or disagreed did change. For the enjoyment of writing conclusions, before the intervention, 42 percent of students disliked writing conclusions strongly and another 42 percent disliked writing conclusions somewhat. After the intervention, the number disliking writing conclusions strongly jumped up to 61 percent while the number disliking them somewhat dropped to 22 percent. This shows that while most students still dislike writing conclusions, the amount they dislike it has increased substantially. The intervention led to an increase in how much students dislike writing conclusions. For how good students think they are at writing conclusions, there was a modest increase as the numbers of students who strongly disagreed with the statement that they were good at writing conclusions decreased ten percent from 27 percent to 17 percent while the number of students who strongly agreed increased from 0 percent to 9 percent. This shows that the intervention led to a slight increase in student confidence in their ability to write a good conclusion. The amount of learning students felt that they did from writing conclusions also decreased. Before the intervention, 15 percent of students agreed strongly that they learned from writing conclusions, but after the intervention zero percent of students agreed strongly. This was made up for by the students who used to agree strongly now agreeing somewhat as the percent of students agreeing somewhat grew 16 percent from 27 percent before the intervention to 43 percent after the intervention. Overall for conclusion writing, while the percent of students who felt like they were good at writing the conclusions increased slightly, the students who disliked writing conclusions disliked them more after the intervention, and the students who thought they learned from conclusions thought they learned less after the intervention. While the overall agreement data show a slight increase in positive attitudes about conclusion writing, a closer look shows that there was less enjoyment and less perceived learning about the conclusion writing process after the intervention (Figure 27, Figure 28, Figure 29).

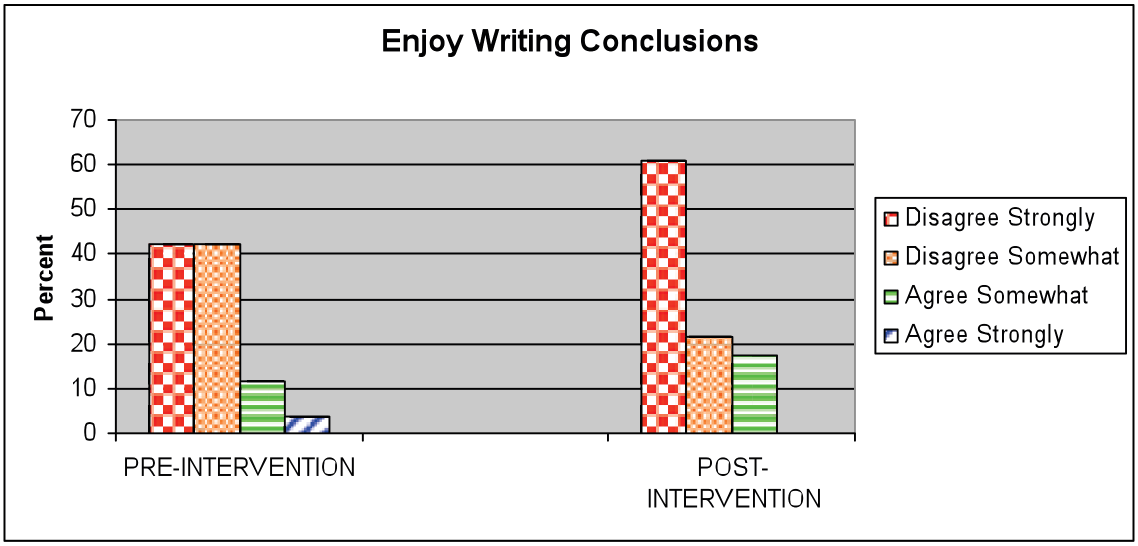


Figure 27. Enjoyment of conclusion writing attitudes from survey data split into percent of students who disagree strongly, disagree somewhat, agree somewhat, and agree strongly with the statements

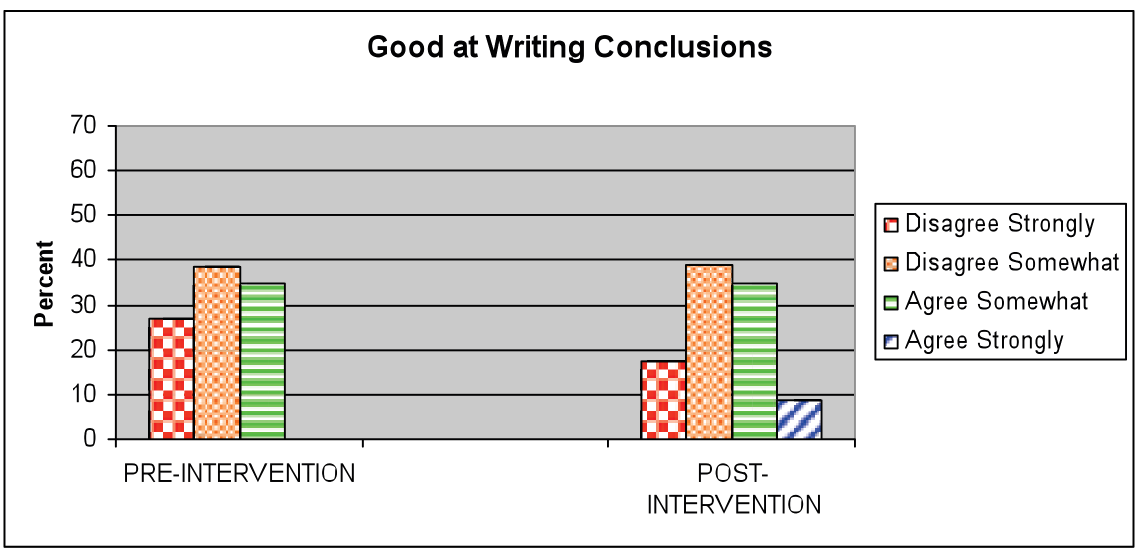


Figure 28. Good at conclusion writing attitudes from survey data split into percent of students who disagree strongly, disagree somewhat, agree somewhat, and agree strongly with the statements

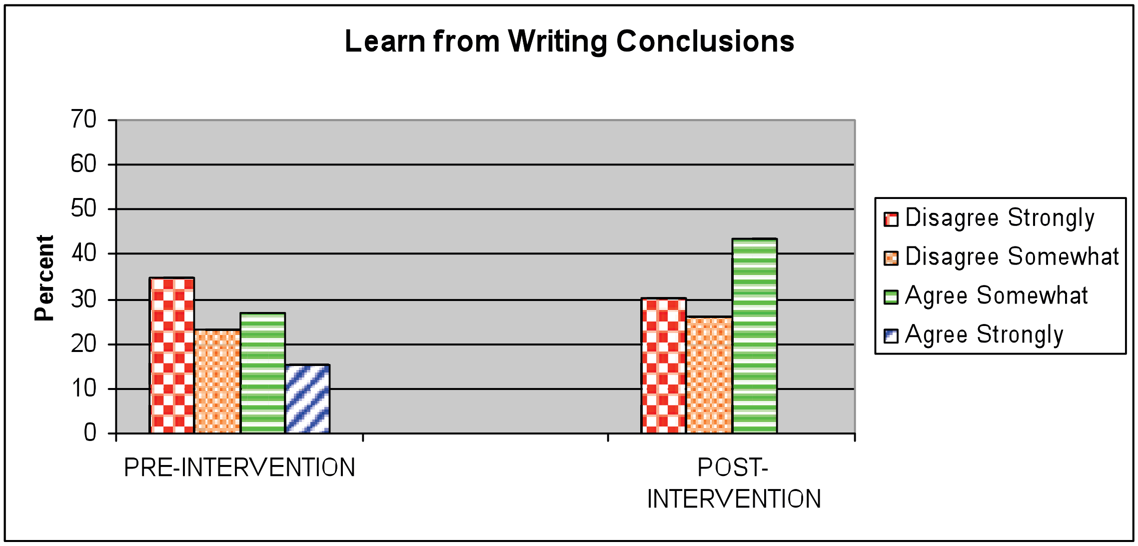


Figure 29. Learning from conclusion writing attitudes from survey data split into percent of students who disagree strongly, disagree somewhat, agree somewhat, and agree strongly with the statements

I believe this reduction in positive attitudes towards conclusion writing is due to the extra work that students were required to do during the intervention. Instead of just writing a one to two sentence conclusion, students were now expected to write multiple paragraphs. Students were also unhappy that they had to rewrite their conclusions so they ended up doing twice the amount of writing. This increased workload likely accounts for the large number of students who responded that they disagree strongly with the statement that they enjoy conclusion writing after the intervention. The lack of enjoyment that students got from writing the conclusions also likely made them feel like they were learning less since their overall attitude towards conclusions was getting more negative. Although student scores increased, because they did not like writing the conclusions, they felt that they were not learning from them.

Observational Data

During the intervention, I collected observational data from my students that strongly reinforces the achievement and attitude data. Observational data was taken in the form of teacher notes on students' quotes and questions asked of the teacher. This observational data was taken on Tuesday, November 6 and Wednesday, November 7, 2007 as students wrote their first draft of their conclusion, then peer-edited their conclusions and wrote a final draft of the conclusions. Teacher notes were also taken during the second and third labs of the intervention on November 13, November 14, and November 29, 2007 in the same fashion. Notes were taken by the teacher writing quotes that the students said on a clipboard during class. If a similar question or comment was made by a different student, I recorded a tally mark by the question (Table 6). During observation, I listened especially to a group of boys who were seated towards the front of the room because they tend to be the most disruptive of my students. I also listened for statements about how much effort students were putting in, statements of understanding or confusion, and statements of complaint or enthusiasm. Comments fit into six major categories: (1) complaints about writing the conclusions, (2) questions asking for reassurance that they were writing the conclusions correctly, (3) questions asking for clarification on what they were supposed to do, (4) statements expressing confusion about what they were doing, (5) statements or questions designed to brag about how good their work was, and (6) questions asking about their conclusions that show that students are thinking deeply about analyzing their data and composing their conclusions.

Table 6. Number of different types of quotes observed per lab

	Complaint	Reassurance	Clarification	Confusion	Brag -ging	Deep Thinking
Mineral Lab First Draft	5	3	0	0	0	0
Mineral Lab Final Draft	4	0	0	4	0	0
Rock ID Lab First Draft	1	0	5	0	0	0
Rock ID Lab Final Draft	1	0	0	0	2	0
Carbon Lab First Draft	2	0	0	0	1	3
Carbon Lab Final Draft	0	0	0	0	3	0

On November 6, students were writing their first draft of their conclusion after conducting the lab on minerals in class. Only two types of questions or comments were made on this day during the conclusion writing portion of class. Five students commented at the beginning of the conclusion writing that, "This is a waste of time," or "This is just busywork." These five students were all expressing complaint and a lack of enjoyment with the writing process. The other question asked was students showing me their completed conclusions and asking, "Did I do this right?" or "Did I include everything?" Three students asked me this type of question asking for reassurance. On November 7, students were peer editing another student's conclusion and then writing their final drafts of the conclusion using the edits the other student had made. Four students asked, "Do I really have to write a final draft?" if the person editing their work had said they would get 12/12. These could be classified as questions of clarification or complaint. During the editing process, two students asked "What do I do?" and another two students asked, "Where is the evidence in here?" These four students were exhibiting confusion.

This observational data showed me that during the first lab of the intervention, some students still had very negative opinions of conclusion writing after the direct instruction portion of the intervention. It also shows that students were not entirely sure what they are supposed to do at this stage in the intervention and they are still adjusting to the new process of peer editing each other's science writing. The students asking me to look over their work showed me that they had not yet got used to having someone other than the teacher review their work for them. This observational evidence relates to my research question because it shows students initially had a largely negative attitude and to be confused about what is expected of them.

During the conclusion writing for the rock identification lab, there was still some complaint and lack of clarity, but students also began to become comfortable with the peer-editing process. The first thing that one student dejectedly said when told we were conducting a lab during class was, "Oh, a lab. That means we have to write a conclusion!" This was, however, the only instance of complaint I heard during the first draft writing process. There were also two students who asked questions looking for clarification using words like, "I don't get it, what would the evidence be," and "There's nothing wrong with the lab, how would I improve it?" This shows that students were trying hard to write their conclusions, but were still struggling to identify the necessary parts of the conclusion. Finally, there were three students who wanted to turn in their conclusions after writing their first draft and asking where they could turn them in. This showed that students were still not entirely used to the peer-editing process and revising their work.

During the peer-editing process for the rock identification lab, there was again a single complaint as a student asked, “Can we do it less intense this time?” This was a significant reduction in open complaining from the first lab of the intervention as students were getting more used to the peer-editing process and adjusting to the increased requirements of the conclusion. There were also two students who bragged after their conclusions were peer-edited and rewritten. One student showed me his edited conclusion and said, “Twelve out of twelve! Read it and weep Mr. Williams.” Another student asked, “Are you going to read these? Are you going to read my excellent work?” This shows that students were becoming more comfortable with the peer-editing process and even becoming proud of the hard work they had put into their conclusions. This relates to my research question as it shows attitudes were becoming more positive towards conclusion writing.

During the final lab, there was some mild complaining, however most students had now got used to the peer-editing and accepted it as part of the class. As a result, students began to brag more about how much and how well they had written. The closest statement I heard to a complaint was, “Wait, if we have to do two drafts, then I’m just not going to try on the first one.” Another student said, “This is going to be so long to rewrite,” to which the student sitting next to him replied, “Mine is longer than that.” Students were still resistant to the peer editing and conclusion writing process, but they had now adjusted to it and were beginning to compete for who was writing the most and the best. There were also three students who asked questions about how to properly address each point of the rubric asking, “How do I address the hypothesis when I wrote, ‘It will have a big impact?’” “What does ‘What data did this lead to?’ mean,” and “How do you connect back to the problem question?” These questions, especially the last one, show a deeper thinking about their conclusion writing and how to best support their statements. Finally, there were the students who were just bragging about how well they thought that they had written their conclusions and how much they had written. One student said, “This is the most writing I’ve ever done in one class period. I’m digging it!” Two other students asked, “My editor said this is the best he’s ever seen. Can you check it?” and “My editor can’t find any errors here. Can you check it?” These statements show that they still did not entirely trust their classmates to accurately assess their work, but they did have a lot of confidence in their writing abilities.

This relates to my research question because it shows that student confidence in their data analysis and conclusion writing was increasing, but they still did not like writing conclusions. That students were saying that their conclusions are the best shows that students were aware that their performance is increasing through the intervention which corresponds with their actual achievement. This observational data also corresponds to the attitude survey data. Students complained often during the intervention and thus it is not surprising that their enjoyment of writing conclusions went down while their opinion that they are good at it increased. There is great correspondence between students’ quotes and their attitudes about conclusion writing and data analysis. The observational data strongly reinforces my findings from students’ achievement results.

Conclusions

At the beginning of the instructional intervention, I asked, “How does peer editing of lab conclusions affect students’ ability to come to logical conclusions using data?” I supplemented this research question with my sub-questions of, “How does peer editing of lab conclusions affect students’ conclusion writing ability?” and, “How does peer editing of lab conclusions affect students’ attitude towards writing conclusions and data analysis?”

I found that the conclusions that the students wrote changed significantly during the intervention. These changes in conclusion scores with and without peer editing show that peer editing does lead to an increase in student ability to develop and write a logical conclusion. However, it also shows that an even larger increase was due to the direct instruction and the rubric given to students to assist them in writing and editing conclusions. While peer editing does seem to have led to an improvement, there was a significant improvement just from giving students the rubric and telling them that it was important to focus on writing good conclusions. From the pre-intervention conclusion to the first draft of the Mineral Lab, before any peer editing, the class average score jumped from 4.58 to 9.15 out of 12. Peer editing also had a positive effect, but it only led to an increase of about one point out of 12. Even in the very first draft of the first intervention conclusion, there were no longer any students writing a one or two sentence conclusion. All students were putting much more effort into their work and writing half of a page to a full page for their conclusions, all directly following instruction with the conclusion rubric. This may be due to students being more aware of the expectations, to the increased emphasis placed on conclusion writing, or to the knowledge by students that one of their classmates was going to be reading and evaluating their work. I had initially expected that peer-editing would lead to the greatest increase in student ability to develop a conclusion, and while peer editing did lead to a slight increase, the greatest increase was due to clear expectations and a clear rubric. These expectations led to an immediate improvement in the work of every student while peer editing led to a significant increase in the work of some students, a slight improvement in the work of other students, and no change in the work of some students.

The greatest benefit of peer-editing seems to be maintaining the initial gain from using the rubric. In March of 2007, I conducted a similar intervention to improve conclusion writing, but with no peer-editing component. In this previous intervention, I found a great initial gain, but then a progressive drop-off of scores until students were back to their pre-intervention scoring levels. By including a peer-editing component, I saw no decline in conclusion scores throughout the intervention and students maintained their improvement consistently. While peer editing did not lead to a great additional increase in scores, I believe it did serve to stop what could have been a drastic decline by ensuring that students were interacting with the rubric and their own work on a consistent basis.

I had additionally expected the attitudes of students towards data analysis and conclusion writing to become negative. In this respect, I was also partially correct. I found that student attitudes towards writing conclusions did become more negative. In the post-intervention survey, more students responded that they disagreed strongly with statements that they enjoyed writing conclusions, were good at writing conclusions, and learned from writing conclusions than in the pre-intervention survey. I also found, however, that with regards to data analysis, student attitudes became more positive. The number of students disagreeing strongly with statements that they enjoyed analyzing data, were good at analyzing data, and learned from analyzing data all dropped to zero in the post-intervention survey while the percent of students who agreed with those statements rose from the pre-intervention survey. I believe that the reason students had more positive opinions of data analysis, but more negative opinions of conclusion writing after the intervention is that the process of peer-editing and writing good conclusions made the data analysis easier, however it also made it a lot more work to actually write the conclusions. Students were very resistant to dealing with increased expectations and expressed dissatisfaction with these increased expectations about how much effort they were required to put into their conclusions. Despite their protests, they put in the effort and met the higher expectations. Even now, after the intervention is over, they continue to protest writing long conclusions, but they continue to use the rubric and write much improved and data-based conclusions. The fact that students find data analysis easier as they write more about it corresponds with the findings in “Scientists' views of science, models of writing, and science writing practices” (Yore, 2004). In that article, Yore states that scientists learn and discover through writing and my students have found that to be true as they stated that they found data analysis easier and more beneficial after a writing intensive intervention.

Limitations of the Study

While I feel that the peer-editing intervention on conclusion writing was largely successful, there are some obstacles that require mentioning. First, it is necessary to mention that the labs for which the students were writing their conclusions were on completely different topics. While all required using data to come to a conclusion, some of the final conclusions were much easier to come to as students had prior knowledge about certain subjects while not knowing much about other subjects. Next time, I might mitigate this problem by having all conclusions written about labs in a similar content area. Also necessary to mention is that during the intervention, there were many students who did not write final drafts of their conclusions, but instead just turned in their first draft that their editor had marked up, but that they had not changed. For example, during the Rock Identification Lab, only five students turned in final drafts while 24 students wrote first drafts. This made it difficult to gather data for the final draft conclusions and led to greatly different sample sizes. Part of this problem is due to the set-up of the intervention which requires students to be in class for two or three consecutive days without absence and part of the problem is due to students not wanting to write any more than they absolutely have to. The students who did rewrite their conclusions had very positive results, but in the future, I need to find some way to motivate students to rewrite their conclusions with greater consistency.

Implications for my Teaching

The greatest impact this study had on me was to emphasize the importance of making my expectations clear to my students all of the time. I realized that although students expressed resistance to the work, they improved their performance because they knew what was expected of them and rose to meet those expectations. If I can make my expectations equally clear in other aspects of my teaching, hopefully students will continue to rise to meet those expectations. One of my students' greatest strengths is that they want to do well in school. While most are unwilling to put in a great amount of effort, if I give them opportunities to do well and make it as clear and easy as possible for them to succeed, they will. One way I discovered to make expectations clear was to use clear rubrics more often for repeated assignments. While use of rubrics had been emphasized in my credential program, I had not used them extensively and had not shown them to the students until this intervention. I believe that the students knowing which rubric they would be evaluated with made it much easier for them to address the issues that I had wanted them to cover. This intervention also informed my teaching as it showed me that clear rubrics and use of peer-editing could be a strategy to use with English-learning students. While I did not have any English learners in my class during the intervention, I believe it would have had a very positive effect on them since it used both content knowledge and writing skills to complement each other. As Merino and Scarcella (2005) mentioned, this integration of content and literacy is greatly beneficial in enhancing both of them.

Future Research

There are two directions future research on this topic could take. The first is investigating other aspects of science that peer editing could improve. I would especially like to see if peer editing would work to improve lab procedures, design of data collection, and inquiry lab investigative work. The other aspect that I would like to investigate is how use of rubrics and clear expectations affect student performance in other aspects of Earth science class. A few areas that I would anticipate using rubrics are for other aspects of the lab reports, evaluating essay questions on exams, and for homework research projects. I believe more explicit rubrics might make students more aware of expectations and thus improve performance.

Final Thoughts

I found conducting this research intervention highly beneficial. It has informed my teaching and improved the conclusion forming and writing of my students. While students are still not doing perfectly in their lab reports and conclusions, they are doing far better work than they were before the intervention. While the intervention was really worthwhile, the intensity of the analysis may be more than is necessary on a daily basis. After fully analyzing all of the student work and attitude information, I found almost exactly what I found on first inspection. The experience of this intervention has made me want to continue to try to improve student work. Hopefully, this will be only a first step in a career of improving student learning.

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