USE OF CLAIM, EVIDENCE, REASONING WRITING

IN A MIDDLE SCHOOL SCIENCE CLASSROOM

by

Jessica A. Patton

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

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

July 2022

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The implementation of this action research focused on students' ability to write scientific explanations after science investigations. This research was conducted in a 6th grade Earth Science classroom in the spring of 2022. Prior to the research, I noticed students struggling with written reflections and explanations of the science concepts. Prior to the treatment, students' reflections were unclear, and connections to the science concepts were missing or incomplete. I implemented the instruction of the CER (claim, evidence, reasoning) framework to help improve my students' scientific reasoning skills and confidence while writing scientific explanations. The results showed overall improvements in students' ability to write scientific explanations and use evidence in their writing. It was concluded that the implementation of the CER framework positively impacted students' writing abilities in the classroom.

CHAPTER ONE

INTRODUCTION AND BACKGROUND

Context of the Study

I teach in the city of Missoula, Montana which is a small metropolis surrounded by wilderness in all directions. Missoula is known for its outdoor recreation and progressiveness compared to other parts of the state. Located in northwestern Montana, it has a population of roughly 75,000 people (city-data.com, 2019). Washington Middle School is centrally located and serves just over 600 students in sixth through eighth grade (National Center for Education Statistics, 2019). Our middle school utilizes small team teaching, where students only see two to four teachers over the course of a day. The school serves a diverse socio-economic population with 29% of students coming from lower socio-economic families (greatschools.org, 2021). During the time of this study, I taught multiple sections of sixth grade science to a total of 60 students. The sixth-grade science curriculum focused on an introduction to Earth sciences. The science classes I selected for my research project contained multiple levels of learning abilities including students with IEPs (Individual Education Plans), gifted learners, and grade-level learners.

While teaching middle school science, I have seen the power that science knowledge brings to young minds. In my classroom, students enjoy hands-on learning experiences; however, during these experiences I have noticed students struggling with written reflections and explanations of the science concepts. Students' reflections were often vague, unclear, and connections to the science concepts were missing or incomplete. This was concerning to me

because written reasoning, explanations, and conclusions are a key part of any science instruction (Short, Van der Eb, & McKay, 2020). In addition to struggling with writing reflections, I have noticed students had writing deficits when it came to writing during labs. I first attributed this to a lack of effort or students' lack of writing endurance. After more time, I came to realize the deficits had more to do with a lack of experience in content writing, and a lack of writing organization skills. These final written steps foster deeper understanding and connections to science content (Drew et al., 2017). Without well thought out or organized written conclusions, students may not be thinking deeply, making connections, or understanding the science concepts. I saw a need to implement writing instruction into my science classroom to address students' learning gaps, and to foster deeper understanding during science lab conclusions.

More pressure has been put on educators to implement writing across curriculum with Montana's adoption of Common Core State Standards. Along with this, our district has adopted the Next Generation Science Standards and is requiring teachers to redesign content to meet these standards. Within these standards there is an emphasis on scientific reasoning (NGSS Lead States, 2013). The issue we are seeing now with the current instructional strategies is that there is rich content but a lack of tools and activities to help students develop the writing skills necessary to express their thinking or reasoning. The goal is for students to make connections between science content and lab experiences. To reach this goal, I realized I needed to implement a writing framework to help students organize their science writing to, hopefully, lead to deeper understanding and connections of the science content. The writing framework I implemented was the Claim, Evidence, Reasoning (CER) framework which guides students to synthesize

science concepts (McNeill et al., 2006). In CER, an argument is defined by three parts: (1) claim— a statement that responds to an original question; (2) evidence— data that supports the claim; and (3) reasoning— an explanation of how the data supports the claim (McNeill et al., 2006). These three parts give a template to written argumentation that is manageable by students. Students make a claim which is a concise statement about an investigation or a scientific concept, then they provide evidence to support their claim (Alegado & Lewis, 2018). Finally, students are asked to explain why their evidence supports their claim using reasoning which requires them to validate the claim using scientific principles (Alegado & Lewis, 2018).

Focus Statement/Question

My focus question was, How does direct instruction and repeated use of the CER framework impact students' scientific explanations after scientific investigations?

My sub questions include the following:

1. Will the use of the CER framework increase the use of evidence-based explanations in lab write-ups?
2. How does the CER framework of writing affect students' attitudes towards scientific writing?

CHAPTER TWO

CONCEPTUAL FRAMEWORK

Overview and Background of Written Argumentation

Argument and analysis are the central features of science. These two skills connect students' inquiry to the process of developing scientific ideas. Students deepen their understanding through written explanations (Short, Van der Eb, & McKay, 2020). The goal of any educator's instruction is to assist students in this deeper understanding. Short, Van der Eb, and McKay (2020) stated that when students are expressing their own ideas they are more likely to do so through writing rather than during class discussion (p. 3).

However, middle school students struggled to meet minimum writing expectations within and beyond science (Drew et al., 2017). According to Drew et al. (2017), students' lack of writing abilities is due to the fact that writing practices are not seen in content classrooms, including science. Teachers need to combat this discrepancy by incorporating writing practice into daily lessons, as writing about science content can prove difficult for students who have not had experience. Students need guidance and scaffolding when it comes to writing about science content, and further, arguing their conclusions about science concepts (Corcoran, Mosher, & Rogat, 2009). Students' deficits with writing in content area classes can be addressed with the implementation of content specific writing instruction. There are standards and writing frameworks that help guide teachers when implementing writing into their science classrooms, the CER framework being one of them.

Writing in science needs to follow national standards and a framework in order for students to deepen their understanding. According to Corcoran, Mosher, and Rogat (2009), how students' understanding of, and ability to use, scientific concepts and explanations can improve over time with appropriate instruction (p. 15). It is with increasing demand that teachers implement more written argumentations and explanations into their instruction (Norris, Krajcik, & Soloway, 2018). In recent years, districts have been transitioning to adopt the Next Generation Science Standards (NGSS), which emphasizes experimentation and learning through inquiry in science (Norris, Krajcik, & Soloway, 2018). Scientific argumentation, or explanation building, is included in the National Science Education Standards (National Research Council, 1996), and the NGSS (NGSS Lead States, 2013). Since the adoption of the NGSS, teachers all over the nation have been looking for ways to integrate this type of instruction into their classrooms.

According to the NGSS Lead States (2013), science is not a group of facts to memorize, but a tool for explaining phenomena. Within the NGSS, there are Science and Engineering Practices (SEPs) which include (a) asking questions, (b) analyzing data, (c) constructing explanations, and (d) engaging in argument from evidence which all play a part in argumentation. SEPs go beyond traditional instruction by promoting sense making of phenomena by constructing evidence-based explanations and argumentation from evidence (Norris, Krajcik, & Soloway, 2018). The national standards give an overarching goal to implement written argumentation into science classrooms.

Writing frameworks for argumentation have been developed overtime to provide teachers and students with a guide to effective argumentation. To improve science understanding and scientific literacy, teachers should implement argumentation and the associated skills (Short, Van

der Eb, & McKay, 2020). Argumentation frameworks derive from Toulmin's Argument Pattern (TAP). TAP consists of five parts: (a) claims, (b) data, (c) warrants, (d) backings, and (e) rebuttals (Erduran, Simon, & Osborne, 2004; Toulmin, 1958). With consideration for national standards and revisions to TAP a framework was developed called Claim, Evidence, Reasoning (CER) (Short, Van der Eb, & McKay, 2020). In CER, an argument is defined by three parts: (1) claim— a statement that responds to an original question; (2) evidence— data that supports the claim; and (3) reasoning— an explanation how the data supports the claim (McNeill et al., 2006). These three parts give a template to written argumentation that is attainable by secondary students. Alegado and Lewis (2018) shared that, "the CER framework helps students synthesize science investigations, data analysis, and scientific concepts" (p. 1). Alegado and Lewis (2018) also suggested that "the CER approach allows students to think more deeply about the science content and ultimately demonstrate a higher level of understanding" (p. 6). This can occur when students are guided by the teacher through the process to write a full argument using the CER format (Alegado & Lewis, 2018). Implementing CER framework can assist teachers in their efforts to meet the writing needs of students and the need for deeper science understanding.

Impact of Written Argumentation

In the classroom, learning to argue is a core process both in learning to think and to construct new understandings (Alegado & Lewis, 2018). Scientific argument is a form of reasoning that requires domain-specific knowledge to construct claims using supporting evidence (Osborne, 2016). The argumentation process is a beneficial educational technique. This process makes students' scientific thinking visible by requiring them to articulate why they believe a claim is true, which allows teachers to identify misconceptions and redirect

teaching (Knight & McNeill, 2015). Additionally, Knight and McNeill (2015) stated that argumentation highlights other viewpoints which will show students that science is not a set of isolated facts but a body of knowledge that is constructed by a community through discussion, critique, and revision (p. 624).

Argumentation in science positively impacts student learning and conceptual understanding. For example, Osborne (2010) shared that there are a number of classroom-based studies, all of which show improvements in conceptual learning when students engage in argumentation. Osborne et al. (2016) pointed out that when students are gaining conceptual knowledge through argumentation they are studying why ideas are wrong which matters as much as understanding why ideas are right. Osborne et al. supports this by referencing a study where students read texts explaining a topic by showing why misconceptions of the topic were flawed and explained why the right ideas were right. In this study, these students had a deeper knowledge on the topic compared to those who had only read texts that explained the correct idea (Osborne et al., 2016). Argumentation reveals to students that scientists must use claims and evidence to support why their findings are right.

Argumentation can be either oral or written and has significant impacts on students' understanding. One study done on two classes comprised of 16- to 17-year-old students found students that engaged in argumentative discussions about answers more often used concept knowledge appropriately (Osborne, 2010). Osborne (2010) referenced a U.K. study dedicated to the teaching of argumentation and reasoning over two years in 11 schools with students from grades seven and eight. In the intervention schools, students' test scores of conceptual knowledge were significantly higher than those students in the control group (Osborne, 2010).

Furthermore, in following years, these students significantly outperformed the control group in science, mathematics, and language arts. Osborne concluded that the use of written argumentation had accelerated students' general academic processing abilities. The same authors of that study have collected data from new studies that confirmed interventions aimed at improving students' ability to construct written arguments have improved student understanding and learning (Osborne, 2010). Overall, argumentation in the classroom has impacts on student achievement and understanding.

Implementation of Written Argumentation

Argumentation needs to be demonstrated, and teachers need to define an explicit outcome. For teachers to successfully engage students in argumentation, they must reject traditional teacher-directed science learning (McNeill et al., 2016). McNeill et al. (2016) noted that teachers attempting argumentation instruction need to model written argumentation and create a classroom culture that promotes authentic argumentation experiences. In this type of classroom culture, student-to-student debate, analysis, and critique is promoted because students are taking on the responsibility of explaining concepts rather than getting it from the teacher or text (McNeill et al., 2016). Students need tools to support them when they are attempting to ask appropriate questions, and to help them identify relevant and irrelevant evidence (Osborne, 2010). In most cases, teachers do not promote or ask students to reason about concepts in this manner. In this situation, students are only expected to respond with short statements that do not include justifications (Short et al., 2020). Short et al. (2020) went on to say that argumentation provides an opportunity to listen and respond to the ideas expressed by scientists or classmates. The traditional call-and-response teaching gives students the impression that science only

consists of facts that are completely agreed upon and that they are unchanging (Short et al., 2020). Teachers can implement the format of argumentation and give students the platform to carry out this complex yet rewarding tool.

The Claim, Evidence, Reasoning (CER) framework can be implemented for guiding students' written argumentation. The CER approach encourages students to connect previously learned content to something that is much more reflective and scientifically literate (Meacham, 2017). When students are developing skills in argumentation, a model argument contains a claim, two pieces of evidence, and reasoning (Short et al., 2020). A claim is provided first to directly answer a question, followed by evidence and reasoning which provide support for the claim (Short et al., 2020). The CER framework helps students create science investigations, preform data analysis, and think deeply about scientific concepts by requiring them to focus on three elements: (a) claim, (b) evidence, and (c) reasoning (Alegado & Lewis, 2018). Students make a claim which is a concise statement about an investigation or a scientific concept, then they provide evidence to support their claim (Alegado & Lewis, 2018). Alegado and Lewis (2018) described evidence as data collected through hands-on investigations or content-related facts from other science resources. Finally, students are asked to explain why their evidence supports their claim using reasoning which requires them to validate the claim using scientific principles (Alegado & Lewis, 2018). Students refer to scientific principles to explain why they made their claim. This reasoning section should support their original claim using the data from the evidence section (Alegado & Lewis, 2018).

When implementing a new framework, teachers should use scaffolds with students. Despite its effect of engaging students with the scientific concepts, producing

evidence-based explanations in science can be difficult for middle school students (Delen & Krajcik, 2018). It can be difficult for students to link sufficient evidence to support a claim (Delen & Krajcik, 2018). To provide help and support, teachers can implement scaffolds. Delen and Krajcik (2018) stated that scaffolding is applied to deliver structure, support, and guidance for students so they can execute a task they would not otherwise be able to (p. 2). To support explanations, generic scaffolds can be designed and applied to support the overall structure of the CER framework, like a prompt to include evidence (Delen & Krajcik, 2018). Delen and Krajcik (2018) noted that teachers can also add more content-specific scaffolds which will assist students in writing even better explanations (p. 3). The CER framework is also easily differentiated because each section allows for students to respond at their own level, from basic information to higher-level thinking (Alegado & Lewis, 2018). As students become familiar with the framework, less scaffolding is needed. Students can eventually create their own CER responses independently, without any prompts (Alegado & Lewis, 2018). Scaffolds can assist students as they first interact and use the CER framework.

CHAPTER THREE

METHODOLOGY

Demographics

I teach two sections of sixth grade Earth science in a 6-8th grade school. I teach at Washington Middle School which is centrally located in our city and serves just over 600 students in sixth through eighth grade (National Center for Education Statistics, 2019). During the time of this study, I taught multiple sections of sixth grade science to a total of 51 students. I selected to implement the research treatment to both sections (all 51 students) of my Earth science class, both containing students with a range of ability levels. In one section of 23 students, there was one student with an Individual Education Plan (IEP). In the other section of 28 students there were three students with IEPs.

During science class I noticed students struggling with written reflections and explanations of the science concepts. This was concerning to me because written reasoning, explanations, and conclusions are a key part of any science instruction (Short, Van der Eb, & McKay, 2020). Without well thought out or organized written conclusions students may not be thinking deeply, making connections, or understanding the science concepts. I saw a need to implement writing instruction into my science classroom to foster deeper understanding during science lab explanations. The goal of this mixed-methods action research study was for students to make connections between science content and lab experiences. To reach this goal, I realized I needed to implement a writing framework to help students organize their science writing to, hopefully, lead to deeper understanding and connections of the science content. The writing

framework I implemented was the Claim, Evidence, Reasoning (CER) framework which guides students to synthesize science concepts. The purpose of this study was to grow students' analytical writing skills by implementing the CER format of writing after a lab procedure.

The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for work with human subjects was maintained (Appendix A).

Treatment

The purpose of my study was to determine if the CER framework of writing impacts students' scientific explanations. I gathered qualitative data through interviews and surveys (Mertler, 2020). The qualitative data focused on the participants' reactions and personal experiences. I wanted to gather data on my students' feelings and reactions to the implementation of the CER framework. Along with qualitative data, I gathered quantitative data by grading a pre- and post-treatment writing assessment. This data provided me with numerical trends and patterns related to gains made in their ability to make claims and provide evidence (Mertler, 2020).

Data Collection and Analysis Strategies

To gather the data needed for this research, there were quantitative and qualitative methods used. Using both quantitative and qualitative data collection methods help to gather more information to support findings and answer if the treatment was effective or not. The instruments included a Pre and Post Intervention Survey, a Pre and Post Student Interview, and a Pre and Post Writing Assessment (Table 1).

Table 1. Data Triangulation Matrix.

	Focus Questions		
Data Collection Instruments	How does direct instruction and repeated use of the CER framework impact students' scientific explanations after scientific investigations?	Will the use of the CER framework increase the use of evidence-based explanations in lab write-ups?	How does the CER framework of writing affect students' attitudes towards scientific writing?
Pre-Intervention Survey	X		X
Post-Intervention Survey	X		X
Student Interview	X	X	X
Pre-Intervention Writing Assessment	X	X	
Post-Intervention Writing Assessment	X	X	

Pre and Post Intervention Survey. The first instrument used in my study was the Pre and Post Intervention Survey (Appendix B). I wanted to observe my students' behaviors and reactions to the implementation of the CER framework. By implementing a survey, I could gather information on students' feelings and perceptions on the treatment. Since surveys can include a combination of types of questions, I included a few open-ended questions and the rest of the questions are Likert style questions (Mertler, 2020). All the Likert questions ask about students' confidence levels during science class and writing assignments. These surveys allowed me to gather a variety of information to answer my research questions relatively quickly (Mertler, 2020). I hoped to answer two questions with these surveys. I looked to see if the CER framework impacted students' scientific explanations after scientific investigations and if the CER framework affected students' attitudes towards scientific writing. I administered these surveys before and after the treatment using Google Forms. I went through these surveys using

thematic analysis to identify common themes and patterns in the answers related to the research questions.

Pre and Post Student Interview. The second instrument I used in my research was the Pre and Post Student Interview (Appendix C). Interviewing can be a powerful way to gather insight on your participants. Interviews gather information through conversation, which allows for participants to share significant insight into their experience during the research process (Charmaz & Belgrave, 2012). This was a suitable approach to collecting data during my research project because it offered an open-ended, detailed view into the students' thinking and reactions to the experience. It helped me answer how students felt confidence-wise during their conclusion making. I wanted to know how the practice and implementation of the CER framework affected their attitudes and confidence while writing explanations about scientific concepts. I asked students at the beginning of the study how they felt about writing explanations after scientific investigations (labs), and then asked them again after the treatment. I randomly selected a few students from each class to conduct these interviews with. The questions and answers were recorded and then transcribed. While reading through transcripts and listening to students' experiences, it is important that I looked closely and worked carefully to reach conclusions and plausible inferences (Mertler, 2020). It helped me answer my research question of, how students confidence levels were affected by taking their answers and our conversations and drawing conclusions from them.

Pre and Post Writing Assessment. The third instrument used was the Pre and Post Writing Assessment (Appendix D). I administered this assessment before the treatment to see how students first worked with the CER framework. Then through the study the students

continued to use this framework while explaining data. I administered this same assessment after the treatment and compared students' responses to the pre-assessment. I analyzed the data collected via the instrument to answer the question, Will the use of the CER framework increase the use of evidence to support explanations in lab write-ups? I wanted to see if the treatment of the implementation of CER framework had positive impacts of students' use of evidence during writing. Using pre and post assessments can lead to an informed decision on whether to continue the treatment moving forward (Frey, 2018).

Analysis Strategies

During my analysis of this qualitative data, I analyzed the students' answers carefully and tried to work towards generalized and plausible relationships between results (Marvasti, 2014). With qualitative data, as the researcher, I attempted to analyze all aspects of the experience including the settings, the participants, other contributions, and of course the data itself (Mertler, 2020). While reading through transcripts and listening to students' experiences I looked closely and worked carefully to reach conclusions and plausible inferences. By analyzing students' answers and our conversations I could draw conclusions from them and answer my research question of, how students confidence levels were affected by the treatment.

To analyze the Pre and Post Writing Assessment, I used quantitative data. Researchers use quantitative numerical data for inferences, and a combination of methods for calculating inferential statistics (Frey, 2018). They can reach inferences by comparing results. When you compare results there is a hope that there is difference, because that means the treatment had an impact, and the difference could not have only been due to chance (Duesbery & Twyman, 2020). I also used the pre- and post- writing assessment to collect numerical data. The pre-treatment

writing assessment was scored on a proficiency scale that was focused on one learning objective – writing a well-constructed scientific explanation using the CER framework. The scale had three degrees of mastery. On the scale, level 1 was the simplest demonstration of the concept, deemed “novice” at mastery. Level 2 is an almost proficient demonstration; a level 2 student is deemed as “approaching” mastery. And level 3 being a proficient demonstration of the concept, the student is deemed as “proficient” at mastering the objective. The proficiency scale can be found in Appendix E. The students were scored only on whole number increments (no partial credit). Analyzing these results and using normalized gains was a key part to the conclusions I made during my study. Analyzing the numerical data in multiple ways and drawing inferences helped me determine if the treatment had an effect.

CHAPTER FOUR

DATA AND ANALYSIS

Results

Data collection in this study included the results of student surveys, students' interviews, and a writing assessment both before and after the introduction of the CER framework. The collection of this data aided in determining if the CER framework would impact students' scientific explanations, if it would increase the use of evidence to support explanations, and if it would affect students' confidence towards scientific writing.

Impact on Students' Scientific Explanations

The pre-treatment writing assessment was scored on a proficiency scale that was focused on one learning objective: writing a well-constructed scientific explanation using the CER framework. The scale had three degrees of mastery. Like previously stated, the scale ranged from a level 1 to a level 3. Level 1 was deemed "novice" at mastery. Level 2 was almost proficient; the student is deemed as "approaching" mastery. And level 3 being proficient, the student is deemed as "proficient" at mastering the objective. The proficiency scale can be found in Appendix E. The students were scored only on whole number increments (no partial credit). However, when averaging all the scores the mean scores did result in decimal values.

I was able to determine that students did improve on writing scientific explanations. The pre-treatment writing assessment mean score for CER writing was 1.6 and the post-treatment writing assessment mean score was 2.1. The normalized gain was 0.35. This normalized gain is considered a medium amount of gain. In the pre-treatment assessment, 8% of students scored

proficient (*n*=4). In the post-treatment assessment, 33% of students scored proficient (*n*=17). Additionally, the percent of students who scored a level 1 (novice) decreased from 45% in the pre-assessment to only 18% in the post-assessment. These results can be seen in Figure 1.

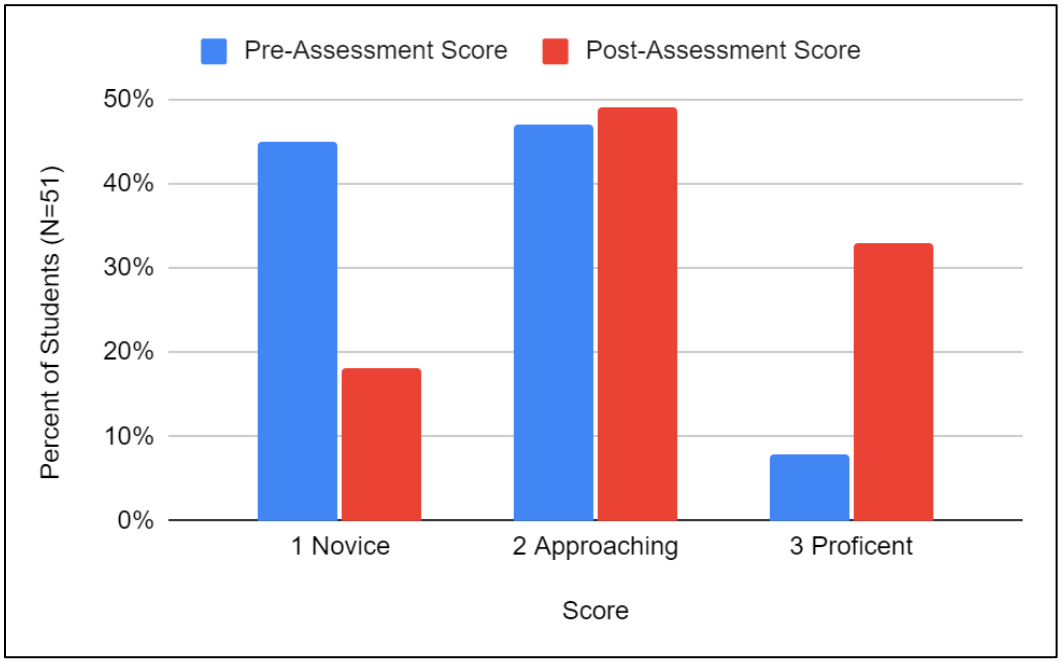

Figure 1. Pre- and Post-Writing Assessment Scores, (*N*=51).

Use of Evidence to Support Explanations

After the treatment, students increased their use of evidence to support their explanations. The increase in student use of evidence is apparent when analyzing assessment scores. When comparing the number of students who scored a 2 or 3 in the pre-treatment writing assessment verses their post-treatment writing assessment, scores on the CER proficiency scale (Appendix E) of "1" indicate that no relevant evidence was cited, while a score of "2" or "3" indicates that a student cited evidence. In the pre-treatment writing assessment 55% of students used or cited evidence scoring a 2 or 3 (*n*=28), compared to the post-treatment writing assessment, where 82%

of students used or cited evidence scoring a 2 or 3 (*n*=42). These data are displayed in Figure 2 and Figure 3.

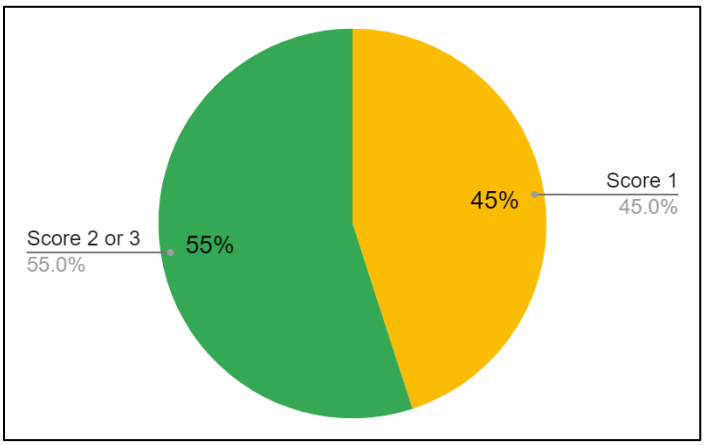

Figure 2. Pre-treatment writing assessment number of students that scored a 2 or 3 versus the number that scored 1.

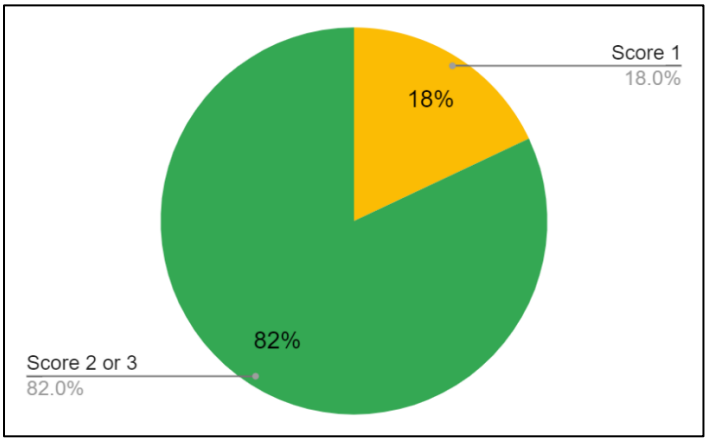

Figure 3. Post-treatment writing assessment number of students that scored a 2 or 3 versus the number that scored 1.

Student data related to the use of evidence and confidence was gathered during student interviews. Before the treatment, when asked how often they make connections between lab work and concepts learned in class most students were uncertain with one student saying, “I think we do it pretty often, but I can’t think of an example.” After the treatment, when asked if the CER framework helped to make those same connections the same student stated, “Yes,

because I find evidence and remember that evidence and where I found the evidence." Other students interviewed reported differently by saying that the CER framework did not help them make connections between labs and concepts learned in class. One student stated that while completing a CER writing that, "…mostly I just use the article or the lab and focus on that." And another student saying, "[CER] doesn't really help because I usually can connect the lab to classwork pretty fast, and I don't need the CER to do that." These statements show that students did not feel like the CER framework helped them make connections between lab work and class content.

In the post-treatment interview, when asked if the CER framework increased their use of evidence to support their scientific explanations, the majority of students stated that they felt that they had improved and were able to use evidence more effectively because of the layout of the framework. One student specified, "[CER] helped me use evidence because it was pretty much required." And another saying, "Yes, because there is a spot that you put the evidence so you remember." And a third student saying, "I've started to [use evidence] more and I've gotten the hang of it and it's a lot easier."

Impact on Students' Confidence Levels

When evaluating results of the Likert survey regarding students' confidence levels, in all areas students' confidence levels increased. When specifically looking at their confidence when writing about science topics, this percentage increased post-treatment by 20%. Also, confidence in their ability to use evidence to support a claim increased post-treatment by 15%. These results are tabulated in Table 2.

Table 2. Pre- and Post- Self-Evaluation Survey Confidence results.

	Pre-Treatment (%)	Post Treatment (%)
I feel confident when writing about science topics.	35	55
I feel confident using data when I am trying to support an argument with evidence.	53	66
I am confident in my efforts on science class writing assignments.	51	65
I am confident in my ability to write a claim in a scientific investigation (lab).	47	67
I am confident in my ability to use evidence to support my claim in a scientific investigation (lab).	61	76
I am confident in my ability to use reasoning that links my evidence to my claim in a scientific investigation (lab).	49	71
I am confident in my ability to include concepts learned in class as part of my reasoning in a scientific investigation (lab).	63	71

Note. Confident students = answered confident or very confident with the statement, (N=51).

Based on students' answers to survey questions, students' knowledge of what is included in a scientific explanation increased. I analyzed if students mentioned that the use of evidence is needed to support a scientific explanation. Initial surveys indicated 41% of students being aware that evidence needs to be included in a scientific explanation (sample size for the 41%). On post-surveys, this number increased with 67% of students indicating that a scientific explanation needs evidence. Additionally, students were asked what they felt was the most difficult part of writing a scientific explanation. On the pre-survey only 9% of students mentioned something about evidence being a difficult component. On the post-survey this increased with 49% of students explaining or outlining how finding and using evidence is a difficult task during scientific writing. This indicates a 40% increase in the awareness that evidence is important to a scientific explanation.

Lastly, when asked in the post-interview how confident they felt while writing scientific conclusions and about their ability to use evidence students all felt like they had improved since the pre-treatment interview. One student said, “I think I’ve gotten increasingly better. At the start, I wasn’t super confident, but I’ve gotten more confident over the quarter.” Overall, in the post-treatment survey and interview students self-reported an increase in their confidence levels towards scientific writing.

CHAPTER FIVE

CLAIM, EVIDENCE, AND REASONING

Claims From the Study

To determine the effects of the implementation of the CER framework on scientific writing after investigations (labs), the original focus questions must be answered and reflected upon.

Impact on Students' Scientific Explanations

First, when evaluating whether the CER framework had an impact on students' explanations after labs there was mixed results. Based on the survey and writing assessment there was a positive impact on students' use of evidence in their explanations. In the post-treatment survey, students showed an awareness of evidence being a crucial part of a scientific explanation. Students also reported that finding relevant evidence can be difficult, but understood the importance of finding and including evidence. In the post-writing assessment there was a significant increase in students scoring a 2 or 3 because they used evidence in their explanation. However, there was a discrepancy between the impact on students' explanation writing and the specific part of the question – the impact it had after investigations (labs). Even though there was a positive impact on students' use of evidence, there was no indication of impact between lab explanations and content learned in class. Based on interview answers, students felt that the CER writing after labs was just focused on the lab and they didn't pull knowledge or content from class. Findings show that students can deepen their understanding through written explanations (Short, Van der Eb, & McKay, 2020). However, my action research did not successfully touch

on this concept. I think that my research needed more time and a few adjustments to answer this question more deeply. Alegado and Lewis (2018) shared that, “the CER approach allows students to think more deeply about the science content and ultimately demonstrate a higher level of understanding” (p. 6). I do think students were given the opportunity to do this, but my data collection tools did not fully allow me to gather enough data to assess any changes in deeper understanding.

Use of Evidence to Support Explanations

Next, there was the question asking if the CER framework would increase the use of evidence to support explanations. After analyzing the data, I concluded that the use of the CER framework did increase the use of evidence and that it overall improved students’ writing. Students’ survey answers indicated that they were more aware of evidence being an important element to scientific writing, and in their post-treatment writing assessment there was an increase in the use of evidence. When introducing the CER framework to students there was little awareness of how to incorporate evidence and reasoning into their explanations. Through direct instruction of the CER framework of writing, students improved in both inclusion of evidence and scientific reasoning. To support explanations, the generic scaffolds can be provided to support students’ writing, like a prompt to include evidence (Delen & Krajcik, 2018). I did provide these scaffolds, including a breakdown of the CER framework. These prompts of what to include in the CER writing, including a place for evidence did help students with their writing. In the post-interview one student stated, “Since there was a spot for [evidence] I remembered to put it in.” These results show that the treatment had an impact on the students’ ability to use evidence and the amount they used evidence.

Impact on Students' Confidence Levels

Lastly, I asked the question if the CER writing would affect students' confidence towards scientific writing. I concluded that the CER framework did lead students to self-report increases in their confidence towards scientific writing. Students reported feeling more confident post-treatment. These results are seen in the Likert survey results. In all categories (Table 2) there was an increase in the percentage of students feeling confident or very confident. Studies show that written argumentation can accelerate students' general academic abilities (Osborne, 2010). This is consistent with the results in the post-treatment interviews as well. During post-treatment interviews students reported feeling more confident in their use of evidence during scientific explanation writing.

Value of the Study and Consideration for Future Research

I consider the skill of writing a scientific explanation a crucial component of a science education. All parts of the scientific explanation – the claim, evidence and reasoning – are important. The values of this study were evaluating and making claims, finding and using relevant evidence, and then using reasoning to create a well written scientific explanation. All these components require critical thinking skills and encourages students to better understand the scientific process. Finding and using relevant evidence to support a claim helps students support their thinking, and then reasoning helps student synthesize their answer and tie it all back together. In revealing the value of the CER framework, this action research has validated my trust in the CER framework to help students construct a solid scientific explanation using claims, evidence, and reasoning.

In the future, further research and steps can and should be conducted to answer the question of the CER framework's impact on students' scientific explanations after scientific investigations. Like I stated earlier, my research was not set up in a way to fully answer this question. By using the writing framework, I wanted students to be able to connect their findings or evidence from the investigation more easily to concepts we were learning in class. I found that the framework did this well with some investigations (labs) but not others. Students only focused on the investigation and didn't always make the connection to class content. In the future, I would be more mindful of what investigations, but really what concepts would work well with CER writing. I would ask myself, what scientific concepts pair well with the CER framework and what concepts would require students to gather relevant and powerful evidence to support their claim/thinking? By asking myself this question I could set up investigations that require students to use inquiry-based thinking and strive to find answers/evidence to support their claims/thinking. After figuring out what types of investigations would pair well with the CER framework, I would like to conduct more action research to look specifically at connections between their writing and concepts in class.

Impact of Action Research on the Author

While the skills related to argumentative and scientific writing are found in the standards and in the NGSS, they were not part of my science classroom or my direct instruction until this research was conducted. I enjoyed implementing more writing into my science classroom. I was pleasantly surprised by students' reactions to this research as well. Students took to the additional writing tasks with stride and I saw improvements every time they wrote a CER. I plan to continue implementing the framework in the future. However, I will implement it more

purposefully. There were some instances during my research that I felt that the CER framework wasn't a perfect fit. There are some labs and articles with which the CER framework works very well, and there are others with which it does not. Based on my research, the CER framework helps students know what should be in their explanations, but they continue to struggle with making connections to scientific concepts learned in class.

In the future, I would like to introduce CER in a more inquiry-based way instead of direct instruction. I would like to introduce new concepts with inquiry labs in which students seek to answer a research question, then organically work on a claim and evidence related to their claim. After multiple rounds of practice with this, I would then introduce the element of reasoning. I feel that if students have a strong ability to construct a claim and evidence first, then the reasoning piece will be learned and adopted more effectively. Studies to do show that producing evidence-based explanations in science can be difficult for middle school students (Delen & Krajcik, 2018). By breaking this process into smaller chunks and introducing one skill at a time, students could more easily master evidence-based explanations. Also, in the future I would like to offer more formative feedback to my students on their CERs.

The information that I have gathered during this capstone research project has shown me the value of reflecting on my own teaching practices. This research experience has been encouraging in that I have seen an implemented treatment lead to several kinds of measurable success. My findings have also shown me that there is, and will always be, room for improvement. I look forward to the future of my classroom because I will use this new gained knowledge to continually engage in more action research to improve my students' learning and my own teaching practices.

REFERENCES CITED

Alegado, K., & Lewis, A. (2018). The four elements of the claim, evidence, reasoning, and rebuttal (CERR) framework. *Science Scope*, *41*(5), 72+.

Charmaz, K., & Belgrave, L. (2012). Qualitative interviewing and grounded theory analysis. In *The SAGE handbook of interview research: The complexity of the craft* (pp. 347-366). SAGE Publications, Inc. https://www-doi-org.proxybz.lib.montana.edu/10.4135/9781452218403

City-data.com. (29, March 2021). *Missoula, Montana.* city-data.com/city/Missoula-Montana.html

Corcoran, T., Mosher, F. A., & Rogat, A. (2009). Learning progressions in science: An evidence-based approach to reform. *Consortium for Policy Research in Education*. https://doi.org/10.12698/cpre.2009.rr63

Delen, I., & Krajcik, J. (2018). Synergy and students' explanations: Exploring the role of generic and content-specific scaffolds. *International Journal of Science and Math Education, 16,* 1–21. https://doi-org.proxybz.lib.montana.edu/10.1007/s10763-016-9767-1

Drew, S. V., Olinghouse, N. G., Faggella-Luby, M., & Welsh, M. E. (2017). Framework for disciplinary writing in science grades 6–12: A national survey. *Journal of Educational Psychology, 109*(7), 935-955. https://doi.org/10.1037/edu0000186

Duesbery, L. & Twyman, T. (2020). How do inferential statistics work? In *100 questions (and answers) about action research* (pp. 113-113). SAGE Publications, Inc. https://www-doi-org.proxybz.lib.montana.edu/10.4135/9781544305455

Erduran, S., Simon, S., & Osborne, J. (2004). TAPping into argumentation: Developments in the application of Toulmin's argument pattern for studying science discourse. *Science Education, 88*(6), 915–933. https://doi.org/10.1002/sce.20012

Frey, B. (2018). *The SAGE encyclopedia of educational research, measurement, and evaluation* (Vols. 1-4). SAGE Publications, Inc. https://10.4135/9781506326139

Greatschools.org. (4, April 2021). *Washington Middle School*. greatschools.org/montana/missoula/615-Washington-Middle-School/#Reviews

Knight, A. M., & McNeill, K. L. (2015). Comparing students' individual written and collaborative oral socioscientific arguments. *International Journal of Environmental & Science Education, 10*(5), 623-647.

Marvasti, A. (2014). Analysing observations. In *The SAGE handbook of qualitative data analysis* (pp. 354-366). SAGE Publications Ltd. https://www-doi-org.proxybz.lib.montana.edu/10.4135/978144628224

McNeill, K. L., Katsh-Singer, R., González-Howard, M., & Loper, S. (2016). Factors impacting teachers' argumentation instruction in their science classrooms. *International Journal of Science Education, 38*(12), 2026–2046. https://doi.org/10.1080/09500693.2016.1221547

McNeill, K., Lizotte, D. J., Krajcik, J., & Marx, R. W. (2006). Supporting students' construction of scientific explanations by fading scaffolds in instructional materials. *Journal of the Learning Sciences, 15*(2), 153-191. https://doi.org/10.1207/s15327809jls1502_1

Meacham, B. (2017). Implementing the claim, evidence, reasoning framework in the chemistry classroom. https://www.chemedx.org/article/implementing-claim-evidencereasoning-framework-chemistry-classroom

Mertler, C. A. (2020). *Action research improving schools and empowering educators* (6th ed.). SAGE.

National Center for Education Statistics. (2019). *Search for public schools - School detail for Washington Middle School.* nces.ed.gov/ccd/schoolsearch/school_detail.asp?Search=1&SchoolID=301857000581&ID=301857000581.

National Research Council. (1996). *National science education standards.* National Academy Press.

NGSS Lead States. (2013). Next Generation Science Standards: For states, by states (life sciences). www.nextgenscience.org

Norris, C., Krajcik, J., & Soloway, E. (2018). Understand NGSS in 5 minutes: Sort of. *THE Journal*. https://thejournal.com/Articles/2018/03/14/Understand-NGSS.aspx?Page=1

Osborne, J. F., Henderson, J. B., MacPherson, A., Szu, E., Wild, A., & Yao, S. (2016). The development and validation of a learning progression for argumentation in science. *Journal of Research in Science Teaching, 53*(6), 821-46. http://dx.doi.org/10.1002/tea.21316

Osborne, J. (2010). Arguing to learn in science: The role of collaborative, critical discourse. *Science, 328*(5977), 463–466, https://doi.org/10.1126/science.1183944

Short, R. A., Van der Eb, M. Y., & McKay, S. R. (2020). Effect of productive discussion on written argumentation in earth science classrooms. *The Journal of Educational Research, 113*(1), 46-58. https://doi.org/10.1080/00220671.2020.1712314

Toulmin, S. E. (1958). *The uses of argument.* Cambridge University Press.

APPENDICES

APPENDIX A

INSTITUTIONAL REVIEW BOARD EXEMPTION

This letter acknowledges receipt of the request for IRB Review and serves as the Approval Letter for your research. Your new **IRB Exempt Protocol # is JP112421-EX**.

Study Title: **Use of Claim, Evidence, Reasoning Writing in a Science Classroom**

The research described in your submission is exempt from the requirement of additional review by the Institutional Review Board in accordance with 45 CFR 690.104(d). The specific paragraph which applies to your research is:

> Research, conducted in established or commonly accepted educational settings, that specifically involves normal educational practices that are not likely to adversely impact students' opportunity to learn required educational content or the assessment of educators who provide instruction. This includes most research on regular and special education instructional strategies, and research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

APPENDIX B

PRE AND POST INTERVENTION SURVEY

General Likert Survey (pre-and post-survey)

This is a survey about your general attitude toward science, and writing. Please answer the following questions honestly and to the best of your ability. This survey is anonymous and will have no impact on your grade in this class.

1. In your own words, what is a scientific explanation?

2. What should a scientific explanation include?

3. What is the most difficult part of writing a scientific explanation?

Use the scale to determine the number that best represents your own confidence on the specific question. Circle the number that best describes you.

I feel confident while conducting investigations (labs) during science class.

1	2	3	4	5
Not confident		Somewhat confident		Very confident

I feel confident when writing about science topics.

1	2	3	4	5
Not confident		Somewhat confident		Very confident

I feel confident using data when I am trying to support an argument with evidence.

1	2	3	4	5
Not confident		Somewhat confident		Very confident

I am confident in my efforts on science class writing assignments.

1	2	3	4	5
Not confident		Somewhat confident		Very confident

I am confident in my ability to write a claim in a scientific investigation (lab).

1	2	3	4	5
Not confident		Somewhat confident		Very confident

I am confident in my ability to use evidence to support my claim in a scientific investigation (lab).

1	2	3	4	5
Not confident		Somewhat confident		Very confident

I am confident in my ability to use reasoning that links my evidence to my claim in a scientific investigation (lab).

1	2	3	4	5
Not confident		Somewhat confident		Very confident

I am confident in my ability to include concepts learned in class as part of my reasoning in a scientific investigation (lab).

1	2	3	4	5
Not confident		Somewhat confident		Very confident

APPENDIX C

STUDENT INTERVIEW QUESTIONS

Student Interview Questions BEFORE treatment:

1. How confident do you feel while writing scientific conclusions after science investigations (labs)? Why?

2. How confident do you feel in finding and using evidence to support your ideas while writing a scientific conclusion? Why?

3. How often do you make connections between lab work/data and the concepts we learn in class?

Student Interview Questions AFTER Treatment:

4. Did the use of the CER framework increase your use of evidence to support your explanations in lab write-ups?

5. Does the use of the CER framework help you when writing scientific conclusions? If so, what was helpful about it? If not, what wasn't helpful about it?

6. While using the CER framework, how confident do you feel while writing scientific conclusions after science investigations (labs)? Why?

7. Does using the CER framework help you make connections between lab work/data and the concepts we learn in class? Why or why not?

8. While using CER, how confident do you feel in finding and using evidence to support your claim?

APPENDIX D

PRE AND POST WRITING ASSESSMENT

Pre and Post Writing Assessment

CER: Claim Evidence Reasoning

Question: How can the amount of acid rain affect the rainbow trout population?

Research and Data: Producing electricity by burning fossil fuels (coal, natural gas, gasoline) releases sulfur dioxide and nitrogen oxides into our atmosphere. These compounds contribute not only to global climate change and poor air quality, but also react with water vapor and oxygen in the air to form harsh acids that fall as precipitation – rain, snow, and hail. These acids also accumulate on Earth and when this acid rain washes into streams and lakes it increases the acidity of the water.

In order to study the effects of acid rain on rainbow trout populations, scientists simulated a freshwater stream environment and observed the changing population of trout as they changed the acidity levels of the water. Below is the data:

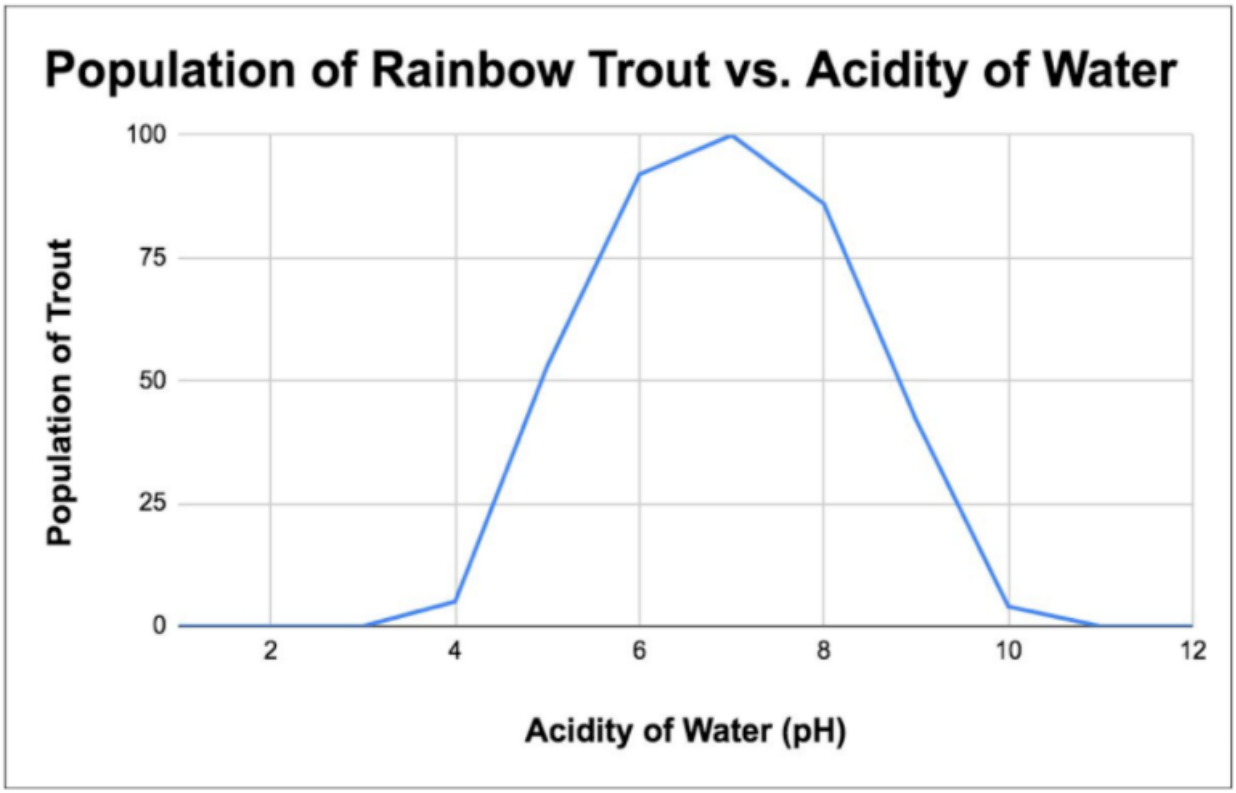

Figure 1: Graph showing the relationship between the trout population and the acidity of the water.

Pre and Post Writing Assessment

CER: Claim Evidence Reasoning

Question: How can the amount of acid rain affect the rainbow trout population?

C Claim	Answer the question in one complete sentence:
E Evidence	Using the graph, provide at least two pieces of data to support your claim:
R Reasoning	Explain how or why the evidence supports the claim using scientific reasoning:

APPENDIX E

CER WRITING PROFICIENCY SCALE

CER Writing Proficiency Scale

Claim: A conclusion that answers the original research question.
Evidence: Scientific data that supports the claim. The data needs to be appropriate and needs to sufficiently support the claim.
Reasoning: An explanation that links the claim to the evidence and explains why the evidence supports the claim based on scientific concepts.

Proficient - 3	Approaching - 2	Novice - 1
The claim is **specific, accurate** and answers the research question completely. Provides multiple pieces of **relevant** and **sufficient** evidence from an experiment or scientific investigation to support the claim. Provides accurate and **complete** reasoning that links **all** evidence to the claim, and uses scientific concepts to **correctly** explain how and why the evidence supports the claim.	The claim is **mostly accurate** and mostly answers the research question. Provides pieces of evidence that are **mostly relevant** from an experiment or scientific investigation that **mostly supports** the claim. Provides a **somewhat complete** reasoning that links evidence to the claim, and **somewhat** uses scientific concepts to explain how and why the evidence supports the claim.	The claim is **inaccurate** or incomplete and does not answer the research question. Provides little to no pieces of evidence that are **not relevant** and/or do not support the claim. Does **not** provide a complete reasoning that links evidence to the claim, and does not use scientific concepts to explain how and why the evidence supports the claim.