WHAT EFFECT DOES THE CLAIM-EVIDENCE-REASONING FRAMEWORK HAVE ON TEACHING AND LEARNING IN A MIDDLE SCHOOL CLASSROOM?

by

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DEDICATION

I dedicate this capstone to my family, personally and professionally. Your support, love, and encouragement throughout this whole process has been unbelievable and I could not have done this without you!

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ABSTRACT

A technique for evidence-based writing called claim, evidence, reasoning was integrated into a middle school science classroom to help students be able to gain the ability to explain not only what happened, but also why. This study analyzed the use of argumentation and the ability of students to make observations through their 9-week chemistry unit utilizing rubrics, student interviews, Likert surveys, and confidence surveys to gauge student success. The results indicated that students improved the quality of their responses on labs where they were prompted to write a claim, evidence and reasoning.

INTRODUCTION AND BACKGROUND

Context of the Study

Columbia Falls Junior High School is a 6-8 public school in a K-12 school district that services 456 students. The school population is fairly evenly dispersed with 46% female and 54% male students with 88% of the population identifying as Caucasian. In each school day, I encounter 134 of those 456 students, teaching 7th and 8th grade general science. Every day, it is my goal to have my students walking away with more information than they walked into the classroom with as well as the ability to connect their experiences to the content that is being given to them. Any science teacher will tell you that it's valuable for students to be able to explain phenomena, not just answer questions or define vocabulary words that demonstrate what they have memorized. The challenging part is to teach students who are both college and career bound that constructing explanations is paramount to all of this.

The Claim-Evidence-Reasoning (CER) framework teaches students to think at a deeper level of inquiry that is needed to be successful academically and in the real world. It is said that analytical thinkers are capable of deducing cause and effect, analyzing data and interpreting results, evaluating reasonability, and synthesizing information. Argumentative reasoning is a skill that takes practice. Students who are taught to successfully use the CER framework are provided with a bridge to exploration in other content areas as well as shown how to think critically in developing reasonable explanations.

The purpose of this action research project is to successfully implement the Claim-Evidence-Reasoning (CER) Framework in my 7th grade classroom to raise student interest and create a classroom in which students experiment and build with things in the classroom; learning real-world skills that scientists and engineers, who discover knowledge and problem solve, use to answer questions and solve problems objectively.

Focus Questions

My primary action research question was, What effect does the Claim-Evidence-Reasoning (CER) Framework have on teaching and learning in a middle school classroom?

My sub-questions include the following:

1. How do I develop students' ability to consistently create better scientific explanations and arguments?
2. Can the Claim-Evidence-Reasoning (CER) framework increase the use of evidence to support a claim in lab reports?
3. How does the CER framework affect student attitudes toward science?
4. Is the CER framework allowing students to feel empowered to explore investigative questions of their own?

CONCEPTUAL FRAMEWORK

Use of Argumentation in Science

According to the Next Generation Science Standards (NGSS) and the Framework for K-12 Science and Engineering, all science students must be able to engage in argumentation based on evidence. Specifically, if students are going to be successful in their post-secondary education or careers, they must be able to integrate knowledge and ideas, delineate and evaluate claims and arguments, and asses the reasoning used in the arguments (Bulgren, 2014).

To teach students about science, they must be engaged in the disciplinary practice of science that specifically focuses on constructing reliable claims that effectively explain nature. This construction of knowledge occurs through argumentation where students are required to support claims with evidence and consider alternative explanations. Therefore, through practice, it is important for students to understand and participate in how explanations are constructed, questioned, evaluated, and revised through the practice of argumentation (Berland & Reiser, 2009). Scientific argumentation is paramount as it is an attempt to validate or refute a claim based on evidence and reasoning (Sampson & Schleigh, 2016, p.ix).

The National Research Council's framework for K-12 science education places a strong emphasis on scientific inquiry. The goal of this emphasis is to help students in their ability to blend scientific skills with real world knowledge. This is where the NGSS standard regarding Developing and Using Models in the science and engineering practices stems from. It asks science teachers to aide students in not only using these theories and models, but also to carry out that use in the same manner as professional scientists and engineers by shaping hypotheses and finding solutions to help create explanations based on observations from the real world around them. Constructing Explanations and Designing Solutions, an additional science and engineering practice, connects students' imagination to their logic by requiring them to use models that represent the physical world (NRC, 2012).

These skills, while emphasized by professional organizations are widely accepted, they're not necessarily a part of regular classroom instruction. There have been several studies conducted that would indicate that students lack the skills necessary to correctly construct an argument within the science classroom. A study was conducted within eight classrooms (*N*=72) and it was found that only 18.1% of students provided explanations with the three expected components; claim, evidence, and reasoning (Ruiz-Primo, Li, Tsai, & Schneider, 2008). The study goes on to state:

> The majority (40.3%) provided only claims without any supporting evidence, and 9.7% provided only data. Also, 19% of students did not provide any "form" of explanation. These results suggest that claim is the easiest component for students to construct and for teachers to focus on (p.19).

With continued emphasis on explanations, teachers who are able to implement this in their classroom, by using a variety of techniques; notebooks, lab activities, and worksheets that still utilize structure but allow students to think independently, will help students to better write explanations that contain evidence.

In order for students to effectively state a scientific claim, they must create a statement about the results of their experiment which is rooted in evidence gathered during an experimentation event and supported with reasoning that links the evidence to a claim. Current adopted science practices and standards strongly emphasize the relevance of argumentative writing in the science classroom. In reference to students' ability to utilize scientific inquiry, the National Science Teachers Association (NSTA) recommends that science teachers help students "learn how to draw conclusions and think critically and logically based on their evidence" (National Science Teachers Association, 2004). In this way, students are given tools within science that help them to ask questions about the world and answer those questions through scientific investigation.

Helping students develop strong scientific arguments during discussion takes time. Students are continually needing to be provided with writing prompts that are scaffolded for different learners over time. In providing students with a variety of supports, they will be able to better make sense of their data and learn how to appropriately share the results of their inquiry investigations which have been justified through effective use of evidence and reasoning to support a claim.

The middle school students I encounter within my classroom have difficulty thinking critically about concepts introduced and are accustomed to traditional thinking in which the information is memorized in order to take a test and then forgotten. By giving students the ability to explain themselves and ultimately think, read, and speak about real world problems in a persuasive manner, it is intended that they will have improved overall abilities to determine the right answer in any scenario. Ionas, Cernusca, and Collier (2012) stated the following:

> To comprehend the material taught, students need to: (a) relate new concepts to knowledge they already possess, and (b) use prior knowledge to understand these new concepts and synthesize new knowledge. When students struggle with concepts they learn, instructors will typically attempt to remedy the situation using a variety of methods at their disposal (p. 349).

By providing students with different methods to create and form explanations, students can be provided with opportunities to explain their thought processes through their explanations from evidence. Additionally, critical thinking skills are directly linked to making positive life decisions over intelligence. Butler, Pentoney, and Bong (2017) stated:

> Over one hundred years of research on intelligence testing has shown that scores on standardized tests of intelligence predict a wide range of outcomes, but even the strongest advocates of intelligence testing agree that IQ scores… leave a large portion of the variance unexplained when predicting real-life behaviors… critical thinking ability had greater association with real life decisions, and it added significantly to explained variance, beyond what was accounted for by intelligence alone (p. 44).

In effective utilization of the CER framework, students are able to think critically, strategically, and creatively. In shifting a science classroom to a room with inquiry at the heart of all learning events, the teacher then becomes a facilitator of knowledge, with students taking the lead.

METHODOLOGY

Treatment

My action research project took place over the course of my Matter and its Interactions unit of learning. The curriculum I utilize is Kesler Science and I have found that students enjoy using it because it's so interactive, putting inquiry-based learning at the center of every learning event. Please see Appendix A for the full schedule of topics and assessment delivery dates.

During the course of the project based learning (PBL) unit, students acquired information through projects, inquiry investigations and note taking activities to understand the learning concepts of atoms; molecules; elements, compounds, and mixtures; balancing chemical equations; and chemical and physical changes. Project based learning is a teaching method in which students are able to gain knowledge and skills by working for an extended period of time to investigate and respond to authentic and engaging questions and problems. Over the course of the unit, students completed six different inquiry labs using the CER framework. The framework was assessed using the same rubric throughout the course of the treatment (Appendix B). This rubric aligns directly with the Kesler Science curriculum that I utilize and was given to students throughout the course of the entire school year for all lab reports.

The treatment for this study was intended to determine the effectiveness of using the Claim-Evidence-Reasoning framework to develop students' ability to make evidence-based claims to think about science and connect their experiences to better explain phenomena. This was done utilizing inquiry labs that were aligned with the PBL unit and presented to the students to give them hands-on experiments to connect their understanding. At the end of each lab, students answered the essential question of the experiment itself with a CER statement. Pre-treatment, students were asked to respond with a claim after an inquiry based lab, which answered the question, “How does the response rate of the nervous system differ between auditory, visual, and tactile (touch) stimuli?” Next, students had to gather data that would help them answer the question and also figure out how to gather evidence that would help them to investigate in such a way that would support their claim. For the next nine weeks, students were given several lab experiments that allowed them to work towards creating better evidence-based explanations, each lab requiring a claim-evidence-response at the end, for six different activities in total. All of these labs centered around a different guiding question so that students were able to apply their understandings in various ways throughout the entire learning event. At the end of the treatment, students completed an inquiry lab in which they answered the guiding question, “What is the difference between a physical and chemical change? Can these be observed during the process of saponification?”

At the conclusion of each of the labs, as students turned in their lab work and it was graded based on student’s responses for each individual claim, evidence, and reasoning section. Using the CER grading rubric, each student was assessed and their score for each individual section, as well as a cumulative total score was calculated (Appendix B). At the conclusion of the treatment, each of these scores was broken down to be assessed.

Instruments

As can be seen in Table 1, I used a variety of instruments to collect student data throughout the treatment.

Table 1. Data Triangulation Matrix.

Research Questions	Data Source		
	1	2	3
How do I develop students' ability to consistently create better scientific explanations and arguments?	CER Rubric – Pre, mid, and post unit treatment	Student interviews	
Will Claim-Evidence-Reasoning (CER) Framework improve the frequency of evidence used to support conclusions in lab reports?	Pre, mid, and post treatment Assessment	CER Rubric – Pre, mid, and post unit treatment	
How does the CER Framework affect student attitudes toward science?	Student Interviews	Confidence Survey – Pre and post treatment	Likert survey
Does the CER Framework allow students to feel empowered to explore investigative questions of their own?	Student Interviews	Likert Survey	

The first instrument is the CER grading rubric, which can be seen in Appendix B. This rubric allowed me to assess student thinking objectively, as well as the accuracy of their science understanding. This rubric was used to support students where their writing needs to be improved and for and for me as their teacher to be able to subjectively analyze student work. This rubric was designed specifically to examine primarily the science content and secondarily the structure and organization of the ideas being communicated. In utilizing this rubric, I was able to provide feedback to students and address the writing and language components of the students' work.

All students were graded using this rubric for each of their inquiry labs six different times throughout the administration of this treatment. As this is the primary quantitative data that was taken for my research, a T-test was used to analyze the data to determine trends throughout the administration of the treatment to determine if students were able to develop their ability to use the CER framework.

The overall goal of the learning environment was to support students in defending their claims about how or why the natural world works through evidence and reasoning. Prior to treatment, students struggled to justify claims with evidence and to engage in arguments. It is because of this that trends in growth for the individual claim, evidence, and reasoning sections were looked at to examine student improvement in each category.

The second instrument used for the treatment was a Likert survey (Appendix C). This was administered to all students prior to the treatment beginning as well as post treatment. In using the survey, I was able to better answer my sub questions about students' attitudes and confidence toward using the CER framework as well as science. As a Likert survey is considered one of the most reliable ways to measure opinion, I was able to pinpoint specific areas where I needed to be improving my practice.

The third instrument used over the course of the treatment was student interviews (Appendix D). Interviews were conducted in a variety of settings, during my prep period as students were in study halls, within the classroom as students completed their work, as students rotated through lab stations, and remotely through online learning. There was a station to the side of my room set-up to meet with students one-on-one. I then categorized students' responses initially into ability levels; gifted and talented, average, and special education.

During each interview, the information was recorded utilizing the Voice Memos application on my iPhone, and I also took notes from the student's responses using pen and paper. Following the interview, I used the recordings to double check the contents of the interview and the information was transcribed into a word document.

The interview data was then organized and coded using a series of symbols and colors in the margins of the transcribed pages. After the data was organized, it was analyzed to see changes in individual student responses as well as among students as a whole in regard to their attitudes toward science.

The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained throughout the course of the study (Appendix E).

DATA AND ANALYSIS

Results

The results of the pre-treatment Matter and Its Interactions Unit lab indicate that the 7th grade median score was 67% (*N*=59). The range of these scores showed a 7-point range with scores from 16% to 75%. Fifty percent of the students fell within 41% and 56%, an almost two-point range. The results of the post-treatment CER activity show a median score of 58% with a range from 42% to 83%, a 5-point difference. Fifty percent of the students fall within 42% and 75%, a 4-point range (Figure 1).

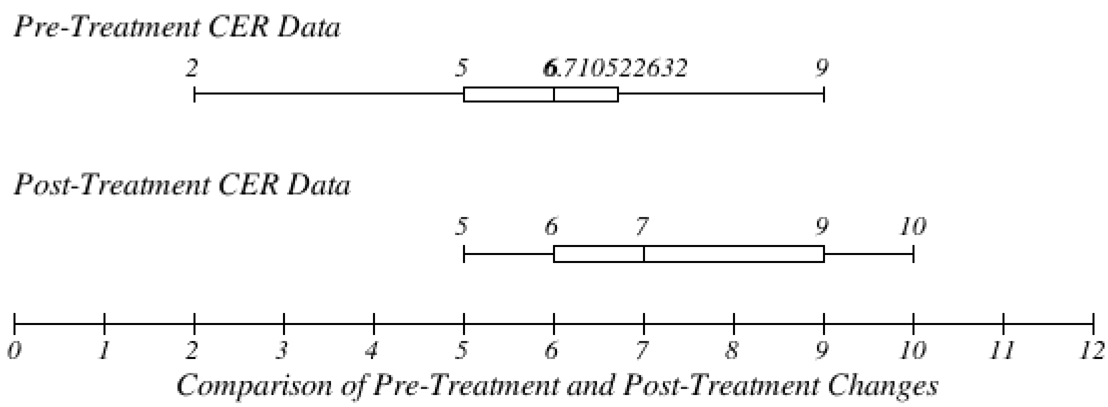

Figure 1. Comparison of Pre- and Post-Treatment CER data.

These results, overall, show an increase in their ability to make evidence-based claims. The overall average results, shown below, showed an increase in student's skills by 9% throughout the course of the treatment (Figure 2). Within the graph, it can be seen that through the treatment, students scored at 50% overall given the rubric for CER. Post-treatment, students scored a 59% overall using their CER rubrics with the largest growth in the area of providing evidence. Additionally, it can be seen that pre-treatment, the range of CER responses was quite large, as compared to post-treatment. This supports the idea that students who began with little to no understanding of the framework saw great improvements throughout the course of treatment.

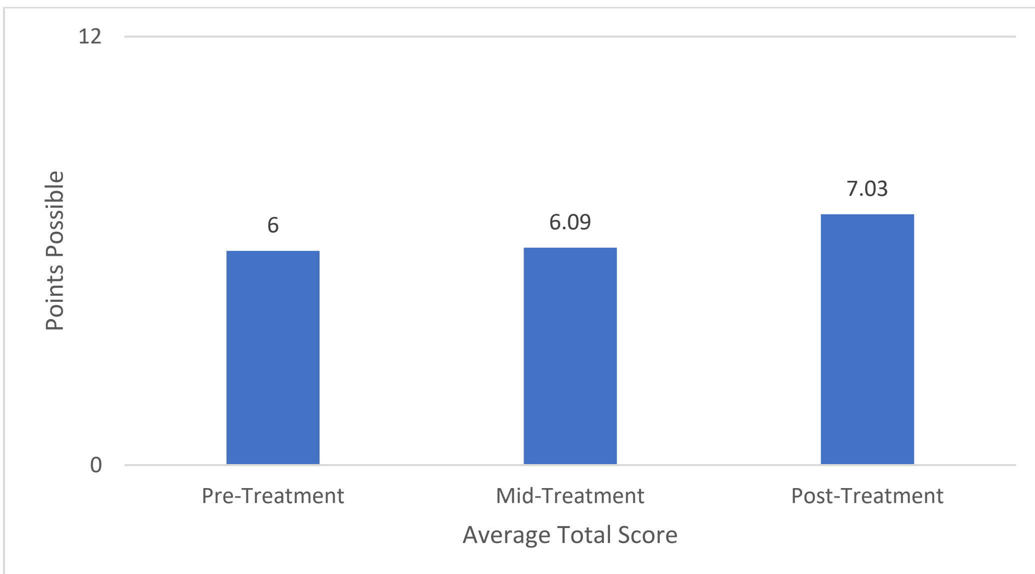

Figure 2. Overall Treatment Mean Results.

Seventh-grade student reports of confidence with regard to science that while 91% of students stated that they like coming to science class, only 78% of students felt confident in their ability to synthesize information surrounding a lab activity (N=47). Seventy-two percent of students agreed or strongly agreed that they pay attention to the teacher in science. While sixty-eight percent of the students agreed or strongly agreed that they work as hard as they can and pay attention in science (Figure 3).

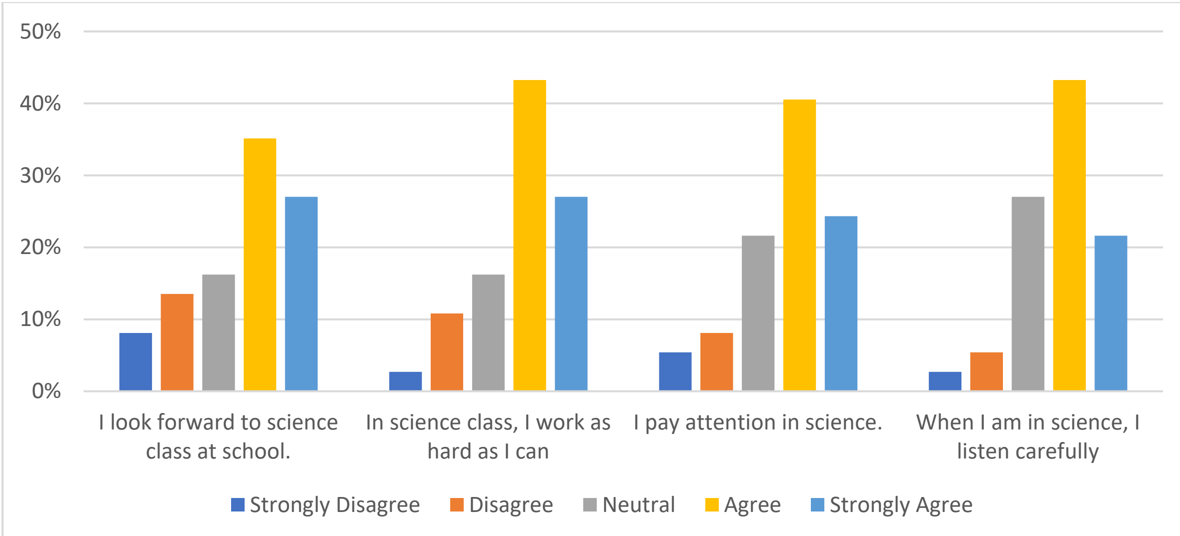

Figure 3. Pre-Treatment Science Attitudes Survey.

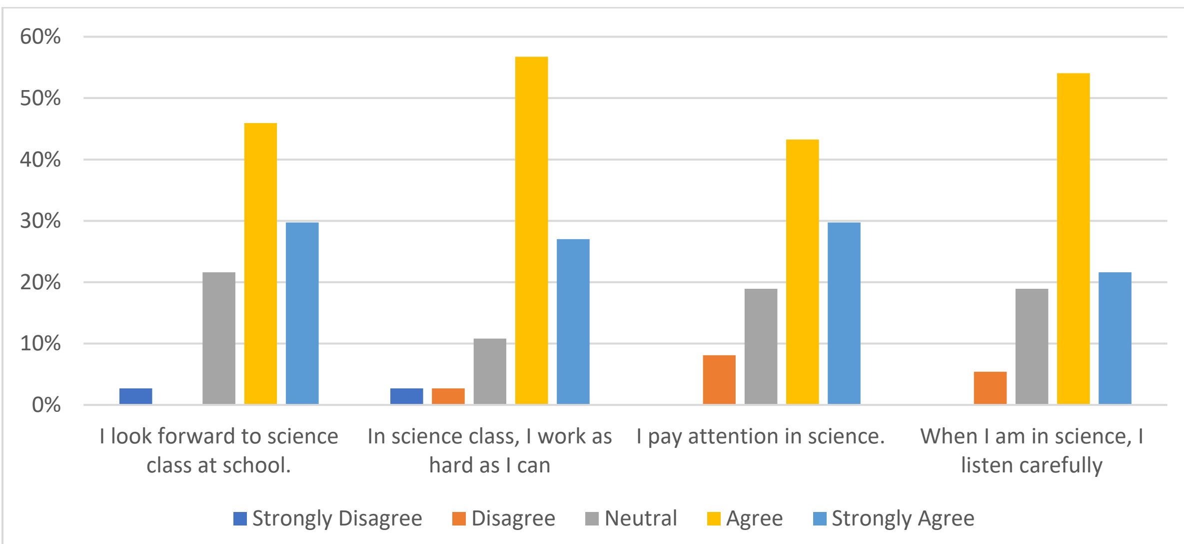

Figure 4. Post-Treatment Science Attitudes Survey.

Level of agreement was compared pre- and post-treatment to determine the variance towards attitudes about science. Overall, there was a 19% increase in agreement about looking forward to science class (Figure 5). This is considered important in terms of student engagement and attitudes toward the classroom space in general. Additionally, during the course of the treatment, there was a net change of 14% in students focus on working as hard as they can (Figure 6). This does not reflect very high gain with regard to behavioral engagement. When asked why they answered the way that they did, one student reported, “because it’s okay it’s just harder to learn than any other classes for me.” The same student also reported, when asked if they work as hard as they can in science that, “I answered the question the way I did because I usually will try and focus as much as I can but sometimes someone will start a conversation, and I’ll get a little side tracked and not get as much done as usual.” When asked about the ability to pay attention in science class, one student responded, “it’s sometimes hard for me because I have a lot of stuff to think about.”

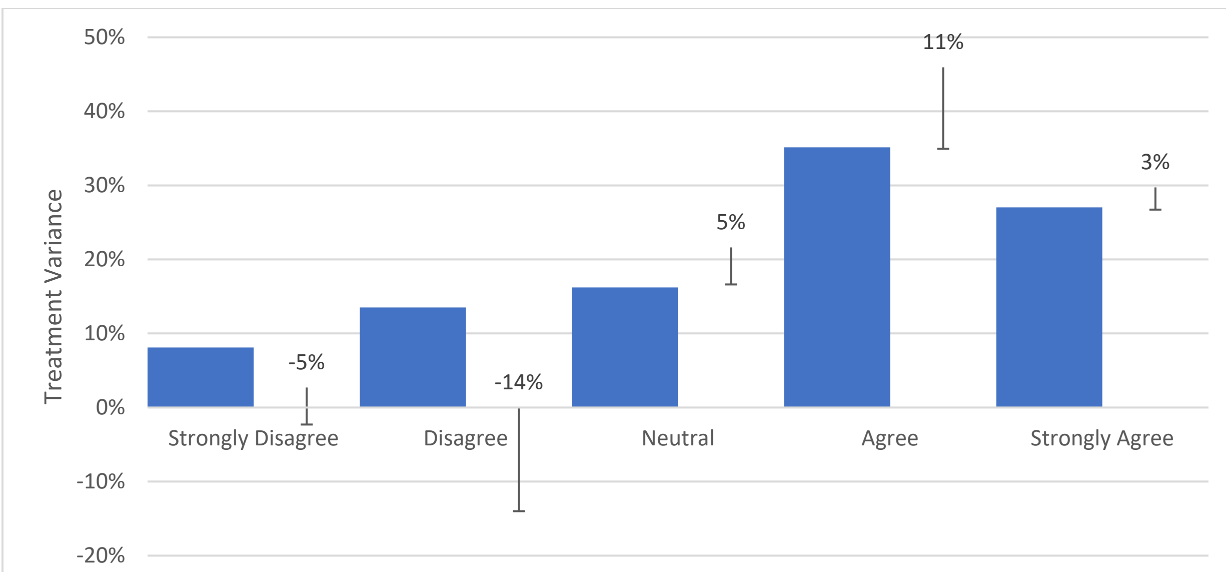

Figure 5. Survey Variance Towards Attitudes About Science.

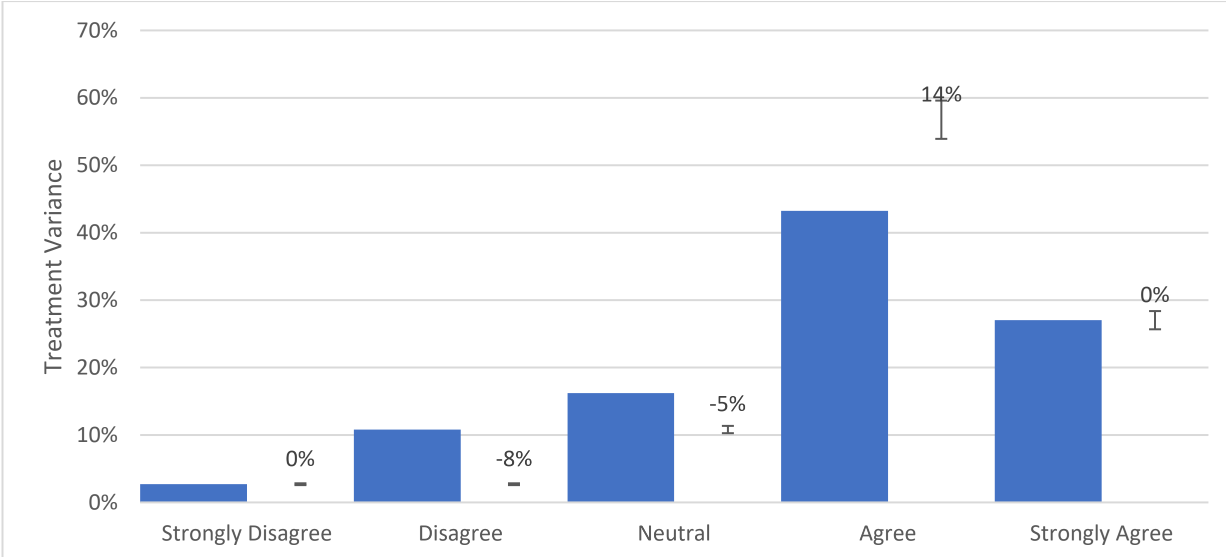

Figure 6. Survey Variance Towards Work Effort in Science Class.

Students written explanations using the CER Framework were evaluated prior to, during, and after treatment. Prior to treatment, 52% students made claims that answered the original question investigated. After treatment, only 57% of students made a claim that demonstrated mastery. One student writing, “It matched my hypothesis, so it was right.” Throughout the course of treatment, students did not make large gains in the ability to create claims that consistently were accurate and complete. Over the course of the treatment, however, students made incredible progress in their ability to provide sufficient evidence to support their claims. Pre-treatment only 46% of students could provide appropriate and sufficient evidence to support the claim that they had made. After treatment, 59% of students were able to include measurements or observations that had been analyzed and interpreted to support their claim. Initially, 52% of students were able to correctly reason as to why the evidence is included or how it supports the claim in their reasoning, but not both. Post treatment, there was a 7% gain in students’ ability to do this, with 59% of students providing reasoning at the mastery, or partial mastery level (Figure 7). This would suggest an overall improvement in student's ability to effectively provide evidence-based explanations to support their claims in lab activities.

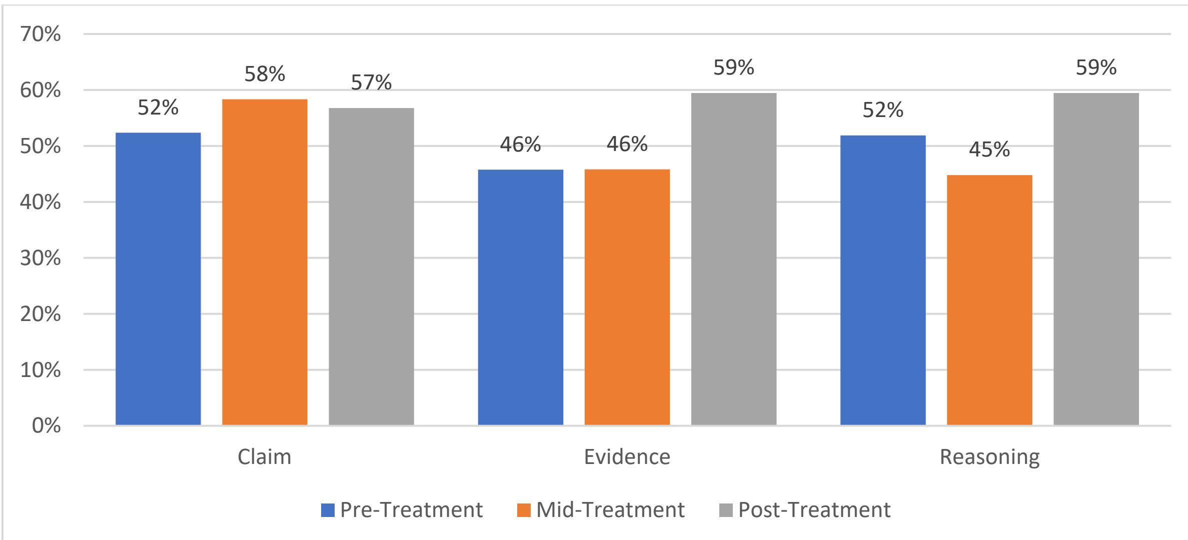

Figure 7. Evaluation of Student Explanations.

Normalized gains were calculated to determine the students' ability to write scientific evidence-based explanations (Figure 8). There was a gain of 0.055 when making claims and 0.073 when reasoning. Because these numbers are <0.3 they are considered to be low gains and therefore, not statistically significant. The area where there was a substantial increase, was in the field of evidence. Students' ability to use evidence that was sufficient to support the claim showed a gain of 0.175, a medium gain, that would demonstrate a very statistically significant change. This gain is likely because so much emphasis was placed on understanding why including useful evidence from the lab itself was important for those reading your lab reports to understand your results. The data reflects that students had difficulties in their ability to use scientific principles in their reasoning but that they were able to utilize the individual lab components to be able to make accurate descriptions from their work. This would indicate that the small increases in reasoning scores was due to more students linking their evidence to their claims, but not a majority of the time.

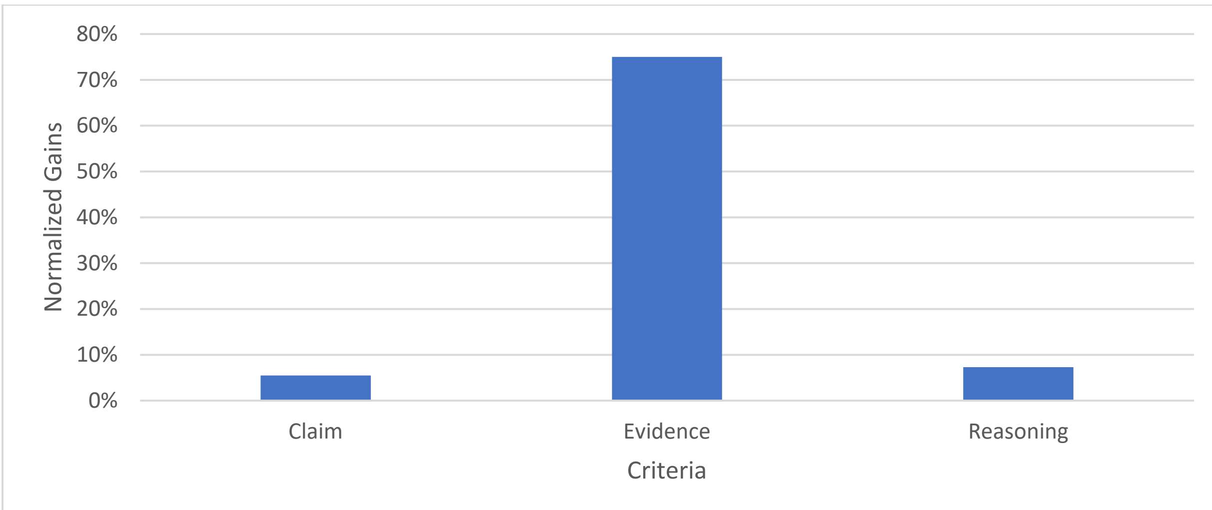

Figure 8. Normalized Gains of Scientific Explanation Criteria.

In student interviews, students were asked to reflect on the overall process of evidence-based explanations and how that related to their attitudes and feelings about science class, overall. Prior to the treatment, students were asked how comfortable they felt using the CER model and one student responded with, “I guess it’s pretty difficult because it doesn’t make any sense about why you would use it.” Post-treatment, that same student stated,

> It just makes sense that you would use something like this. I want to be a welder when I grow up and if I can’t explain to someone why a piece needs repaired; they aren’t going to pay me any money to do the work. Someone else will come along and they’ll get the money for the project. So, you have to be able explain why something connects to the question.

This would indicate that the student gained the understanding of why this methodology is important in overall learning. While not all students reported as thoroughly post-treatment, 100% of students (N=9) were in agreement that this is an important skill set to learn as a student in order to gain for real-world application.

CLAIM, EVIDENCE AND REASONING

Claims from the Study

This study was able to demonstrate that using the Claim, Evidence, Reasoning (CER) framework, that students can make evidence-based conclusions to show their understanding of content. Throughout the whole process, I was able to better see how students effectively gained and processed information. They were able to draw conclusions and not only write them down, but also explain why their position was important to them. As a teacher, it is always my hope that students are challenged in my classroom, but also that they're being given information that they can use when it comes time for them to go out into the real world. My research targeted specific areas to help me gauge if I am doing that.

In response to my primary question, "What effect does the Claim-Evidence-Reasoning (CER) Framework have on teaching and learning in a middle school classroom?," I found that through use of a CER rubric, surveys, and interviews with students, that they gained confidence in their ability to make evidence-based conclusions that supported a claim based on a given guiding question. Overall, thirty-six percent (N=59) of the students CER rubric scores increased from pre- to post-treatment and in follow-up with student interviews, three different students reported that making connections through lab activities helps them to learn. The written explanations of phenomena from the students show an overall increase in focus on evidence. From this, I learned that students don't necessarily see how they saw their actual change in ability to use argumentation, but they did increase their ability to implement evidence into their rationale. The increase in grades over the course of the treatment would indicate that students had begun to grasp the material and their ability to reflect on its meaning and level of application in the real world.

In response to my sub questions about developing students' ability to consistently create better scientific explanations and arguments and student attitudes toward science, I discovered with qualitative data pre-treatment that the majority of students, 67% (N=32), believed that science had a lot of details and it could be difficult because there are so many new words. Post-treatment, these attitudes were different with students reporting 78% of the time that science can be difficult, but if you can relate your personal interest to what you're learning then it's much easier. This increase in attitudes would indicate that students were working hard to create better scientific explanations and arguments based on the application to the world around them.

With regard to my sub question about the CER framework improving the frequency of evidence used to support conclusions in lab reports, students improved their understanding of how to make evidence-based arguments. Prior to the treatment, students averaged 50%. Following the treatment, the average increased to 59%. While this is not as dramatic an increase as I had hoped, students saw a 13% percent increase in their ability to focus on using quality evidence when writing explanations of scientific phenomena. Because of this, the number of explanations that focused on confirming predictions was reduced and students became able to better think critically while I, as the teacher, was able to move away from the center of attention in student learning.

My final sub-question regarding the CER framework and if it was allowing students to feel empowered to explore investigative questions of their own yielded the most disappointing results. Just from visual analysis and my journal of reflections, students did not ask questions that would have helped them to further their thinking to ask questions of their own. Additionally, at the end of the treatment, one student still reported, “there are lots of details in everything, and it is all very hard to remember.” However, in the Likert survey results, students responded 81% of the time ($N = 32$) that post-treatment, doing experiments in science class is not frustrating. This is compared to 21% of students feeling this way prior to the treatment. While they did not feel like they wanted to explore investigative questions of their own following classroom investigations, they did gain a stronger interest in science, a better attitude toward the subject, and unknowingly had the confidence to want to excel.

Value of the Study

The purpose of this was to examine the effect of the CER framework on both teaching and learning in a middle school classroom. I believe that this research will have a tremendous impact on my teaching. The experience has inadvertently forced me to become a more reflective and intentional teacher while allowing me the space to create something that is more focused for my students. My focus on the claim-evidence-reasoning framework was able to establish a consistent and thoughtful routine in my classroom and really helped to establish for students that what we are doing will always be able to connect to the real-world.

Conducting this research, at first, had an interesting impact on our classroom environment. Because I was asking more of students, in that they needed to think further, they initially struggled significantly. However, once they began to understand the purpose of what we were doing more clearly, it became an opportunity for them to think at a higher level and want to be more successful. Lab activities have always broken up the monotony of a traditional science classroom and have always helped students to not only engage, but express how quickly class seems to go by. When kids are engaging at this level, it's really something that I very much look forward to and it helps me to feel motivated to continue with a higher level of enthusiasm for the topic. Additionally, even though the activities used still needed to be created, when the students were carrying out their lab activities, I was able to take a seat from a birds-eye view to help regulate and clear up any confusion, but I could step back because they were fully invested in the activity taking place.

Prior to the research taking place, I really took some time to reflect on what would be most meaningful for my students to take away from my classroom. This even led me to change my intended capstone project as my overall goal was to have students leaving my classroom with more than what they entered into my room with, to have confidence in their science abilities, and to be able to relate what they were completing to the real world. I really feel like this was observed in my classroom while my students were present and that the work I did to accomplish these goals was meaningful and worthwhile. While there are absolutely areas that can be improved and not every student walked out of my classroom with a lifetime of love for science, the large majority of students responded well to the treatment.

My research is also applicable to other teachers who are seeking ways to help student engage deeper with the content. This model of teaching, while daunting at first, is a really good way to focus on real-world application and to incorporate different levels of learning for all different students. Additionally, in my classroom it has fostered an environment of not just interaction but also collaboration. By focusing on evidence-based application, the benefits of what students are able to take from my classroom will apply to not only their in-class experiences, but also beyond the classroom.

The biggest take-away from my research was that if I make little, lasting changes in my work now, the lasting takeaways for my students can be tremendous. While I wasn't sure the magnitude of impact my work would have, I do believe that the students who saw the most tremendous gains, would not have otherwise. For them, it shifted their whole mindset and approach to learning and that is a very powerful thing.

Impact of Action Research

I am considering which steps I want to take moving forward from this. I absolutely plan to continue using the CER framework in my daily classroom routines, but I also plan to implement more project-based learning into my classroom. This was the first time any of my students had been introduced to this concept which, at a seventh-grade level, can be a very powerful learning tool. So much of what is done in the middle school science classroom is done to foster good science habits and help students to establish a positive relationship with science. By giving students more applicable opportunities to learn, I will be accomplishing just that.

I implemented this treatment plan in my fourth year of teaching science and second year at Columbia Falls Junior High. While I am still becoming familiar with my curriculum, I think that this treatment plan has helped me to feel more confident in my knowledge base regarding science content. This is because I am able to relate it for my students more clearly in helping them understand overall application to the real world, even though it may not be towards their specific area or subject of interest.

I would not only like to continue to integrate this methodology into my own curriculum, but I would like to be able to help empower my colleagues to do the same in their classrooms. While initially, this is a lot of work and a complete shift in the traditional teaching mindset, the payoff for both teacher and students is tremendous. By bringing this to my team, I think that full, consistent integration would be nothing but a positive thing. Because I feel that this was a successful project and I have so much positive momentum moving forward, I believe that that energy will be contagious to integrate these ideas through my department.

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APPENDICES

APPENDIX A

TOPICS AND SCHEDULE

	Topic	Activities	Tentative Dates
Week 1	Nervous System	Intro, Station Lab, Notes, Inquiry Lab	December 9-13
	Conduct Student interviews Administration of confidence survey/Likert survey CER Pre-assessment		
Week 2	Atoms	Station Lab, Evidence Project	December 16-20
Week 3	Atoms, Molecules	Evidence Project, Synthesis, Station Lab	January 6-10
Week 4	Molecules, Elements, Compounds & Mixtures	Inquiry Lab, Stations Lab, Notes	January 13-17
	Conduct Student interviews CER assessment 2		
Week 5	Balancing Chemical Equations	Stations Lab, Inquiry lab, Notes	January 20-24
	Finish conducting student interview CER assessment 3		
Week 6	Law of Conservation of Mass, Physical & Chemical Changes	Inquiry lab, stations lab, notes	January 27-31
	CER assessment 4		
Week 7	Chemical & Physical Changes, Chemical Reactions	Inquiry labs, notes	February 3-7
	CER assessment 5		
Week 8	Chemical Reactions, Calorimetry	Inquiry Lab, Synthesis	February 10-14
	CER summative assessment		
Week 9	Crime Scene Analysis	Project, Assessment	February 17-21
	Conduct Student Interviews Administration of confidence survey/Likert survey		

APPENDIX B

CLAIM, EVIDENCE, REASONING RUBRIC

Grading Rubric

	4	3	2	1	0
Claim	Claim is accurate and complete	Claim is accurate but not complete	Claim is partially accurate or complete	Claim is inaccurate	No claim is stated
Evidence	Provides appropriate and sufficient evidence that includes measurements or observations that have been analyzed and interpreted to support the claim	Provides appropriate and sufficient evidence to support the claim	Provides appropriate but insufficient evidence to support the claim or also includes inappropriate evidence	Provides inappropriate evidence that does not support the claim	No evidence is given to support the claim
Reasoning	Explains correctly, using scientific principles, why the evidence is included and how it supports the claim.	Explains correctly why the evidence is included or how it supports the claim but not both.	Explains why the evidence is included and how it supports the claim, however some of the reasoning is incorrect.	Explains why the evidence is included or how it supports the claim, but not both and some of the reasoning is incorrect.	No reasoning is given to link the evidence to the claim
Mechanics	The writing is easy to follow with lots of academic language and details. Contains no grammar or spelling errors.	The writing is easy to follow with lots of details and a few grammar or spelling errors.	The writing is hard to follow with only some details. Contains some grammar or spelling errors.	The writing is hard to follow with few details. Contains a lot of grammar or spelling errors.	The writing is hard to follow with no details. Contains a lot of grammar and spelling errors.

APPENDIX C

LIKERT SURVEY

The purpose of this survey is for you to help your teacher improve. Several statements about science are listed below. Please circle the number, using the code below, that describes how much you agree with each statement. Your responses will remain anonymous and will never be linked to you personally. Your participation is entirely voluntary. If there are items you do not feel comfortable answering, please skip them. Thank you for your cooperation.

1	2	3	4	5	6
Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree

1. I look forward to coming to school.	1	2	3	4	5	6
Supplemental Question: Why did you answer the way you did in the last question?						
2. I look forward to science class in school.	1	2	3	4	5	6
Supplemental Question: Why did you answer the way you did in the last question?						
3. I would rather solve a problem by doing an experiment than be told the answer.	1	2	3	4	5	6
4. More time should be spent on hands-on project in science activities at school.	1	2	3	4	5	6
5. I get bored when I watch programs on channels like Discovery Channel, Animal Planet, NOVA, Mythbusters, Etc.	1	2	3	4	5	6
Supplemental Question: Why did you answer the way you did in the last question?						
6. I like to get science books or science experiment kits as presents.	1	2	3	4	5	6
7. I like learning how things work.	1	2	3	4	5	6

8. Science is too hard when it involves math.	1	2	3	4	5	6
Supplemental Question: Can you give me an example from I time when you felt this way?						
9. Science is a difficult subject.	1	2	3	4	5	6
10. Doing experiments in science class is frustrating.	1	2	3	4	5	6
11. I can make detailed, relevant observations.	1	2	3	4	5	6
12. I can organize data into tables, graphs, and charts.	1	2	3	4	5	6
13. I can analyze observational data (finding patterns)	1	2	3	4	5	6
14. I can explain why the data is the way that it is.	1	2	3	4	5	6
15. I can answer questions about data, no matter how difficult the question.	1	2	3	4	5	6
16. I can communicate the results of an experiment I've done clearly to others.	1	2	3	4	5	6

APPENDIX D

STUDENT INTERVIEW QUESTIONS

1. How do you feel like this class is going?
    - Why do you feel that way?
2. How would you describe a scientist? Science in general?
    - What did you draw from to create these descriptions?
3. What about science class do you like?
    - Is there more than that piece that you like?
    - Have you always liked science class?
4. Is there any part of science class that you look forward to?
    - Why?
5. What about this class do you think will help you as you go into high school?
    - Why do you think that?
    - Will you take special/elective science classes in high school?
6. How comfortable are you answering questions using the Claim-Evidence-Reasoning tables?
    - Is this more comfortable than you were at the beginning of the year?
    - Can you give me a specific example?
7. In which other classes have you used Claim-Evidence-Reasoning?
    - Does it look the same in each class?
    - When did you first hear about this?
8. Do you feel like you are learning in this class?
    - How do you know if you are learning?
    - Can you give me an example of what that looks like?

- What activities do we do that help you learn?

- What activities are hardest for you?

9. Is there anything else you would like for me to know?

APPENDIX E

IRB EXEMPTION

MONTANA STATE UNIVERSITY

INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
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MEMORANDUM

TO: Allyson Reamy and Walter Woolbaugh

FROM: Mark Quinn *Mark Quinn CJ*
Chair, Institutional Review Board for the Protection of Human Subjects

DATE: October 30, 2019

RE: *"What Effect Does the Claim-Evidence-Reasoning (CER) Framework have on Teaching and Learning in a Middle School Classroom?" [AR103019-EX]*

The above research, described in your submission of October 30, 2019, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

_X_ (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

_X_ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation; and (iii) the information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by section 16.111(a)(7).

___ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

___ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

___ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

___ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX F

CLAIM, EVIDENCE, REASONING SENTENCE STARTERS

SENTENCE STARTERS:
CLAIM, EVIDENCE, REASONING

CLAIM

- Directly answer the question/ prompt.

Sentence Starters

- I observed ____________ when ___________.
- I compared ____________ and ___________.
- I noticed _______, when _______.
- The effect of _________ on ___________ is ___________

EVIDENCE

- The scientific data that supports the claim.
  - Data are observations or measurements OR results from an experiment.
  - Specific Examples
  - Use numbers and data table information

Sentence Starters

- In the data …
- The evidence I use to support ____________ is _____________.
- I believe ____________ (statement) because ____________ (justification).
- I know that ____________ is ____________ because ____________ .
- Based on ____________ , I think ____________ .
- Based upon ____________ , my hypothesis is ____________ .

REASONING

- Explains why the evidence supports the claim, providing a logical connection between the evidence and claim.
  - Why is claim valid?
  - include general scientific principle
  - background/ prior knowledge

Sentence Starters

- Based on the evidence, we must conclude… because…..
- The most logical conclusion we can draw from this evidence is that…. because….
- These facts work together to build a case that… because…
- All of this proves that….. because…
- The reason I believe ____________ is ____________ .

APPENDIX G

CAUGHT: UNIT OVERVIEW

CAUGHT: Unit Overview

This calendar is based on nine weeks of daily 45-minute classes, but this is only to show the overall time needed. The pacing is flexible and can be adjusted to fit any length or frequency of classes.

45 min

Week 1 ______	Storyline Intro	Nervous System Station Lab		Notes/ Extend	Nerv. Sys. Inq. Lab
Week 2 ______	Nerv. Sys. Inq. Lab	Atoms Station Lab		Notes/ Extend	Evidence Project
Week 3 ______	Evidence Project	Synthesis	Molecules Station Lab		Notes/ Extend
Week 4 ______	Molecules Inquiry Lab		Elements, Compounds and Mixtures Station Lab		Notes/ Extend
Week 5 ______	Balancing Chemical Equations Station Lab		Balancing Chemical Equations Inquiry Lab		Notes/ Extend
Week 6 ______	Law of Conservation of Mass Inquiry Lab		Physical and Chemical Changes Station Lab		Notes/ Extend
Week 7 ______	Chemical and Physical Changes Inq. Lab		Notes/ Extend	Chemical Reactions – Forensic Edition Inq. Lab	
Week 8 ______	Chemical Reactions and Mass Inquiry Lab		Calorimetry Inquiry Lab		Synthesis
Week 9 ______	Crime Scene Project				Wrap/ Assess

Note: The crime will not involve violence.