THE EFFECT OF ADDING REBUTTAL TO CLAIM, EVIDENCE, AND REASONING TO ENHANCE STUDENTS' ABILITY TO ENGAGE IN SCIENTIFIC ARGUMENTS

by

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DEDICATION

This research is dedicated to my wife Tanya and my daughter Kendall. You are my motivation to keep growing as a learner and my support to push past the setbacks. I could not have done this without your love and support.

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ABSTRACT

Claim, Evidence, Reasoning, and Rebuttal (CERR) is a teaching strategy used to engage students in constructing and presenting a scientific argument to their peers. The purpose of this study was to measure and determine if building an argument was enhanced by students engaging in a scientific debate and defending an opinion. At the start of the unit, students were given a Likert Scale pre-survey to gauge their interest, confidence, and opinion of using argument in learning science material. An outline was used to pick a claim, record evidence, and provide reasoning in the construction of their arguments. Once students were ready to present to a group of their peers, they were evaluated through observation with the CERR Rubric. Immediately after presentations, volunteers were selected to conduct interviews reflecting on the project and the rebuttal portion in particular. The final instrument used was the Likert Scale post-survey to measure any change in student attitude from start to finish. Students showed positive trends towards argument being a helpful skills and attitude about science in general from start to finish. Having the opportunity to choose a topic, research and construct a strong argument, and engage in debate with peers created an environment that peaked students competitively, as well as prepared them for further scientific research in the future. CERR is a useful classroom tool that can increase student interest and apply to real science practice.

CHAPTER ONE

INTRODUCTION AND BACKGROUND

Context of the Study

I have been a teacher in northwest Iowa my entire professional career. My experience in teaching covers all middle school science coursework, high school biology and chemistry, and collegiate-level chemistry lab. There is a polarizing belief amongst teachers and districts that students will either understand science content, or they will not. Every learner is unique and a requirement for every learner to grow is finding their own voice (Bray & McClaskey, 2013, p. 15). Gathering evidence and analyzing a claim is an important step in making a good scientific argument. With the current available technology, young people have access to more content than ever before. Unfortunately, not all the content is credible. Students are easily influenced by unreliable sources and are not being taught the necessary skills to sift through good and unreliable content. This is why I wanted to focus my study on the development of scientific arguments through Claim, Evidence, and Reasoning (CER), and to understand if the addition of a rebuttal at the end of the CER process would be beneficial to students' growth in learning science material and morale in the classroom.

North Middle School in Sioux City, Iowa, has an enrollment of 1,203 6th-8th grade students. Fifty-eight percent of the students at North Middle School qualify for free and reduced lunch (Sioux City Schools, 2023). I have been a teacher at North Middle School for four years and have taught 6th, 7th, and 8th grade science during my time there. I currently teach one

accelerated 7th grade science class and four traditional 7th grade science classes. Class sizes range from 23 to 30 students. I teach four sections of science that contain 25% ESL students.

This study took place during the spring semester of the 2023-2024 school year focusing on 7th grade students. The content covered in this semester included biological systems, growth, reproduction, photosynthesis, cellular respiration, and interactions in ecosystems. Utilization of this course content will be beneficial due to the abundance of CERR lessons available to implement. In past years, students have struggled to understand the topics of photosynthesis and cellular respiration. The goal of this study was to better understand the development of argumentative skills in students. Using a proven technique such as Claim, Evidence, Reasoning, and Rebuttal (CERR), should help to improve students' understanding of these topics.

Focus Question

My focus question was, When compared to the traditional Claim, Evidence, and Reasoning (CER) method, how does the addition of Rebuttal (R) to the Claim, Evidence, Reasoning (CER) teaching technique impact student growth in the science classroom?

CHAPTER TWO

CONCEPTUAL FRAMEWORK

Introduction

Science education requires students to do more than just memorize facts; it requires problem solving and procedure. There are different techniques science teachers use to address these needs, and one of the most common methods is called Claim, Evidence, and Reasoning (CER). In CER, the first step in solving a scientific problem is answering a question by making a claim, and no claim would be credible without evidence or relevant without reasoning. A claim can be described as what is known. Evidence can be described as the how it is known. Reasoning can be described as one's thought process (Robertson, 2021). If the goal is to teach students to think as scientists, the teacher needs to teach students to build their knowledge through a method like CER. Once students can construct an argument, they can enhance their learning by presenting what they know. Adding rebuttal to the CER formula is a logical step in enhancing scientific argument.

Activities applied within the CERR framework support the relationship between language and science by implementing the Next Generation Science Standards (NGSS). Evaluating and using evidence in science arguments is a key science and engineering practice of NGSS, which aims to eliminate rote memorization and develop deeper understanding of core science ideas (Nunez et al., 2018, p. 51). With a deeper understanding developed, CERR should help students communicate ideas being learned in the classroom to real world jobs and issues. In fact, over 90 percent of white-collar workers and over 80 percent of blue-collar workers identified writing and

literacy skills as important to job success (Graham & Herbert, 2010, p. 7). Understanding what to write, record, present and respond for each step of CERR will give learners practice thinking through problems they will encounter later in life. CERR is a solid method for teachers to apply in their classrooms that will train students to organize and apply their thoughts for the modern work environment.

CER Breakdown

Importance of Making a Claim

In a scientific argument, making a claim is a natural starting point. Claim, Evidence, and Reasoning (CER) can be applied to any scientific topic requiring exploration. Curiosity, the starting point of a claim, drives questions that are asked and explanations that are conducted in a classroom (Brunsell, 2012). Using students' curiosity is the key point in this skill, as a teacher would usually start with a driving question to help guide students down the right path. However, there are steps required, and developing curiosity into purpose is an important step. By turning curiosity into purpose, students will be better equipped to start an argument with a strong claim.

Developing a strong claim is the definitive first step in creating a successful scientific argument. The importance of making a claim to start an argument is found in both Common Core Science Standards and NGSS. These documents emphasize the need to take a critical stance when confronted with a claim and evaluate the quality of what they see, read, or hear (Ault et al. 2015, p. 21). At the very highest level of education, decisions about argumentation and evaluation are being emphasized. To have the necessary skill set to combat a claim and evaluate

information presented, students must practice developing scientific claims and evaluating the quality of modern scientific claims in the classroom.

Importance of Finding Evidence

After a claim is made, gathering evidence is the essential next step in the development of a scientific argument. Evidence-based arguments are discussions that present and provide support for claims with evidence and premises (Belland et al., 2008, p. 402). Providing support for any claim requires research be done by the presenter. As a teacher, it is imperative guidance is given to students in the research process. Good research typically follows an organizing framework, and any beginning researcher would likely be lost without that guidance (Hancock et al., 2021, p. 4). It is the job of an educator to prepare students for research by providing an organizing framework. In the CERR model, students start by answering a main question. However, there are simple yet effective sub questions all researchers should be trying to answer in their research.

Sub questions are used as guiding tools for young researchers to help in the execution of finding good information as well as helping young learners evaluate what information they are looking for. After determining what is going to be studied, students should be asking why the topic is important to study and how they are going to study it (Hancock, Algozzine, & Lim, 2021, p. 4). Asking these questions allows students to go in depth when finding evidence. The analysis of information to fit sub questions helps students follow an organizational framework. Furthermore, the analysis researchers go through in determining credible information should ultimately enhance their learning.

Importance of Providing Reasoning

The last step in CER, reasoning, is crucial in the analysis of an argument for students. To quote Osbourne (2018),

> Scientific reasoning is domain specific and dependent on a knowledge of the content and concepts of science; a body of procedural knowledge about standard methods; and an epistemic knowledge of how such procedures warrant the claims that scientists advance. (p. 10).

Scientific reasoning is knowledge which can be applied and used. For a 21st century learner, gaining useful knowledge from school curriculum is the goal. In 2022, the Gallup poll estimated only 49% of students are engaged while at school and at least 19% of students are actively disengaged. The high rate of disengagement puts pressure on educators that often leads to burn out (Kern, 2022). Based on these results, it is clear students want to be taught lessons and skills that are applicable and relevant to real world use. To develop a successful school culture that generates engagement in the classroom, it is crucial for teachers to use lesson plans to focus students on learning content that is valuable and useful for the students once they leave the classroom.

How is CER Applied into the Real World

Debate in Science

CER is a method of learning which allows students to grow into roles as well-versed leaders and decision makers. As stated previously, students are likely to encounter some influential claims that are attention-seeking, rather than scientifically based. Science students need effective strategies of rebuttal and must be prepared for criticism in a public debate. Schmid

and Betsch (2019) revealed audiences could be persuaded when given facts about a topic or after exposure to rhetorical techniques often used in denialism. It is important to give learners the tools and practice they need to analyze topics presented to them. Students skilled in implementing CERs can apply their experiences to their own work as they enter higher academia.

Debate is a useful skill to practice at every level of learning. Tawil (2016) discussed a study performed in a college course that had students engage in scientific debate as a project. The goal was to improve critical thinking as it is an important skill for science classrooms and science fields. Critical thinking forms the foundation for good problem-solving skills that help students become proficient in making arguments that influence broad audiences. In higher education, a commitment to finding evidence and reasoning to back up a claim is an important part of the learning process. Students with skills in CER will have the experience and knowledge to excel in scientific fields once they enter the workforce and/or higher education.

Debate in Society

While there are many benefits of applying CER to scientific fields, this important framework can be utilized across a wide variety of societal topics. In fact, debate has been a well-known pedagogical technique since the early days of recorded teaching and learning. Debate remains virtually unchallenged as an exercise in higher learning and nearly every university uses debate to bolster their reputation by inviting scholars to participate in some form of this skill (Tumposky, 2004). Debate is well established as a method for exploring topics, sharing ideas, and presenting new information for learners and educators at all levels.

Debate was found to be beneficial in the professional sector as well. Mumtaz and Latif (2017) conducted a study with medical students that revealed 69% of the participants agreed debate was successful in alleviating potentially difficult scenarios with patients. The study also found 61% of students believed debate was an effective tool in helping them learn more about controversial issues (Mumtaz & Latif, 2017). The positive feedback from such studies helps to reinforce the importance of debate in solving problems that are faced by the average person. Logic dictates students should be learning how to debate at a younger age, to ensure they are prepared for the different roles they will hold later in life.

Debate in Middle School

Middle school is a unique point in a student's growth as a learner as they transition from childhood to adolescence. Debate in middle school is a literary practice well suited to increase reading comprehension and critical literacy skills while also capitalizing on their developing civic identities. Research has demonstrated debate encourages students to analyze complex texts, take different perspectives on controversial topics, and use their voices to advocate for social justice (Mirra et al., 2016). The thoughts of middle school students can be fascinating, but they can often be repressed or misdirected in a self-destructive manner. Debate is a possible outlet that can also provide training in expressing oneself.

Middle school students with experience participating in debate could gain skills such as public speaking and proper argumentation which could translate to academic success. It is important for middle school students to develop these skills because they are capable of critical and complex thoughts; by engaging in debate, these students could be better positioned to pursue their education further (Baushard & Rao, 2015). The importance of organized debate at the

middle school level is evident in supporting literature. Using CER is a simple, yet effective practice for teachers to implement in the classroom that provides students with a framework to develop an argumentative skill set assisting them in becoming higher order thinkers.

How does Rebuttal Fit into CER?

What is Rebuttal?

Claim, Evidence, and Reasoning is a simple three step process that addresses the completion of an argument from start to finish. It is logical to continue the process of information gathering from reactions and to adjust after an argument is presented. A rebuttal directs presenters and researchers to consider two aspects: (1) a prior argument for the rebuttal to oppose, and (2) an argument that shows an openness to doubt or a reframe of the topic of focus for which the argument is directed (Walton, 2009). There are many terms synonymous with argument, but rebuttal links the researcher to focus on challenging a claim that already exists to reframe it or change the statement completely.

The accepted definition of rebuttal has changed over time. Recent studies have tied the suggestion arguments refuting a claim are counterarguments, while responses refuting counterarguments are now considered rebuttals (Chuang & Yan, 2022). The realization that rebuttals address a process of understanding a topic of interest will help students to engage in healthy conversation challenging their knowledge and leads to growth. The breakdown of an argument has led researchers to change their thinking as more information regarding the topic becomes available. The consensus appears to favor the use of rebuttal in the argumentation process.

Benefits of Rebuttal

The benefits of following CER with discussion and/or rebuttal can be easily measured. A study involving undergraduate students explored the extent to which a rebuttal-writing task can serve as a learning tool to support student growth. The results address the idea that students happily received the rebuttal task and were more engaged as participants of the topic (Man et al., 2021). Positive feedback and increased engagement from students because of using rebuttal encourages educators to apply CERR as a tool in their own classrooms.

Measurable growth is another factor in favor of the use of rebuttal. Rebuttal is considered valuable in fields such as politics and science, and its use facilitates an examination of the views and beliefs an individual holds (Orbach et al., 2019). By challenging their own beliefs, students must complete research and aspire to a level of understanding that exceeds memorization. Displaying growth from a learned practice is important in determining if such a practice should be used by educators. The evidence links to the notion students enjoy engaging in rebuttal and benefit as learners from its use.

How does Rebuttal Fit into CER?

Knowing the benefits of argumentation and rebuttal is valuable, but the execution of rebuttal as part of CER requires planning and timing. Argumentative skills address an important role in developing an explanation, model, and theory of a concept. The execution of this process should not be overlooked (Astira & Dwiastuti, 2019). Building an argument is only part of the argumentation process. By presenting a rebuttal there are opportunities for the teacher to grow as a facilitator rather than being the dominant voice in the classroom.

Students also have opportunities to grow by finding their voice and coping with challenges to their own claims. Results from Angeloudi and Papageorgiou (2022) link an improvement in argumentation skills after intervention from CERR by assessing the structure and content of the arguments. Students can gather knowledge step by step, which deepens their understanding of a topic and thus helps them be more prepared when responding to a rebuttal. Using rebuttal as a part of CER will help students build a better argument and gain a deeper understanding of a chosen topic.

Conclusion

The importance of using strong claims, evidence, and reasoning is a simple, yet effective tool all teachers can use to help students build strong arguments. This is shown by the value placed on the ability to debate and make strong arguments at the middle school level, science field, and society in general. These skills lead to many real-world applications such as public speaking and critical thinking skills. Adding rebuttal to CER is a logical benefit that enhances student learning. Rebuttal ultimately leads students to be better prepared and have a deeper understanding of topics they choose research and present.

CHAPTER THREE

METHODOLOGY

Demographics

The citizens of Iowa have always been proud of the public schools provided to their children and the education their children receive there. Sioux City, IA is no exception to that rule and was the location where this research was conducted. According to the U.S. Census Bureau (2020), the population of Sioux City was 85,797 in 2020 making it the fourth largest city in the state. Of those people 76.3% were white, 20.9% were Hispanic, and several other ethnicities were under 5%. The district middle schools are split up into three separate schools: North Middle, East Middle, and West Middle. This study was conducted with students attending North Middle.

North Middle School has the largest student population out of the three Sioux City schools and each core subject teacher has five sections they teach. In this study students were focused on topics regarding DNA and genetics. The participants in this study were in 7th grade accelerated science at the time research was conducted. There were twenty-eight students in this class, and they were all participants in the study. Eight out of the twenty-eight (*N=28*) students were of a minority race and 78% were in the talented and gifted program (TAG). The experience level of participants engaging in debate was minimal which made it ideal to measure growth in constructing and presenting a factual argument through CERR.

Research Question

My focus question was, When compared to the traditional Claim, Evidence, and Reasoning (CER) method, how does the addition of Rebuttal (R) to the Claim, Evidence, Reasoning (CER) teaching technique impact student growth in the science classroom? The research methodology used for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained (Appendix A).

Treatment

A mixed methods approach was used for this study. Components of the study used observational studies to gather qualitative data and correlational designs to gather quantitative data. The objective of observational study is to elucidate cause and effect relationships when it is not feasible to use controlled experimentation (Rosenbaum, 2005). It would be ideal to compare two equal groups in a controlled experiment, but in a classroom setting this is rarely viable. Using various methods of data collection, thematic evidence was gathered for analysis where comparisons were not possible (Table 1). I took on the task of participant as observer during the study. In this role the researcher continues to observe and take notes on what is observed while also interacting with the participants in the study (Mertler, 2020). Using this approach allowed me to gather data from the students while still being part of the classroom environment.

As stated previously, correlational designs were also used to gather quantitative data. Researchers use correlational designs to compare 2 or more variables to investigate to what extent the variables are related (Seeram, 2019). In this case, the treatment group will be 7th grade

students' Likert scale results at the start of the unit compared to the results after presentations take place (Table 1). The comparison will be focused on finding a correlation coefficient between the two scores. A correlation coefficient reports two aspects of the relationship between given variables: the direction of the relationship and the strength of the relationship (Mertler, 2020). This approach allowed me to compare the effectiveness of CERR on student learning, determining how much impact the treatment had on student survey results.

The treatment plan in Table 1 outlines the use of rebuttal in addition to CER during instruction regarding the DNA and genetics unit. Table 1 also displays a rough outline of the unit where all the instruments were to be used. Adjustments were made based on time constraints of each class, but the general order was followed accordingly. By applying the treatment, data was able to be gathered and analyzed for further use in practice.

Table 1. Treatment plan for DNA and Genetics unit.

Lesson	Treatments Implemented
Lesson 1: Mutations	• CER outline used as practice for vocabulary terms or key concepts • Close read, practice sheets, and Likert Scale Survey
Lesson 2: DNA	• CER outline used as practice for vocabulary terms or key concepts
Lesson 3: CERR Construction and Presentations	• Construction of CER to be presented in small groups • Practice presenting arguments and documentation of rebuttals • Rubric used to evaluate CERR during presentation • Student interviews conducted following presentations

	• Likert scale survey given following presentations

Data Collection and Analysis Strategies

Both quantitative and qualitative research will require several collection techniques to display the data. The data collection techniques were chosen for their diverse qualities, comparative ability and usefulness, and applicability for the participants and researcher. The data collection techniques used during the research process are listed in the data triangulation matrix.

Table 2. Data Triangulation Matrix.

Data Collection Instruments	When compared to the traditional Claim, Evidence, and Reasoning (CER) method, how does the addition of Rebuttal (R) to the Claim, Evidence, Reasoning (CER) teaching technique impact student growth in the science classroom?
Pre and Post Intervention Likert Survey	X
Evaluative Presentation Rubric	X
Comparative Content Assessment	X
Student Interviews	X

Each of the instruments was essential in gathering the quantitative and qualitative data needed. It was important to have variety in the data collection methods for the analysis of results in answering the usefulness of rebuttal. The practice of each data collection method is described in more detail below.

Data Collection Instruments

Four data collection instruments were developed and used for the purposes of research in this study. Pre and Post Intervention Likert Surveys (Appendix B) were used for self-reflection of growth and confidence from start to finish. The Evaluative Presentation Rubric (Appendix C) allowed for the researcher to measure student performance and success in CERR presentations. Comparative Content Assessments (Appendix D) and Student Interviews (Appendix E) were valuable for the thematic evidence they provided. To understand the reasons each of these instruments were beneficial in the research process, more information is required.

Pre and Post Intervention Likert Survey. An example of an intervention survey is shown in appendix A. This survey will be conducted before CERR strategies are put in place and after students have completed CERR and been evaluated. The Likert Scale is a convenient method to measure unobservable constructs of attitudes and feelings about the research that would be missed using observations or a grading rubric (Jebb et al., 2021). There were two goals in giving this survey to students. The first goal was to measure student growth in CERR based on their attitudes and feelings for the topic. The second goal was to measure how much confidence and/or academic growth students attained.

An effective tool for gathering quantitative data is the Likert survey. The Likert scale is a simple and powerful way to construct an attitude scale, built on the premise groups of related questions measure subjects' attitudes about issues addressed by those statements (Batterton & Hale, 2017). The statements students will answer on this survey will be dichotomous (agree/disagree) and scaled (strongly agree/agree/disagree/strongly disagree). Researchers refrained from including a neutral option because it will require students to consider how they

truly feel. The neutral or no opinion option has a tendency for people taking the survey to choose that option rather than consider how they feel about the question (Mertler, 2019). These results were analyzed by using mean, median, and mode visuals to display the data. The use of the survey provided thematic evidence for how useful students found rebuttal as part of CERR.

Evaluative Presentation Rubric. An example of the rubric used is found in appendix B. The rubric will be used as a guideline for students to follow as well as an evaluation to be used by the teacher in assigning scores for students. The goal of the rubric is to provide clear instructions for students to follow pertaining to claim, evidence, reasoning, and rebuttal (CERR). From that point on, the rubric will serve as an indicator for how well students understood CERR and if they were able to use CERR to make a successful scientific argument.

This rubric was developed and chosen as a tool for gathering quantitative data for research for two reasons. The first is that a rubric sets clear expectations for students to follow and shows participants how to meet those expectations. When the intended learning outcomes are best indicated by performances (things students would do, make, say, or write) then rubrics are the best way to assess them (Brookhart, 2013). Using a rubric will be the most accurate way to measure growth of student learning in this research. The second reason why rubrics are an effective method for gathering data for action research is rubrics make students accountable for their performance, which was reflected in the data gathered. Student feedback has indicated substantial changes occur between initial drafts and final submissions, which result in student growth and improvement (Jones et al., 2017). Data gathered from the rubrics was displayed in a quantitative format using mean and frequencies. The growth of students from start to finish was a

key indicator of the effectiveness of CERR research and using a rubric helped students to make adjustments that lead to better results.

Comparative Content Assessment. The comparative content assessment used can be found in appendix C. The CER template is included because it is the template students used to build their CERR arguments. The content outline is included because of the themes available for use for qualitative analysis. This outline also provided insight into which students were having success or difficulties in constructing their argument, which can be used to show correlation between assessment scores.

As a traditional form of gathering data, an outline may seem a little unorganized. However, it is evident there is opportunity to measure themes beyond making observations by using these outlines as data. An outline is a useful tool because it gives students structure in completing an assignment and helps them identify key concepts. There are two main ways outlines help students; outlines help students save time when making edits to their writing and it helps students stay organized in their construction of a project (Ali and Hasanah, 2020). To sort this qualitative data, themes repeated most often and a bar graph were used to display the data. Having organized writing by students using this template allowed for better themes to show when these outlines were used to find data.

Student Interviews. The student interview template used in this research is found in appendix D. Student interviews are valuable because they show the general feelings of students for CERR, both positive and negative. The purpose of using student interviews is to obtain more qualitative data about CERR. Being able to build and present an argument are skills applicable in several academic areas outside of science, and the themes presented through student interviews

indicate that (Abate et al., 2020). It was important to see if students found CERR applicable to other areas beyond the science classroom. Four to five students participated in the interviews to speak about their experience in the project. In implementing these interviews, the research sought to find out what students liked or disliked about the project, how the project could be improved, and how the project would benefit them in real world applications.

Semi-structured, in-depth interviews are utilized extensively as an interviewing format possibly with an individual or sometimes even with a group (Strauss, 2008). The semi-structured approach helped guide both the teacher and students to better represent their experience than open-ended interviews. The students were better able to reflect on their own experiences when the questions were developed for them. The student interviews were used as a sounding board and a way of checking the instructor understood the reported responses of the respondents, especially when it comes to picking up subtleties such as irony, emotions, silences, or other gestures (McGrath et al., 2019). The data was sorted by key words, phrases, and themes present throughout the process. By conducting these interviews in person, I gained a perspective different from the other instruments in place.

Analysis Strategies

To analyze the quantitative data collected, a straightforward approach worked because the data could be compared between groups that were given a summative assessment where one group had been through CERR training, and the other group had not. For this approach using descriptive statistics suited the results best. Descriptive statistics are simple mathematical procedures that serve to simplify, summarize, and organize large amounts of numerical data

(Mertler, 2020, p. 180). The data collected were simple enough that descriptive statistics fit because they will be scores on a summative assessment.

There were a lot of responses from students as well as multiple questions sorted through. Inductive analysis was the best technique to use in the qualitative data analysis of the research. Inductive analysis is the effort of the researcher to reduce the volume of information that has been collected and then organize the data into important patterns and themes (Mertler, 2020, p. 173). As previously stated, there was a lot of volume in the responses by students which made it crucial to organize the data into themes reflecting the data accurately.

CHAPTER FOUR

DATA ANALYSIS

Introduction

The data gathered in this study were mixed method results meaning quantitative data and qualitative data were used. The quantitative instruments that were chosen for data collection in this study were Pre-Post Likert Scale Surveys (Appendix B) and CERR Rubrics (Appendix C) during student presentations. Qualitative data was collected by conducting Student Interviews (Appendix E) after students had researched and presented their chosen arguments.

Pre-Post Likert Scale Survey Results

Pre-Survey Results

In the analysis of data in this research process, Pre-Post Likert Scale Surveys (Appendix B) allowed for a comparison of student growth from the start to finish of this study. All students participated in the CERR presentations to some extent. Students completed a Likert Survey (Appendix B) of seven questions before starting their CERR project and after their final presentations. At least 52% of students agreed with questions on the Pre-Survey (Appendix B), except for generally liking science and understanding science at 48% agreeing or strongly agreeing. Forty-eight percent (Figure 1) of students disagreed with the statement they, “liked science” while 52% of students disagreed, they could, “understand science concepts without difficulty.”

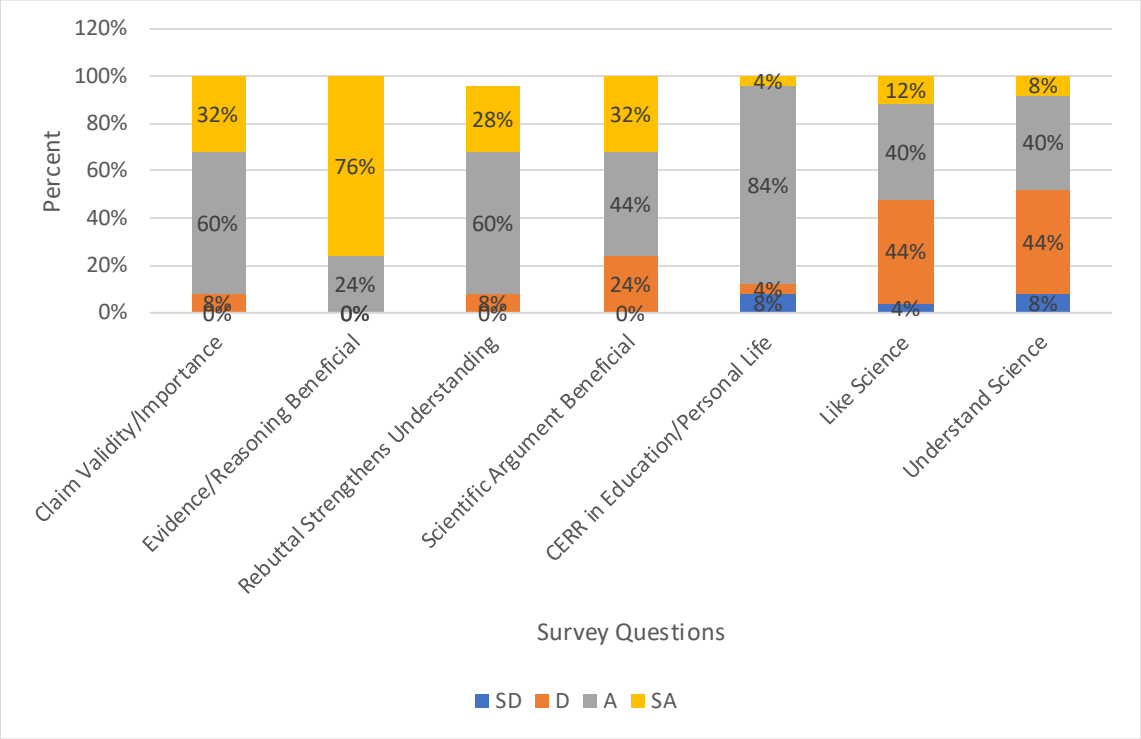

Figure 1. Note. Results in the form of a bar graph for the pre unit survey for 7th grade accelerated science class. 92% of students agreed or strongly agreed that starting with a claim has validity in the pre-survey. 100% of students agreed or strongly agreed that gathering evidence and reasoning are valuable in constructing an argument. 52% of students agreed or strongly agreed that in general, they like science in the pre-survey. 48% of students agreed or strongly agreed with the pre-survey statement that they can understand scientific concepts without much difficulty, (N=25).

This data comes from the seventh grade accelerated science course which includes twenty-eight students total. A positive shift in attitude and confidence as well as in rebuttal skill would be a good indicator of CERR as an effective teaching strategy.

Post-Survey Results

Post-Survey Attitude. The upward trends observed and gathered by the researcher from pre-post surveys were generally positive. Post-survey (Appendix B) results had a higher average score of students agree on each respective question at 79% compared to the pre-survey (Appendix B) results at 77%. From pre- to post-survey, there was an 11% gain in students that agreed or strongly agreed with the statement, "generally, I like science." An unpaired T Test for this survey statement had a p value of .29. On a less significant scale (p=.46), an increase of 6% of students agreed with the statement, "I can understand scientific concepts without difficulty" (Figure 2).

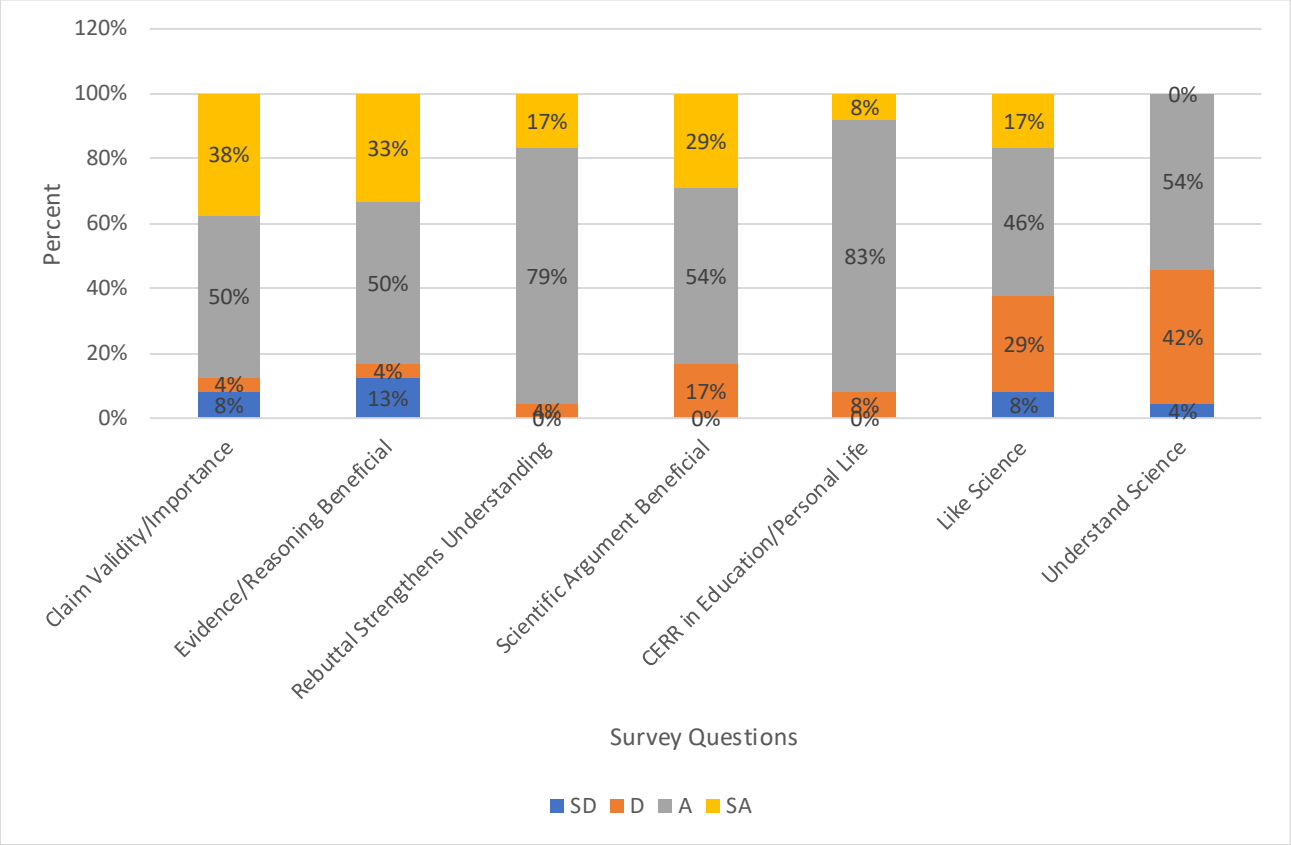

Figure 2. Note. Results in the form of a bar graph for the post unit survey for 7th grade accelerated science class. 96% of students in the post survey agreed or strongly agreed that having a conversation about a topic in the form of rebuttal strengthens one's understanding. 91% of students agreed or strongly agreed that argumentative skills, such as CERR, in their own personal experience. 63% of students agreed or strongly agreed in general, liked science. 54% of students agreed or strongly agreed with the statement that they can understand scientific concepts without much difficulty, (N=24).

From the results gathered, students that participated in CERR had more confidence in understanding scientific concepts and had a better attitude towards the subject. Beyond science in general, it was important to gather student opinions on the effectiveness of CERR as a teaching technique.

Post Survey CERR Opinions. Pre-post survey (Appendix B) questions focused more on CERR allowed for data to have an upward trend throughout the unit such as rebuttal increasing

student understanding and being able to make a scientific argument is a valuable skill to have. From pre- to post-survey there was an increase of 8% from 88% to 96% of students that agreed or strongly agreed rebuttal increased their understanding and/or passion about science topics. The results from a paired t-test showed that the increase was 62.7% significant. In addition, there was a 7% increase of students from 76% to 83% in the pre survey to post survey that agreed or strongly agreed that being able to make a scientific argument was a valuable skill to have. Not only was student opinion on argument being used as a learning tool high in the pre-survey, but student opinion increased after the unit was implemented. Having a tool students believe is effective in the classroom encourages the use of it for teachers.

CERR Rubric

The DNA and genetics unit in which the Student Interviews, Pre-Post Likert Surveys, and CERR Rubric were applied centered around the development of a claim, finding evidence and reasoning to support the claim, organizing information into a virtual or poster presentation, and engaging in a discussion with their peers. During student's presentations, the participants in the study were assessed through observation by their teacher using a CERR Rubric (Appendix C). There were four categories observed in the study: (a) claim and evidence, (b) reasoning, (c) rebuttal, and (d) cohesiveness. The rubric used a scale from one to four to assess the participants on how well they performed in each category. To reach a four, students needed to demonstrate several instances or examples for each category.

CERR Rubric Results

Participants in this study that scored three or four in each category (Figure 3) met the standards set to perform well in CERR. Meeting these standards indicates a student can develop and implement a scientific argument.

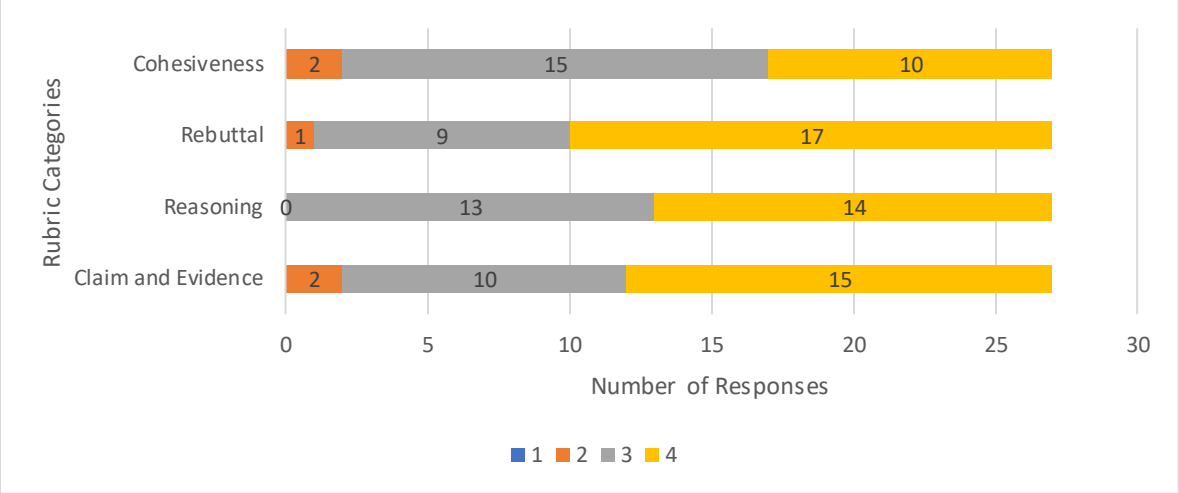

Figure 3. Note. CERR rubric scores during student presentations. The categories evaluated were cohesiveness, rebuttal, reasoning, and claim/evidence on a scale of 1 to four. Each of the four categories had at least 93% of students meet expectations by scoring a 3 or better, (N=27).

For each category in the rubric (Figure 3), at least 90% of students scored three or more. Out of 27 students, 96% (n=26) of them scored a three or higher on the rubric score. Sixty-five percent (n=17) of those twenty-six students scored the highest score of four, which was the best score for each rubric category. Rebuttal was an unknown variable because the students had little to no experience defending an argument in science class to that point. Going through each step of CERR allowed students to build a strong argument where they felt prepared and confident engaging in rebuttal.

Student Interview Data

Introduction

Student Interviews (Appendix E) were conducted after the students had completed their presentations. Eleven out of twenty-eight students volunteered to participate in the interviews. The interviews were done between the teacher and students in a one-on-one format. The interview consisted of eight questions and students were allowed to skip a question if they did not want to answer. After the interviews were conducted, the data was sorted into themes relevant to the study (Figure 4).

Favorite Part of CERR

During each interview, students were asked what their favorite part of CERR was. The data collected was sorted into themes beneficial for teachers to consider when using CERR in their classrooms (Figure 4). To preface participants' favorite part of CERR, it is important to note 100% of students stated they had a positive experience in engaging in CERR (Appendix E). In the student interviews 90% of students listed their favorite part of CERR (Figure 4) as either building a scientific argument, engaging in a scientific argument with their peers, or choosing which topic to argue and research. 45% of students stated their favorite part of CERR was organizing and researching their arguments. To a lesser extent, students also stated they enjoyed engaging in rebuttal at 27% and choosing an argument at 18%. Students enjoyed the preparation in constructing an argument. To quote a student, "I felt like a lawyer getting ready for a case." Being able to construct their argument helped students feel comfortable engaging in arguments with their peers.

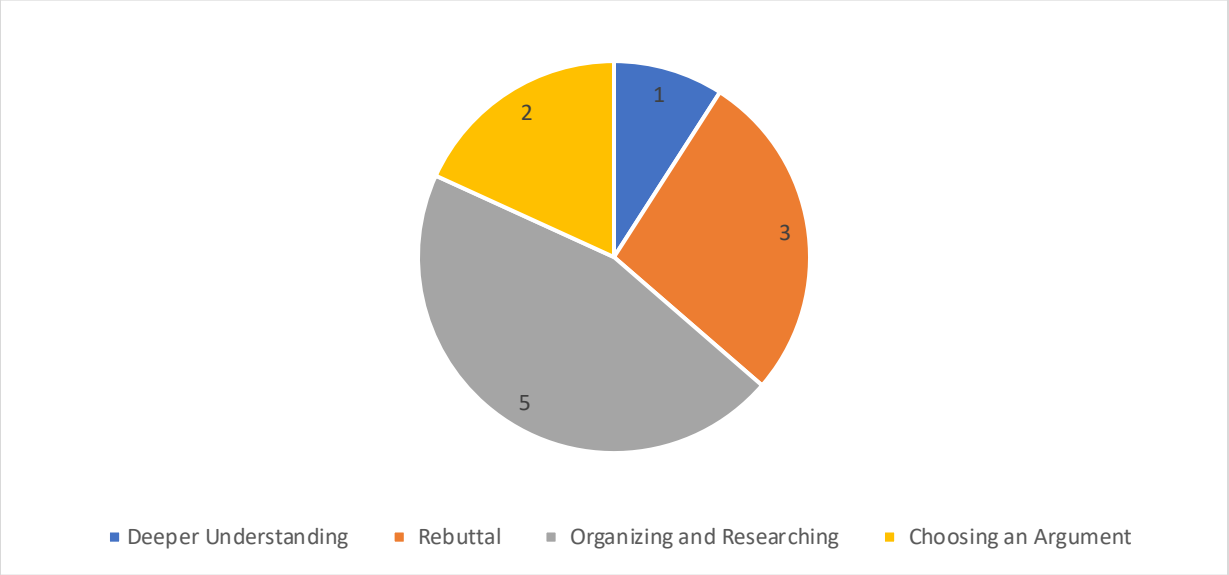

Figure 4. Note. Student interviews favorite part of CERR. Student responses were recorded, then analyzed to identify themes and sort them into 4 categories, (*N*=11).

Themes in Helpfulness Understanding Topic

Students were asked several questions in the Student Interviews (Appendix E). With the focus of determining the effectiveness of rebuttal as a learning tool in mind, as well as how rebuttal was effective, students were asked to reflect on what helped them as learners. Based on the results collected, there were two main themes that the participants thought were helpful in understanding the topic while using CERR which were deeper understanding and new information (Figure 4).

Out of the eleven students interviewed, two students (18%) stated CERR did not help in their understanding of their chosen topic, while nine students (82%) stated CERR did help. Four of the nine students (44%) said CERR helped them gain a deeper understanding of DNA or genetics (Figure 5), while five of the nine students (56%) stated they learned new information about DNA or genetics from the use of CERR (Figure 5).

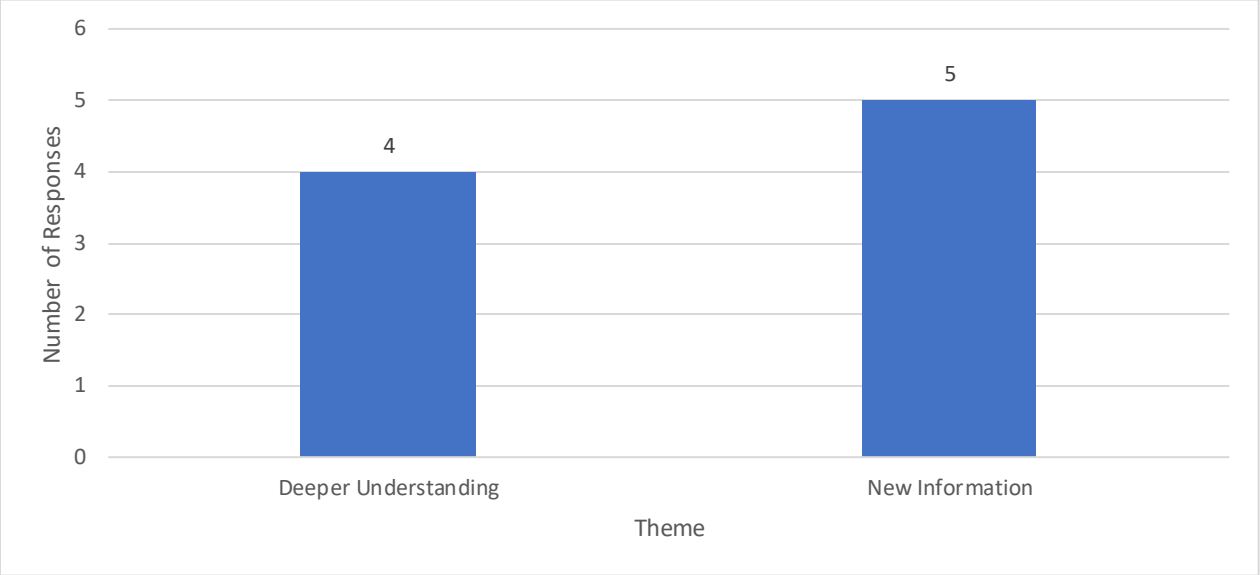

Figure 5. Note. Themes in what was most helpful in understanding the topic. Data was analyzed into two main themes, (*N*=11).

These themes are indicators that CERR helps students learn new content as well as develop more in depth understanding of topics as they move forward in their education.

CERR Use in Making Scientific Argument

In addition to themes identified for how CERR helped students understand a topic, students commented on how CERR and rebuttal in general helped students make a scientific argument. It was critical to ask the participants questions they had no preparation for to get genuine feedback from them. The results for how CERR helped make a scientific argument were separated into four themes (Figure 6).

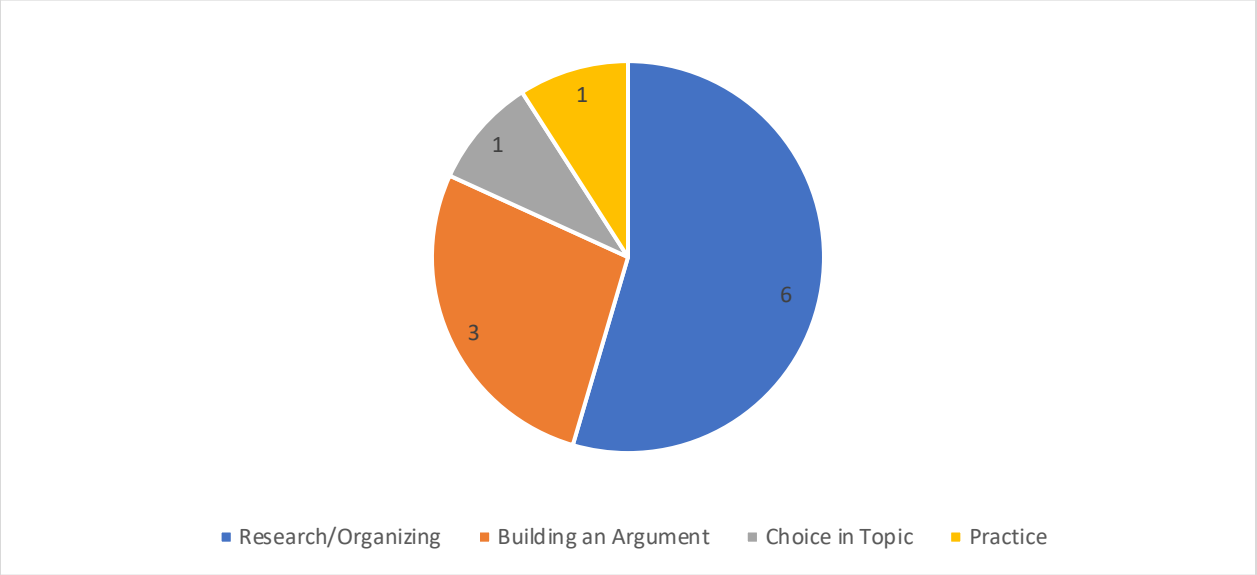

Figure 6. Note. How CERR helped in making a scientific argument. Four categories were formed from student responses, (*N*=11).

Most students believed constructing and researching was the best way to form a solid scientific argument. All eleven participants provided responses for this question that were split into four themes (Figure 6). Six of the eleven students (55%) stated having to make a scientific argument helped them in research and organizing. Three students (27%) stated building their argument through research and organization was most helpful in having a successful presentation, while choosing a topic (9%) and practicing making an argument (9%) were listed by one student each. The themes provided in the student interviews developed deeper understanding because students were doing more research and preparation for their topic.

Conclusion

The focus of this study was to determine if rebuttal influences students' ability to learn. Student Interviews (Appendix E) were the source of qualitative data from this study. Participants in the interviews revealed they enjoyed the construction of an argument and gained a deeper understanding as a result. The CERR Rubric (Appendix C) and Pre-Post Likert Surveys

(Appendix B) were the two sources used in gathering quantitative data. Students showed an ability to argue a topic after conducting research and had an increase of opinion on how they felt about science after using CERR.

CHAPTER FIVE

CLAIM, EVIDENCE, AND REASONING

Introduction

The purpose of this study was to determine if adding rebuttal to CER would lead to growth in student learning and a positive trend in student attitude towards scientific topic such as gene modification. The feedback was gathered using Pre-Post Likert Scale Surveys (Appendix B), CERR Evaluative Rubric (Appendix C) and Student Interviews (Appendix E). From the results gathered, two claims can be made: (1) there was a positive impact on student attitudes towards the topic, and (2) a positive impact on student growth in understanding the topic.

Claims From the Study

Positive Impact on Student Attitudes

The first claim was that students' attitudes towards learning about a scientific topic, such as gene modification, would be positively impacted. This impact was observed through various instruments such as Likert Scale Surveys and student interviews. The data from the surveys had positive trends in student feelings towards CERR and science in general. There was an increase in students agreeing that being able to make a scientific argument was a beneficial skill to have and an increase in students agreeing that they could use the skills gained from CERR in a professional and/or personal setting. By engaging in CERR students believe they are better at making a scientific argument and they believe those skills are transferable to their lives in the present and future. Along those same lines, in the student interviews conducted in this survey,

100% of students said their experience using CERR was positive and 100% of the interviews recommended other teachers use this teaching method in their own classrooms. Being able to use a proven teaching technique that students feel positively about and recommend to other teachers encourages growth and improvement.

Positive Impact on Student Understanding Through Participation

The second claim from this study is that there was a positive impact on student understanding of the topic, genetic modification, because of student engagement and participation. The instrument used to gather this data was the CERR rubric. Students were rated on a scale of one to four, with one being the lowest and 4 being the highest score. At least 93% of students scored a three or higher in every category, with 96% of students meeting the expectations for the rebuttal category. The high scores that were observed from students show that students had done an adequate amount of research and understood their topic thoroughly. In addition to having well organized presentations, students were prepared to have a debate with their classmates once their rehearsed material concluded. The final piece of evidence was the district required exam about the topic at the end of the unit. Out of 28 students, the class average was 96%, which was the highest score from all the exams by 3%. There were several examples on essay questions that tied back to student presentations. By using CERR students were able to learn more about a scientific topic through engagement and participation.

Value of the Study and Consideration for Future Research

Value of the Study

The value of this study came from the students' attitude and belief in their ability because of their participation. There was some data I collected that was either not completely relevant or did not contribute to the focus of my research such as the data collected from the CER outline instrument. The most valuable contributions that support a change in student attitude and belief in their ability came from feedback through interviews and Likert Surveys. In the interviews, students were able to express that the experience was positive and reflect on why. As one student stated for their final thoughts on the CERR project, "overall, I want to say it was very good. The experience was hands on and applicable." Based on the themes observed, students enjoyed preparing for an argument and found it useful to have evidence to back up their claims. Students felt they were ready for the challenge to research and back up a strong claim.

In addition, the CERR Likert Survey results had trends I observed to be beneficial for classroom use. It should be noted there were some results from pre to post survey that were either a minimal gain or a slight negative gain in some categories. I believe this was due to students already having experience in my class in conducting CER and the high scores observed in the pre survey. With that being stated, the three highest gains from pre to post survey based on percentage were related to the usefulness of rebuttal in making an argument and an attitude towards science. The survey results show students found making an argument to be a useful part of learning and engaging in argument increases enthusiasm.

Future Research

There are two main themes to be considered in future research of CERR. The first theme that I would focus on would be gathering data from pre-post tests. I would also consider researching the effect that writing a scientific argument has on student learning for a certain topic.

Pre-Post Testing Results

Throughout this research process, the results were based off human opinion. The student interviews could have been biased and Likert scales are based on self-reflection, which may not be accurate. It would have been valuable to have pre-post test results that could have proven a significant improvement in student learning. If building an argument and using rebuttal is to be proven as an effective learning method, there needs to be data gathered that shows improvement on test scores because of using rebuttal as a learning method.

Having students construct arguments as a research paper is another promising area of research for CERR. Through this research project, students created an outline using CER, then used that information to counter arguments in the form of rebuttal. I think with a little guidance and assistance, students would be more than capable of organizing their projects into a scientific paper. This is a cross-cutting concept that could be done by one single teacher or used in an English/Language Arts class. Students need the opportunity to share what they are finding and discover how their findings are useful as they grow. More research needs to be done to prepare students in vocalizing or even publishing their findings.

Impact of Action Research on the Author

This study has been a humbling and satisfying challenge. I have grown as a writer, researcher, and teacher throughout the action research process. Before deciding to complete my master's the longest paper I had written was roughly ten pages long and had only been reviewed once or twice. For this capstone paper, I have compiled sixty-three pages and have been through at least ten rounds of review and corrections. Having the opportunity to practice writing and receiving feedback is a tough, but truly valuable experience. I have improved so much in the way that I organize my writing. Researching and collecting data has opened my eyes to the value of innovation in my classroom. It has helped me shift to a more professional and curious approach in the way I think about educating my students. In the past, I had run my classroom with the sole purpose of making sure things went as smoothly as possible in my classroom. I have found the role of teacher much more enjoyable in being more inquisitive about what students think and hearing them out, even if students are being critical. I have become more comfortable in being told when I am being unfair by a student, whether it is true or not. After completing this program, I plan on continuing my education by getting my EdD in curriculum and instruction. The positive experiences I had in conducting my research and collaborating with faculty and classmates have led me to this decision. I will use the lessons of my action research for the rest of my professional career as I continue my education and continue to innovate in my classroom.

REFERENCES CITED

Abate, T., Michael, K., & Angell, C. (2020). Assessment of scientific reasoning: Development and validation of scientific reasoning assessment tool. *EURASIA Journal of Mathematics, Science and Technology Education, 16*(12).

Angeloudi, A., & Papageorgiou, G. (2022). Primary students' argumentation skills on evaporation: A teaching intervention. *Preschool and Primary Education, 10*(1), 1-24.

Astira, S., & Dwiastuti, S. (2019). Analysis of argumentation skills in biological learning in senior high school students. In *Journal of Physics: Conference Series* , 1338(1), 012032. IOP Publishing.

Ault, M., Craig-Hare, J., Frey, B., Ellis, J. D., & Bulgren, J. (2015). The effectiveness of Reason Racer, a game designed to engage middle school students in scientific argumentation. *Journal of Research on Technology in Education, 47*(1), 21-40.

Bauschard, S., & Rao, P. A. (2015). The value of speech and debate in the middle school years. *Rostrum, 61*.

Belland, B. R., Glazewski, K. D., & Richardson, J. C. (2008). A scaffolding framework to support the construction of evidence-based arguments among middle school students. *Educational Technology Research and Development, 56*, 401-422.

Bray, B., & McClaskey, K. (2013). A Step-by-Step Guide to Personalize Learning. *Learning & Leading with Technology, 40*(7), 12-19.

Brunsell, E. (2012). *Designing Science Inquiry: Claim + Evidence + Reasoning = Explanation*.Edutopia. https://www.edutopia.org/blog/science-inquiry-claim-evidence reasoning-eric-brunsell.

Chuang, P. L., & Yan, X. (2022). An investigation of the relationship between argument structure and essay quality in assessed writing. *Journal of Second Language Writing, 56*, 100892.

Graham, S., & Hebert, M. (2010). *Writing to read: Evidence for how writing can improve reading: A report from Carnegie Corporation of New York*. https://acuresearchbank.acu.edu.

Hancock, D. R., Algozzine, B., & Lim, J. H. (2021). *Doing case study research: A practical guide for beginning researchers.* Thousand Oaks, CA: SAGE Publications.

Kern, M. L. (2022). A useful model for focusing on well-being in schools. In R. Gilman, E. S. Huebner, & M. J. Furlong (Eds.), *Handbook of positive psychology in schools: supporting process and practice* (pp. 12).

Man, D., Chau, M. H., & Kong, B. (2021). Promoting student engagement with teacher feedback through rebuttal writing. *Educational Psychology, 41*(7), 883-901.

Mirra, N., Honoroff, B., Elgendy, S., & Pietrzak, G. (2016). Reading and writing with a public purpose: Fostering middle school students' academic and critical community literacies through debate. *Journal of Language and Literacy Education, 12*(1), 1-22.

Mumtaz, S., & Latif, R. (2017). Learning through debate during problem-based learning: An active learning strategy. *Advances in physiology education*, *41*(3), 390-394.

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.

Nunez-Eddy, E., Wang, X., & Chen, Y. C. (2018). Engaging in argumentation. *Science and Children*, *56*(2), 51-59.

Orbach, M., Bilu, Y., Gera, A., Kantor, Y., Dankin, L., Lavee, T., Kotlerman, L., Mirkin, S., Jacovi, M., Aharonov, R., & Slonim, N. (2019). A dataset of general-purpose rebuttal. *arXiv preprint arXiv:1909.00393*.

Osborne, J. (2013). The 21st century challenge for science education: Assessing scientific reasoning. *Thinking skills and creativity*, *10*, 265-279.

Robertson, S. (2021). Claim, Evidence, Reasoning: How to get more value out of your research presentations. Massachusetts Institute of Technology.

Schmid, P., & Betsch, C. (2019). Effective strategies for rebutting science denialism in public discussions. *Nature Human Behavior*, *3*(9), 931-939.

Sioux City Community Schools. (2022). *North Middle Demographics.* Retrieved March 14, 2023, from https://www.siouxcityschools.org/page/our-district.

Tawil, M. A. (2016). Classroom debates: A tool to enhance critical thinking in science. 1-48

Tumposky, N. R. (2004). The debate. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *78*(2), 52-56.

U.S. Census Bureau. (2024). Sioux City, IA. U.S. Department of Commerce. Retrieved February 25, 2024, from https://data.statesmanjournal.com/census/total-population/not hispanicwhite/Sioux city-city-iowa/160-1973335/#cmap.

Walton, D. (2009). *Objections, rebuttals, and refutations.* 1-10.

APPENDICES

APPENDIX A

MONTANA STATE UNIVERSITY'S INSTITUTION REVIEW BOARD COMPLIANCE

Hello Rozeboom, Ryan,

Your protocol was reviewed by the IRB and has been approved.

PI: Rozeboom, Ryan
Approval Date: 1/12/2024
Title: THE EFFECT OF ADDING REBUTTAL TO CLAIM, EVIDENCE, AND REASONING TO ENHANCE STUDENTS' ABILITY TO ENGAGE IN SCIENTIFIC ARGUMENTS

Protocol #: 2024-1194-EXEMPT
Review Type: Exemption
Expiration Date: 1/12/2029

Work described under this protocol may now commence. The PI is responsible for ensuring that the protocol accurately describes research practices being conducted.

> Review Category designation determined by the IRB can be found in the final section of your protocol.
> IRB-stamped active Consent Forms are attached within your protocol where applicable.
> Any changes must be submitted via Amendment prior to implementation.
> Per the Common Rule, research only requires Interim (annual) Review by the IRB if 1) it was reviewed via Full Committee or 2) is regulated by the FDA.
> All research is subject to post approval monitoring.
> All protocol types must be renewed 5 years after approval.
> Inform the IRB once your research is complete so that the protocol may be inactivated.

Please contact your IRB Program Manager with any questions or if you are in need of assistance. Thank you for your diligence in the care of human subjects research participants.

Institutional Review Board for the Protection of Human Subjects | Office of Research Compliance | Montana State University

APPENDIX B

PRE AND POST INTERVENTION LIKERT SURVEY

Please answer the following questions. The following survey is to be conducted on a voluntary basis and will be anonymous for all participants. Any student that is unwilling to participate or have their results used in this research will not be penalized in any way.

1. Starting with a claim has validity and importance in a scientific argument.
   Strongly Disagree Disagree Agree Strongly Disagree
   1……2…….3……4

2. Gathering evidence and reasoning are beneficial in constructing a good argument.
   Strongly Disagree Disagree Agree Strongly Agree
   1……2……..…3……..4

3. Having a conversation about a topic in the form of rebuttal, strengthens your understanding and passion about a topic.
   Strongly Disagree Disagree Agree Strongly Agree
   1……2…..……..3…….4

4. Being able to make a scientific argument is a beneficial skill to have.
   Strongly Disagree Disagree Agree Strongly Agree
   1……2…….3…….4

5. I feel that I can use argumentative skills, like CERR, in my own personal and school experiences.
   Strongly Disagree Disagree Agree Strongly Agree
   1……2…….……..3……4

6. In general, I like science.
   Strongly Disagree Disagree Agree Strongly Agree
   1……2……..3…….4

7. I can understand scientific concepts without much difficulty,
   Strongly Disagree Disagree Agree Strongly Agree
   1……..2……....3……4

APPENDIX C

EVALUATIVE PRESENTATION RUBRIC

CERR RUBRIC

Students will create their own CER sheets and present them. This rubric has the expected guidelines for them and will be used as data for a CERR study. All participants will be used anonymously. No student is required to provide their data if unwilling to do so.

	4	3	2	1
Claim and Evidence	Student has a definitive claim. The claim is backed up by at least 3 pieces of evidence. The evidence is sourced and relates to the claim.	Student has a definitive claim. The claim has at least 2 pieces of evidence. The evidence is sourced and at least some of the evidence relates to the claim.	Student has a claim. The claim has at least 1 piece of evidence. At least 1 piece of evidence is sourced, but most of the evidence does not relate to the claim.	Student is missing a relative claim. There is no evidence backing up the claim. No evidence is sourced and does not relate to the claim.
Reasoning	The reasoning is relevant and coherent to the evidence and claim. The reasoning engages debate.	Most of the reasoning is relevant and coherent to the evidence and the claim. Most of the reasoning engages debate.	Some of the reasoning is relevant and coherent to the evidence and the claim. Some of the reasoning engages debate.	None of the reasoning is relevant and coherent to the evidence and the claim. None of the reasoning engages debate for the topic at hand.
Rebuttal	Students lay out their claim, evidence, and reasoning to make their argument. Students respond to questions and statements with evidence.	Students lay out their claim, evidence, and reasoning to make their argument. Students respond to questions and statements with some evidence.	Students lay out their claim, evidence, and reasoning, but it is unorganized. Students respond to questions and statements with minimal evidence.	Students are not organized in laying out their claim, evidence, and reasoning. Students do not respond to questions and statements with evidence.
Cohesiveness	The presentation is clear and coherent. Student has a well organized presentation that is easy to follow.	The presentation is moderately clear and coherent. Student is somewhat organized in their presentation and is mostly easy to follow.	The presentation has some clarity and coherence. The presentation is only minimally organized and has components that are able to be followed.	The presentation is not clear and coherent. There is no organization to the presentation and cannot be followed in a manner that makes sense.

APPENDIX D

COMPARATIVE CONTENT ASSESSMENT

CERR OUTLINE

CER Outline What Evidence are you using? Use the graphic organizer below to support your argument.	
My Claim	
Evidence	How does this evidence support my argument?
	1. 2. 3.
Resource:	4.
	1. 2. 3.
Resource:	4.
	1. 2. 3.
Resource:	4.

APPENDIX E

STUDENT INTERVIEWS

STUDENT INTERVIEWS

Disclaimer: Participation in this research is voluntary and anonymous for all participants. Any student unwilling to participate will not be penalized in any way.

1. Overall, would you rate your experience in building a CERR and participating in the activity as positive or negative?

2. What was your favorite part of CERR?

3. What was your least favorite part of CERR?

4. Was CERR helpful in your understanding of the unit at large? How so?

5. Was CERR helpful in preparing you for the DCA at the end of the unit?

6. How did CERR help you to make a scientific argument?

7. Would you recommend other teachers use CERR in science classrooms?

8. Is there any other thoughts you have about your experience using CERR that you would like me to know?