IMPACT OF CLAIM, EVIDENCE, REASONING INSTRUCTION IN THE ENGLISH CLASSROOM ON ARGUMENTATIVE WRITING IN SCIENCE AND ACROSS THE CURRICULUM

by

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DEDICATION

To my husband and children who are my inspiration to never stop learning and my encouragement when the path is hard. James, Harmony and Gabby, I hope the persistence you have witnessed through my journey will instill in the resiliency to achieve any task set before you and the tenacity to reach any goal to which your hearts aspire. Seth, thank you for everything you have shouldered to make this goal a reality and your constant love, patience, and encouragement that got me through the darkest hours.

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I wish to gratefully acknowledge the invaluable assistance provided to me by the department of Science Education in the College of Letters and Science at Montana State University-Bozeman. Dr. John Graves was my project advisor whose foresight and patience fueled this project's completion. Diana Patterson and Madeline Felts fielded endless questions and managed the intricacies of graduate programing to assure all requirements were fulfilled.

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ABSTRACT

Engaging in argumentation from evidence is a critical skill for participation as productive citizens in the 21st century enabling us to access the evidence in the world around us to make well-reasoned decisions about our lives, and the future of our country and world. The purpose of this study was to improve written explanations in the science classroom and other content areas by engaging the students' reasoning capabilities and improving student confidence in answering short answer questions.

Instruction included introduction of the Claim, Evidence, Reasoning (CER) framework in the English language arts classroom to promotes mastery of argumentative writing in the science classroom and other content areas through the use of graphic organizers and accessible non-content-based lessons. To assess the impact of the instructional treatment, student writing samples were collected during traditional instruction pre, and post-treatment and evaluated by rubric as measurement of skill growth. Pre and post-treatment, students were asked interview questions and given a self-confidence survey to determine student confidence, attitudes, and motivation regarding writing short answer explanations.

The results indicated that instruction with the CER framework in the English classroom significantly impacted the frequency of writing well-reasoned arguments in science and other subject areas while maintaining student confidence in writing.

CHAPTER ONE

INTRODUCTION AND BACKGROUND

Context of the Study

Holloman Middle School is a small middle school located on Holloman Air Force Base in Alamogordo, New Mexico. The school serves students whose parents have access to the military base through active duty, retired, or civilian military service, and has a population of 200 students in grades six through eight. Our ethnic diversity seems less important to the students than their military affiliation for the connection it provides since the students immediately find common ground. However, our ethnic diversity is 49% Caucasian, 18% Hispanic, 15% two or more ethnicities, 10% Black, 6% Asian, and 2% Native American/Hawaiian. Our eighth-grade class contains only 71 students. Our students transition frequently from school to school across the country and the globe. This makes it extremely important for our teachers to frequently assess for learning gaps and focus not just on local but national educational standards. The Secretary of the Air Force and the Base Wing Commander hold our school to high expectations in preparing our students for any possible educational transition. My students comprise the lower 69% of the eighth grade English students, including all special education students and students who speak English as second language. The other 31% of our eighth-grade English students have advanced to the nineth-grade curriculum (T. Grimes, personal communication September 2019).

I had the unique opportunity to teach eighth-grade English during the 2018-2020 school years, even though my background and experience are in science. Surprisingly, the content area was an excellent fit due to my love of reading and high content knowledge in writing from my research background. As I progressed through the first year, I noticed a continuing problem with my students' writing on all ability levels. My students would consistently use evidence to prove a claim without any justification, and without sufficient reasoning their arguments fell flat. I tried several lessons recommended by other teachers in the English department for addressing this problem, but the students still fell short of my expectations. This deficit was magnified in the students in my second year because the students who had been educated on base from 5th grade or earlier had several English teacher changes in each grade level making them markedly behind in their writing skills.

Coincidentally, our school district implemented "Writing Across the Curriculum" and began to transition to the Next Generation Science Standards in 2018. Foreseeing issues writing in all content areas, I looked to my science background for answers to my students' writing problems (NGSS Lead States, 2013). I was immediately drawn to the Claim, Evidence, Reasoning (CER) framework to address the concern (McNeil, Lizotte, Krajcik, & Marx, 2006). CER is a key strategy in developing the science and engineering practice of engaging in argument from evidence in the Next Generation Science Standards (NGSS Lead States, 2013). If I could teach my students to be proficient in this area they would be better prepared to communicate their understanding in not only science and English but in all content areas.

In addition, they would be learning a critical skill for participation as productive citizens in the 21st century. I was hopeful that the Claim, Evidence, Reasoning Framework would aid them in developing the skills to access the evidence in the world around them to make well-reasoned decisions about their lives, and the future of our country and world. Every day, these students are bombarded with half-truths and false claims; if I can develop their proficiency in reasoning, they will be successful in my English class, in school, and, most importantly, in the world.

The purpose of this study was to determine the impact of the Claim, Evidence Reasoning Framework taught in the English classroom on eighth-grade students' reasoning ability in writing in the science classroom. This supported our district and school's Writing Across the Curriculum initiative, increased inter-departmental cooperation, and improved understanding of science and engineering practices.

Focus Question

My focus question was, How does instruction with the CER framework in the English classroom impact the writing of well-reasoned arguments?

My sub-questions include the following:

1.) Does the use of the CER framework in English class impact the frequency of well-reasoned, evidence-based claims in science and other subject areas?

2.) Does use of the CER framework improve student confidence in answering short answer questions?

CHAPTER 2

CONCEPTUAL FRAMEWORK

Next Generation Science Standards

In *A Framework for K-12 Science Education*, the National Research Council asserts that "Science, engineering, and technology permeate nearly every facet of modern life, and they also hold the key to meeting many of humanity's most pressing current and future challenges" (p. 1). Unfortunately, the workforce in the United States lacks the education to meet these needs. With this challenge at the forefront of their minds, the council in collaboration with the National Science Teachers Association and many others set forth to introduce science education standards that would develop sufficient scientific literacy in citizens. These standards enable them to make evidence-based decisions on related issues in their everyday lives and have the ability to enter careers in science (National Research Council, 2012).

The result of the collaboration of these two scientific bodies was the Next Generation Science Standards (NGSS) that are being adopted by more and more states each year (NGSS Lead States, 2013). These innovative standards have sent teachers looking for effective ways to implement the three dimensions of the framework; science and engineering practices, crosscutting concepts, and disciplinary core ideas. The three dimensions of the NGSS work together to create a strong foundation for students on which to build science knowledge over time. The dimension of science and engineering practices includes the eight skill sets students will perform: asking questions and defining

problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument, and obtaining, evaluating and communicating information. The crosscutting concepts dimension teaches students to see connections across content areas and include patterns, cause and effect, scale, proportion and quantity, systems and system models, energy and matter, structure and function, and stability and change. The disciplinary core ideas dimension focuses on a small number of concepts that are developed on a continuum from kindergarten through twelfth grade covering physical science, life science, and Earth and space science. Teaching the cross-cutting concepts and disciplinary core ideas in the new standards is a fairly comfortable transition for teachers because they resemble the standards that are being replaced. However, the new standards demand teachers use a higher level of thinking and engagement in inquiry using the science and engineering practices to prepare students to be the decision makers of the future, a future that holds limitless possibilities for the feats that science may achieve (National Research Council, 2012).

Engaging in Argumentation from Evidence

One of the most challenging science and engineering practices for students and adults alike is the practice of Engaging in Argument from Evidence (McNeill & Krajcik, 2012). This practice is of central importance in scientific discovery (Kuhn, 2010). In science, researchers can never stand alone when making a discovery; scientific knowledge is socially constructed (Driver, Newton, & Osborne, 2000). Researchers must communicate and defend their discovery to the scientific community; whose

responsibility is to try to refute the claim to verify its validity. Without discourse, science would be stagnant, never growing into a fuller understanding of the world around us or designing new and innovative products (Toulmin, 2003).

The challenging component of teaching this skill to students is impressing upon them the necessity of a practice that does not come naturally (McNeill & Krajcik, 2008). Students frequently find verbalizing and defending their claims with evidence challenging (Sadler, 2004 as cited in McNeill & Krajcik, 2008). These difficulties are understandable because the task we are asking our students to undertake requires them to simultaneously process not only their claim and the evidence to prove it, but also anticipate the responses of those that would challenge their claim (Kuhn, 2010). By engaging in this process of argumentation, the students are given the opportunity to cultivate a deeper understanding of the concepts and content knowledge involved. To accomplish this task students need a substantial amount of support and scaffolding for the successful production of quality arguments (McNeill & Krajcik, 2008).

Cognitive Development

Students as young as six years old use concrete reasoning but begin transitioning to what Piaget termed the formal operational stage around age eleven. The transition into the formal operational stage allows them to begin to use symbols to understand abstract concepts and make claims based on previous experiences. This includes conditional reasoning, allowing students to make if-then inferences that are essential in advanced math and science (Inhelder, 1958). Markovits (2017) suggests that the development of logic continues in the formal operational stage in slow advancements in reasoning ability.

Reasoning with abstract concepts, that students do not have an existing knowledge of, is a much more difficult developmental task and often does not develop until late adolescence (Markovits & Lortie-Forgues, 2011). This ability to reason with little to no knowledge about a topic is critical in science and engineering and allows students to make predictions about unfamiliar unobservable phenomena, but is unlikely to fully develop before high school (Venet & Markovits, 2001). These developmental stages must be considered when planning lessons for middle school students and lessons planned out with a significant amount of scaffolding.

Reasoning Strategies

Over time, many different iterations of the same basic reasoning strategy have been implemented, and most have their origins in the work of Stephen E. Toulmin (2003). In 1958, Toulmin proposed that there was a pattern to the way we construct and assess the "soundness, strength, and conclusiveness of arguments" in everyday life (p. 2). He proposed that these patterns are centered around the science of logic and are developed through instruction. He stated that "Logic is concerned with the soundness of the claims we make- with the solidity of the grounds for them- or, …the case we present in defense of our claims" (p. 7). Each time we make an assertion or claim we put ourselves at risk of being challenged to produce sufficient backing for our claim, and the facts and argument we use will depend on the nature of the claim. However, Toulmin proposes that there is a layout or pattern that every argument has in common, beginning with committing ourselves to a claim or belief. We then must follow that claim up by answering the question "What do you have to prove this?" and provide the data or

information that the assertion is based on. Once we establish that we have this evidence, we must address the next logical question, "How did you get there?" At this point, Toulmin states that, "we must bring forward not further data, …but propositions of a different kind: rules, principles, inference-licenses or what you will…to show that, taking these data as a starting point, the step to the original claim or conclusion is an appropriate or legitimate one" (p. 91). He called this line of reasoning warrants. These warrants, he proposed, were hypothetical statements that act as bridges to connect the assertion we make with the data we provide to prove it. For example, if our claim is that "Harry is a British subject" and our information to prove that is that "Harry was born in Bermuda," we naturally need to provide a reason that a man born in Bermuda is a British subject (pp. 96-97). Toulmin purports that, we could then provide the following reasoning or logic as our warrant to support our claim with rebuttals accounted for in our exceptions, "A man born in Bermuda (data) will generally (qualifier) be a British subject (warrant) on account of the legal provisions governing nationality (backing) unless both his parents are not British or he has become a naturalized citizen of another country (exceptions)" (p. 97) (Figure 1*)*. In his discussion of the acquisition of these skills, he states that, "rational procedures and methods do not exist in the air, apart from actual reasoners: they are things which are learned, employed, sometimes modified, on occasion even abandoned, by people doing the reasoning" (p. 196). This statement has been proven, over time, to be very prophetic since many educators have utilized his work to support the development of argumentation skills (McNeill, 2006).

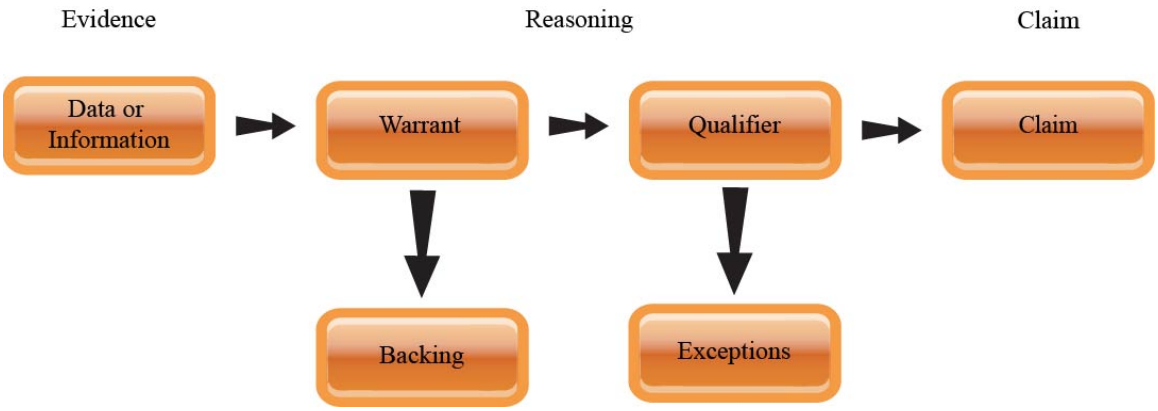


Figure 1. Toulmin's (2003) layout of an argument.

Instructional Strategies for Middle School

In 2006, McNeill, Lizotte, Krajcik, and Marx, inspired by Toulmin's model, set forth to develop a strategy that would make this valuable tool accessible to their middle school students. This strategy is known as the Claims, Evidence, and Reasoning (CER) framework and simplifies the task of argumentation for adolescents still developing the formal operational stage of metacognition. Middle school teachers have the daunting task of guiding the minds of their students through this important transition. McNeill et al. took this into consideration when developing the CER framework by reducing the complexity of Toulmin's model for their students. They used Toulmin's claim and defined it as "an assertion or conclusion that answers the original question" (McNeil et al., 2006, p. 158). They called Toulmin's data, evidence and defined it as "data that supports the claim…from an investigation, or another source such as observations, reading material, or archived data" (McNeil et al., 2006, p. 158). This simplification is most pronounced in the area Toulmin referred to as the bridge between the claim and the data answering the question 'How did you get there' (Toulmin, 2003). Toulmin's model

details the complicated relationship between the warrant, backing, and qualifiers (Toulmin, 1958). To simplify this complex task, McNeill et al. (2006) refer to these steps together as reasoning. Reasoning is defined as the justification of the claim and shows the logic behind why the evidence supports the claim. This framework was developed for use in the science content area but McNeill et al. stress that using the same framework across all domains would promote mastery in written explanations.

CHAPTER 3

METHODOLOGY

Treatment

The purpose of this study was to determine if instruction with the Claim, Evidence, Reasoning (CER) framework in the English classroom promotes mastery of written explanations in the science classroom and other content areas. The subjects of the study were 44 eighth grade students at Holloman Middle School who were enrolled in one of three sections of the eighth grade English language arts class.

In December, prior to the treatment, logic problems were introduced as bell work to familiarize students with logical thought processes and prepare them for the use of the vocabulary during the treatment. The treatment lessons began in January of 2020 with instruction of the CER framework as part of the Argumentative Writing unit. Instruction included an introduction to the CER framework, non-content based CER writing lessons, and a lesson examining writing in the core content areas of science, history, and English language arts.

The weeklong instruction in CER began with an in-depth discussion of what a claim is, and what evidence and reasoning look like in different subject areas. Notes were taken directly on the CER Graphic organizer to make a visual connection to the framework (Appendix F). This was reinforced by using a scaffolded version of the graphic organizer to analyze the 2014 Audi A6 “My dad is a space alien” television commercial (Appendix G). In the commercial, the girl gives evidence that her father is a

space alien but does not follow it up with reasoning to link the evidence to the claim. Students worked in groups to assign reasoning to each of her claims in the organizer.

This lesson was followed by a puzzle activity modeled after the "Sesame Street Picnic" activity from the *Journal of College Science Teaching* that oriented students to how claims can change with new evidence and why explaining your reasoning is important (Del Carlo, 2017). The students worked in groups to solve the mystery of what Mickey and his friends were doing in the puzzle. They began by engaging their prior knowledge about Mickey and his friends and what questions needed to be answered to figure out the puzzle mystery in the graphic organizer (Appendix H). Each group was given four unconnected pieces to inspect for clues about what was going on in the puzzle and logged these clues into the chart provided with any claims backed up by reasoning. The activity was concluded by the groups sharing their claims. The class discussed how evidence and reasoning back up claims so that they support your argument when other groups have different claims and how claims need to change with the introduction of new evidence.

To conclude the treatment, students analyzed their writing samples from each content area with the CER Rubric and reflected on how their writing could be improved in a paragraph with the planning completed in the CER graphic organizer (Appendix B & F). The CER framework continued to be stressed as a tool throughout other lessons in the English classroom and the CER graphic organizer was made available for student use in any class. The research methodology for this project received an exemption by Montana

State University's Institutional Review Board and compliance for work with human subjects was maintained (Appendix A).

Data Collection and Analysis Strategies

To assess the impact of student growth due to the implementation of the instructional treatment, student writing samples were collected from traditional instruction in the core content areas of science, history, and English language arts. These pre and post treatment writing samples were evaluated from each content area with the CER Explanations Rubric that was adapted with the permission of Kevin J. B. Anderson from his rubric that combines McNeil's CER rubric with Smarter Balanced Assessment Consortium's (SBAC) Common Core Argumentative Writing rubric (K. Anderson, personal communication October 15, 2019) (Appendix B). The rubric contained five levels of mastery, from skill not present (0) to skill fully mastered (4). The rubric was available to the students and used to self-evaluate and peer-evaluate practice short answer explanations during the treatment. The mean of student writing data collected pre and post-treatment were analyzed for change and reported in box and whisker plots. The statistical significance of the gain was analyzed with a paired t-test and the effect size of the means with Cohen's d.

Pre- and post-treatment, students were given the Writing Self-Confidence Survey to determine student confidence, attitudes, and motivation with regards to writing short answer explanations (Appendix C). The post-survey, Claim, Evidence Reasoning Self-Confidence Survey, repeated the same questions as the pre-survey with the addition of questions specific to the treatment with CER (Appendix D). Students were asked to rate

their effort, motivation and confidence in aspects of writing short answer explanations on a scale with Strongly Disagree (1), Disagree (2), Agree (3), or Strongly Agree (4). The Likert-scale data was analyzed quantitatively in six scales: Effort, Motivation, Confidence in Writing, Confidence in Writing Claims, Confidence in Using Evidence, and Confidence in Using Reasoning. The paired t-test was used to determine if there was a significant difference between pre- and post-treatment and displayed visually chart. The final five questions in the post-survey were analyzed as a CER treatment scale for mean and displayed graphically with a diverging bar chart to determine student attitudes about the treatment's value. The reflective short answer questions were analyzed for themes and used to support other findings.

Student Pre and Post-treatment Interviews were used to qualitatively assess student confidence, attitudes, and motivation in regard to writing short answer explanations (Appendix E). Three students from each class were interviewed through random selection during their English class period. The data was analyzed for themes and used to support other findings.

Observations were recorded in the Researcher Reflective Journal before, during and after the treatment. The data from the journal was analyzed for themes and used to support other findings. The data collection instruments are summarized in the triangulation matrix below (Table 1).

Table 1. Data triangulation matrix.

	Data Collection Methods		
Research Questions	Source 1	Source 2	Source 4
How does instruction with the CER framework in the English classroom impact the writing of well-reasoned arguments?	Student Short Answer Writing Samples assessed with CER Explanations Rubric (3 samples collected pre-treatment, and post-treatment)	Explanations Self Confidence Survey Reflection Questions	Researcher Reflective Journal
Does the use of the CER framework in English class impact the frequency of well-reasoned, evidence-based claims in other subject areas?	Student Short Answer Writing Samples assessed with CER Explanations Rubric (3 samples collected pre-treatment, and post-treatment)		Researcher Reflective Journal
Will the use of the CER framework improve student confidence in answering short answer questions?	Student Interviews	Explanations Self Confidence Survey Open-ended Reflection Questions	Researcher Reflective Journal

CHAPTER 4

DATA AND ANALYSIS

Results

Analysis of the student writing data showed an increase in the mean student writing rubric scores in all subject areas after the instructional treatment using the Claim, Evidence, Reasoning (CER) Explanations Rubric (Appendix B, Figure 2) (*N*=44). The magnitude of the treatment's effect was 3.49 with Cohen's d, indicating that the groups differ by 3.49 standard deviations of 0.4 where a standard deviation of 0.8 is considered a large effect size. This change in student achievement was also verified with a paired t-test which indicated a highly statistically significant mean difference in the students' average writing scores before and after the treatment (*N*=44). Students' post-treatment writing scores (2.62 ± 0.44) were higher after the CER treatment when compared to the pre-treatment writing scores (1.14 ± 0.41) with a highly statistically significant mean increase of 1.48 (CI 95%, 1.37 to 1.59) with a p-value of <0.001 and a t-value of 27.34. This analysis was supported by student feedback when asked if she thought learning the CER framework had helped her write better answers. One student responded, "Yes, it helps me make sure my answer will make sense to the teacher. That it has a claim with evidence, and I explain my reasoning." The reflective response questions also support this finding with 84% of students reporting positive effects. One student said, "It has helped me be more organized on the my answers." Another student stated, "It helps guide me so that I don't put a one sentence answer, or so that I explain myself in more detail."[sic]

Student writing samples were analyzed for change by comparing pre and post-treatment writing samples (Figure 2). Representative samples from the science classroom, utilizing CER prompts from STEMscopes by Accelerate Learning, show an increase in student mastery when compared to their pre-treatment work samples.

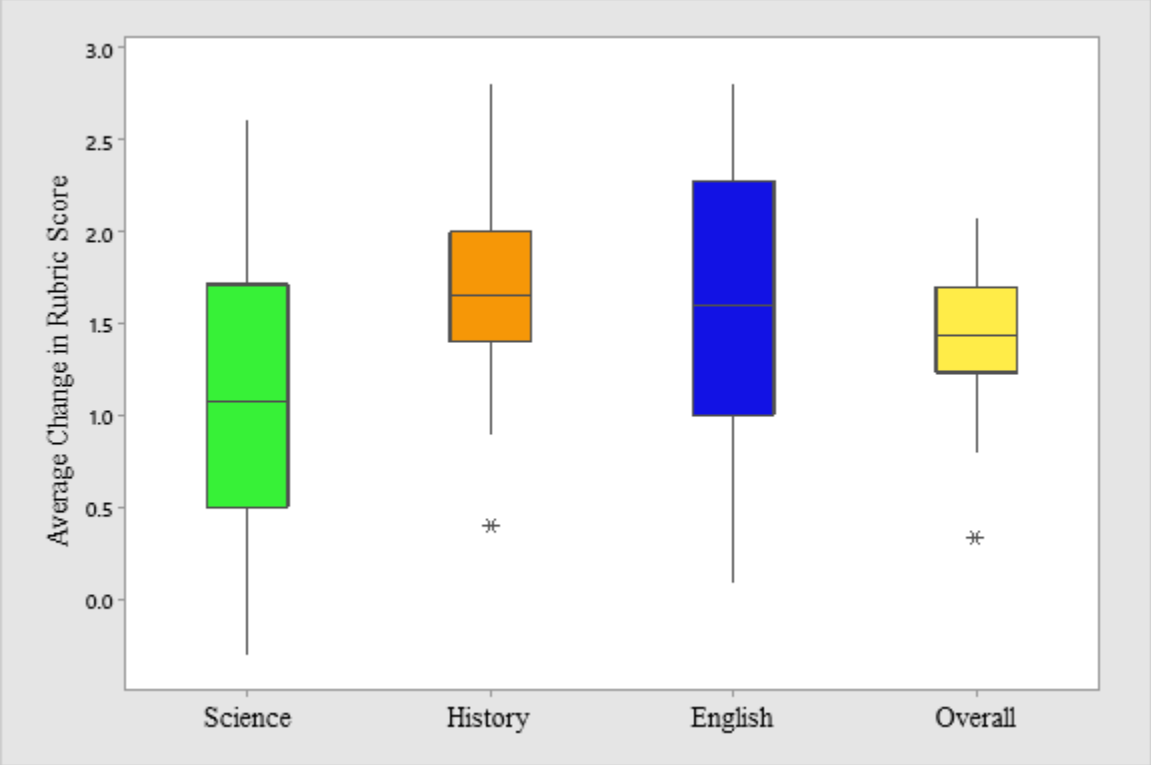


Figure 2. Average change in writing scores from CER Explanations Rubric (*N*=44).

A student who scored in the first quartile of the data answered a question about chemical reactions in a hand warmer in pre-treatment writing with "I think 2 because I've used hand warmers and they use oxygen to warm up the other substances. 100℃ is boiling so74 is just above warm, it would be hot. Below 30 would freeze so the two others would freeze your hands not warm them." [sic]Then answered a question about Newton's Laws in volleyball in post-treatment writing with "The higher they need to hit the ball into the air takes more force to do so. So the more force they hit the ball with, the

more their hands hurt."[sic] These samples represent a small change when comparing pre-treatment science writing samples with post-treatment science writing samples indicated by a change in writing rubric score of 0.2.

In comparison, a student who scored in the fourth quartile of the data answered the pre-question about hand warmers with "I think number two would be the best for the handwarmers because number two is the only one that goes up in temp in one hour. I know this because the graph cites it."[sic] Then answered the post-question about Newton's Laws with "Mandy experienced more pain than the other girls because Newton's third law of motion explains that every action has an equal and opposite reaction. Mandy hit the ball heights with ten meters of height, which means 10 meters of force went back to her hand. Nicole and Sara hit the ball with less force which means not as much forces coming back to which means less pain." [sic] These samples represent a larger change when comparing pre-treatment science writing samples with post-treatment science writing samples indicated by a change in writing rubric score of 1.0.

The writing samples shown are representative of student work that scored close to the median (1.05) of the data when comparing pre-treatment science writing samples with post-treatment science writing samples with a change in science writing rubric score of 1.10 (Figures 3, 4).

Scenario

Researchers were investigating various chemical reactions that might be used in hand warmers. The data they collected is listed below.

External Data

Reaction Number	Starting Substances	Substance Added To Starting Substances	Starting Temperature °C	Temperature After 1 Hour °C
1	Sodium thiosulfate	Water	22	10
2	Cellulose, iron, water, activated carbon, vermiculite, salt.	Oxygen (From being exposed to the air)	22	74
3	Citric Acid	Sodium bicarbonate	22	18

Prompt

Based on the provided data, make a claim about which reaction would be appropriate for hand warmers, cite the evidence, and provide your reasoning.

Number 2 because over the time the temp. for the heat warmer would be the highest and warmest Temp. out of reaction #1 and 2.

Figure 3. Pre-treatment science writing sample of the median rubric score.

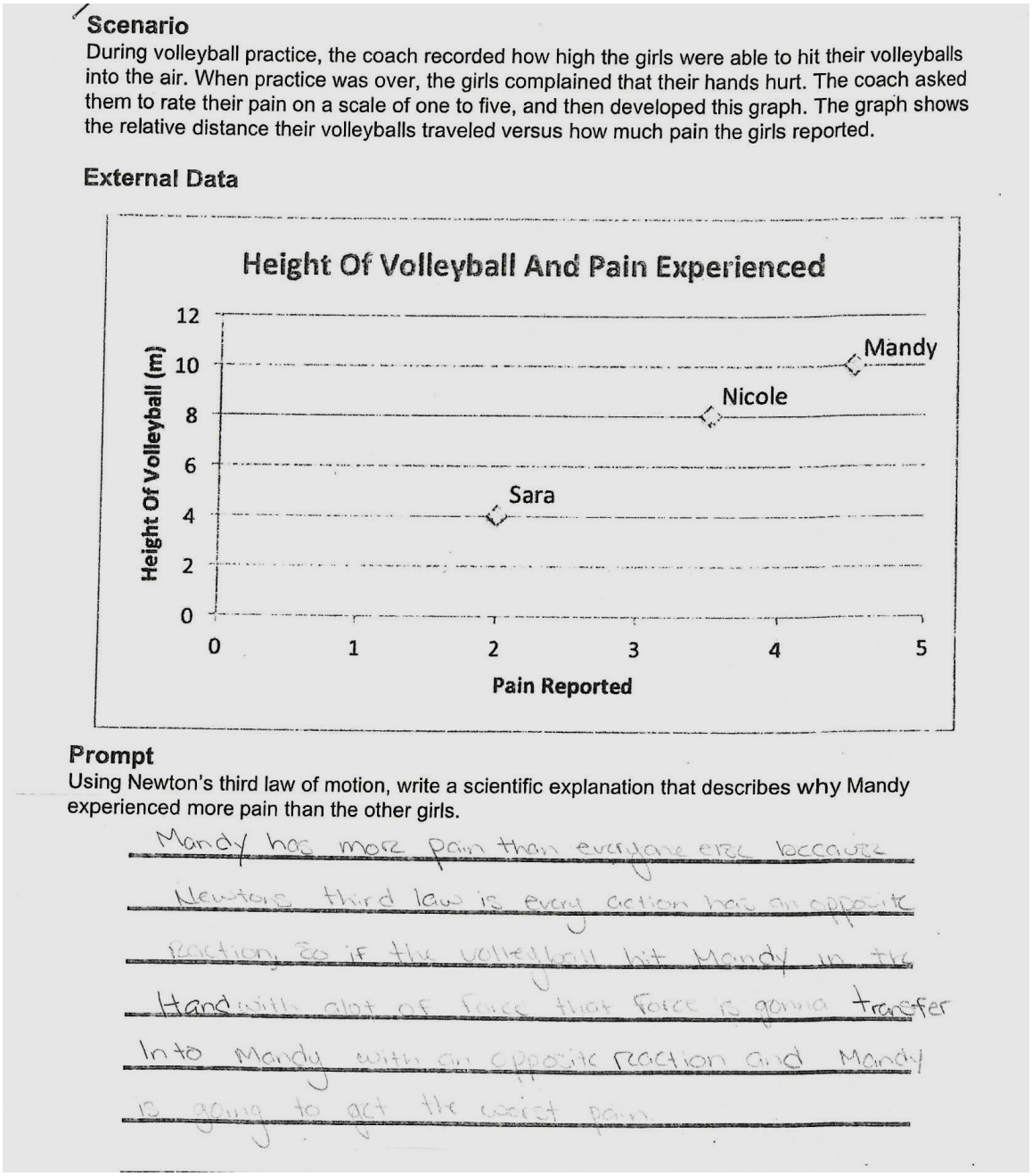


Figure 4. Post-treatment science writing sample of the median rubric score.

The mean post-treatment writing rubric scores increased for each of the CER framework areas of claim, evidence, and reasoning after treatment. This change in student achievement was verified with a paired t-test which indicated a statistically highly

significant mean difference for each of the three areas. For the claim portion of the framework, students' post-treatment writing scores (2.76 ± 0.56) were higher after the CER treatment when compared to the pre-treatment writing scores (1.36 ± 0.10) with a highly statistically significant mean increase of 1.44 (CI 95%, 1.27 to 1.61) with a p-value of <0.001 and a t-value of 16.86. For the evidence portion of the framework, students' post-treatment writing scores (2.60 ± 0.47) were higher after the CER treatment when compared to the pre-treatment writing scores (1.08 ± 0.46) with a highly statistically significant mean increase of 1.52 (CI 95%, 1.35 to 1.68) with a p-value of <0.001 and a t-value of 18.13. For the reasoning portion of the framework, students' post-treatment writing scores (2.50 ± 0.58) were higher after the CER treatment when compared to the pre-treatment writing scores (0.81 ± 0.42) with a highly statistically significant mean increase of 1.69 (CI 95%, 1.51 to 1.87) with a p-value of <0.001 and a t-value of 19.13.

Of these three components, only the average change in reasoning ability in writing samples improved more significantly than the change of the writing score overall (Figure 5). This was verified with a paired t-test which indicated a statistically highly significant mean difference between the average change in reasoning ability of (1.69 ± 0.59) when compared to the average overall change in the sample (1.44 ± 0.34) with a mean increase of 0.25 (CI 95%, 0.12 to 0.39) with a p-value of <0.001 and a t-value of 3.82. Student feedback also supports these results. When a student was asked if he thought learning the CER framework had helped him write better answers, he responded,

"Yes, because it's more simplified and once I have the claim down finding the rest is fairly easy."

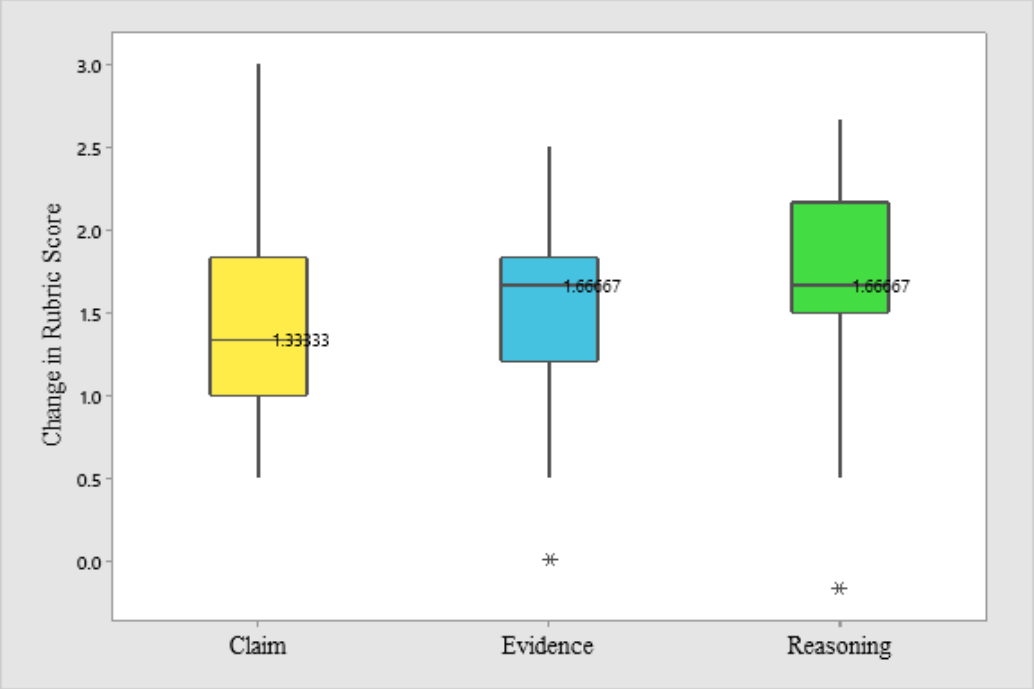


Figure 5. Change average writing scores from CER Explanations Rubric (*N*=44).

The median post-treatment writing rubric scores were the same in science and history and higher in English language arts (Figure 6). In science, students' post-treatment writing scores (2.54 ± 0.90) were higher after the CER treatment when compared to the pre-treatment writing scores (1.10 ± 0.71) with a statistically significant mean increase of 1.44 (CI 95%, 1.19 to 1.69) points with a p-value of <0.001 and a t-value of 11.73. In history, students' post-treatment writing scores (2.39 ± 0.73) were higher after the CER treatment when compared to the pre-treatment writing scores (0.75 ± 0.09) with a statistically significant mean increase of 1.64 (CI 95%, 1.41 to 1.87) points with a p-value of <0.001 and a t-value of 14.44. In English language arts, students' post-treatment writing scores (2.95 ± 0.59) were higher after the CER treatment when

compared to the pre-treatment writing scores (1.42 ± 0.76) with a statistically significant mean increase of 1.53 (CI 95%, 1.25 to 1.81) points with a p-value of <0.001 and a t-value of 11.03.

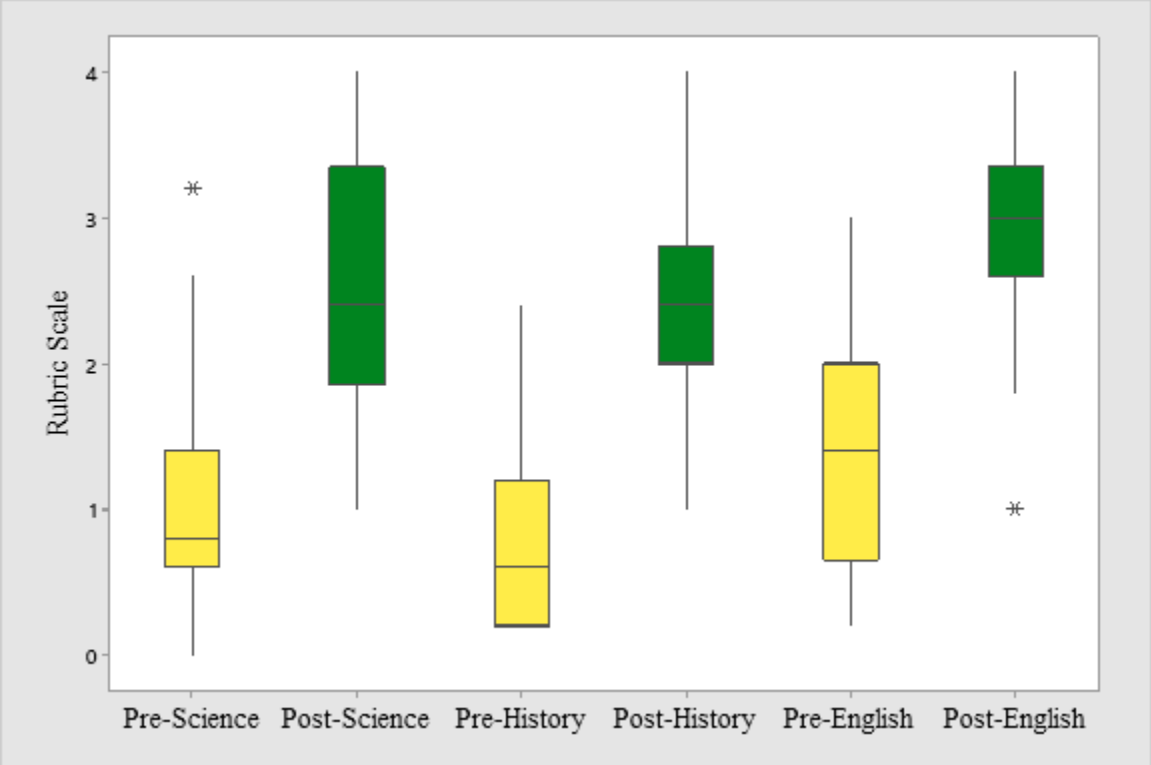


Figure 6. Pre and post-average writing scores from CER Explanations Rubric (*N*=44).

The Researcher Reflective Journal noted that "the special education students appear to be benefiting greatly from the CER graphic organizers and have asked to take a few with them to other classes." This observation is supported by the increase in the average special education(SPED) student's writing rubric scores with a mean change of 1.57 (*N*=10) which compares closely to the mean change in rubric score of the general education(GenEd) students at 1.40 (*N*=34) (Figures 7). The reflective response questions also support this finding with special education student's making comments like "I'm still

get confuse but it helps me to write my ideas down"[sic] and "It has gave me a different way of thinking about short response answers and has gave me a better layout to have better evidence."[sic]

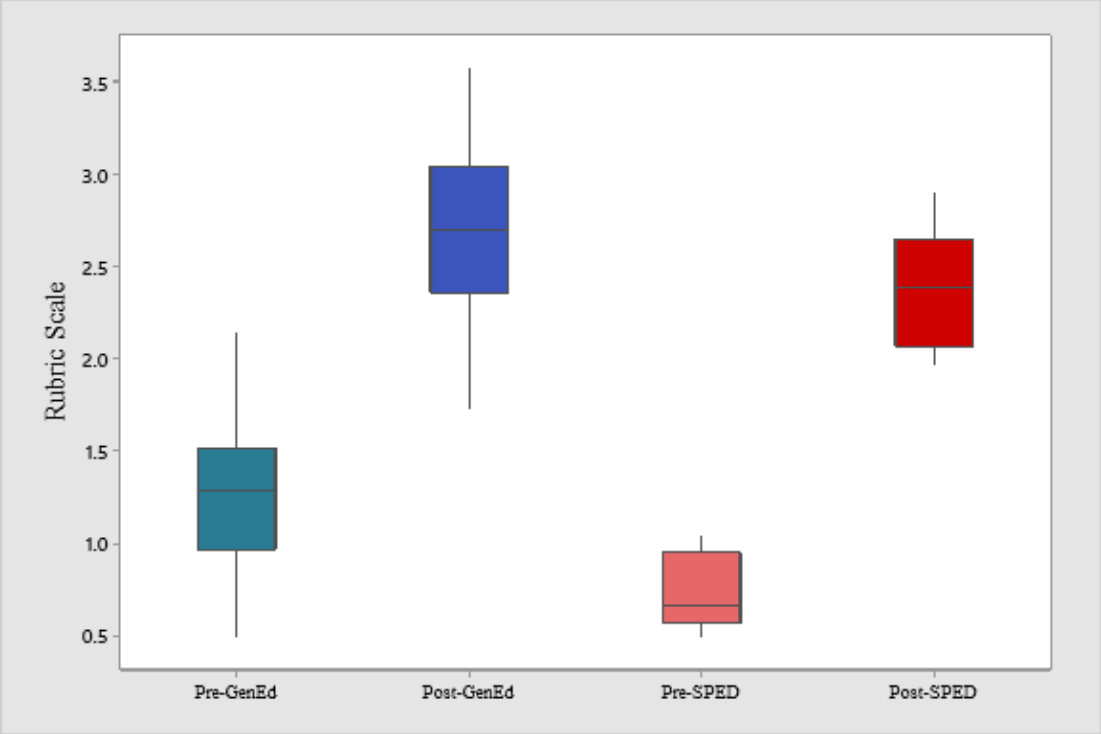


Figure 7. Pre and post average writing scores from CER Explanations Rubric for general(N=34) and special (N=10) education students.

The writing sample representative of a SPED student is from the fourth quartile of the data representing a large change when comparing pre-treatment science writing samples with post-treatment science writing samples with a change in writing rubric score of 1.8 (Figures 8, 9).

Scenario

Researchers were investigating various chemical reactions that might be used in hand warmers. The data they collected is listed below.

External Data

Reaction Number	Starting Substances	Substance Added To Starting Substances	Starting Temperature °C	Temperature After 1 Hour °C
1	Sodium thiosulfate	Water	22	10
2	Cellulose, iron, water, activated carbon, vermiculite, salt.	Oxygen (From being exposed to the air)	22	74
3	Citric Acid	Sodium bicarbonate	22	18

Prompt

Based on the provided data, make a claim about which reaction would be appropriate for hand warmers, cite the evidence, and provide your reasoning.

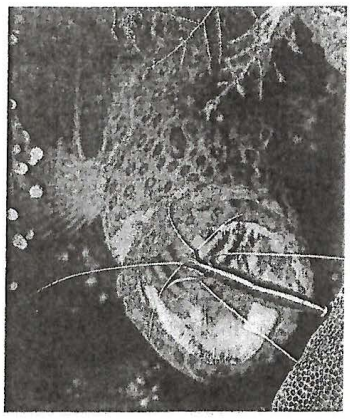
1 because it's the best, 2 would get too hot, 3 has critic acid.

Figure 8. Pre-treatment science SPED writing sample in the fourth quartile.

Scenario

Cleaner shrimp is the name given to shrimp that clean other organisms of parasites, which are tiny harmful animals. These shrimp live on coral reefs throughout the oceans. Cleaner shrimp hang out in sections of the coral reef and wait for fish to approach to be cleaned, similar to a car wash station. With no hesitation or fear of being eaten, the cleaner shrimp enters the mouth of the larger fish and vacuums up parasites and dead cells. Cleaner shrimp go wherever they want, even through the delicate gills of larger fish, to pry out the parasites. The larger fish get cleaned, sanitized, and groomed, and become healthier from this service. The cleaner shrimp get fed.

External Data



Prompt

Write a scientific explanation that explains which type of relationship is described in the scenario above.

It benefits both because the fish got cleaned and the shrimp got fed. "The larger fish get cleaned, sanitized, and groomed, and become healthier from this service. The cleaner shrimp get fed." The shrimp clean the fish by feeding on the parasites.

Figure 9. Post-treatment science SPED writing sample in the fourth quartile.

The results of the pre and post-treatment Writing Self-Confidence Survey were analyzed in 6 discreet scales; Effort, Motivation, Confidence in Writing, Confidence in Writing Claims, Confidence in Using Evidence, and Confidence in Using Reasoning. The

mean of the student responses for each of the confidence scales was compared with a paired t-test which indicated little change in students' self-confidence from the pre-treatment survey to the post-treatment survey. The paired t-tests confirmed the null hypothesis that there was not a significant difference between pre- and post-treatment confidence (Table 2). This data is supported by 16% of all student comments to the reflective post-treatment question, "How has the Claim, Evidence, Reasoning Framework helped you answer short response questions in your classes?" stated that students feel "It has not helped me." This view coincides with the initial pre-treatment interview comments, like "Umm, good I guess, I like them," and "I also feel comfortable with them. They are not very hard. I don't have to show the whole paragraph on the subject, just a little bit," when asked, "How do you feel about answering short response questions?"

Table 2. Writing self-confidence t-test chart.

Scale	|t-value|	P-value
Effort	0.46	0.646
Motivation	0.16	0.875
Writing	0.43	0.672
Claim	1.37	0.179
Evidence	1.46	0.152
Reasoning	1.78	0.082

The final five questions in the post-Writing Self Confidence Survey were analyzed as a CER treatment scale with an average mean of 2.59 (Figure 10). The student responses for the CER value scale were compared with a Chi-Square test and resulted in a p-value of one which supports the null hypothesis that the students neither agree nor disagree that the treatment helped them improve.

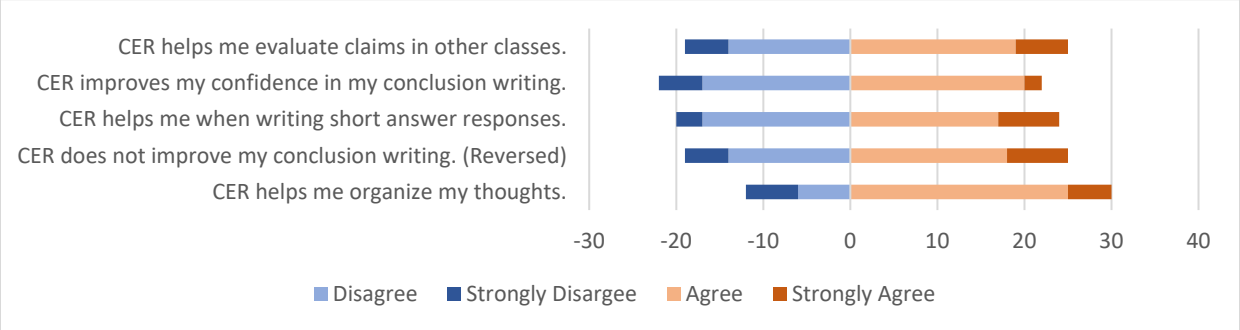


Figure 10. CER scale responses on the writing self confidence survey (*N*=44).

CHAPTER 5

CLAIM, EVIDENCE, REASONING

Claims from the Study

Instruction with the Claim, Evidence, Reasoning (CER) framework in the English classroom significantly ($p = <0.001$) impacted the frequency of writing well-reasoned arguments in science and other subject areas. The mean writing sample rubric scores increased significantly ($p = <0.001$) as a whole and individually in science, history, and English language arts. Science saw the least growth in writing scores of the content areas tested with a mean increase of 1.44, even though its mean pre-treatment score (1.10) was higher than those seen in history. However, history saw the most growth in writing scores, an increase of 1.64 points, with the initial scores being the lowest of all content areas tested with a mean of 0.75 points and answers frequently exhibiting no more than sentence fragments. This brings the median history scores (2.4 points) post-treatment even with the median post-treatment scores for science, but below the median post-treatment scores (3 points) for English language arts. English language arts had a higher mean pre-treatment score (1.42) due to the students' recognition of higher expectations for writing in that class and the anticipation of a grade related to writing quality for the samples. The higher post-treatment scores can be expected to be influenced by the same effect, and the instruction of the CER framework in that class. The higher scores attributed to history may also be contributed by a similar effect, as the history teacher, discouraged by the poor writing submissions in his class, asked the students to use a

strategy similar to CER referred to as Restate, Answer, Cite, Explain (RACE) during the treatment time period. The Researcher Reflective Journal notes that "the students report that they learned the RACE strategy in history, and I explained that the R and the A in RACE are combined in the C of CER. The students seemed to accept this explanation with little issues." Whereas, in science, the students rarely write more than a sentence, and the CER prompts were administered outside the primary class time during the intervention period on the days designated for science. These circumstances could contribute to the smaller evidence of growth in that subject area.

The three components of the CER framework, claim, evidence, and reasoning, improved on an almost even level post-treatment. The reasoning component did improve more than the other components. This is directly linked to the purpose of the CER framework developed by McNeill et al. (2006) to simplify the reasoning process for adolescents still developing the formal operational stage of metacognition. This is supported by the student comment that CER "makes the writing more simplified and easier to understand the point I'm making."

The students' confidence in writing did not change significantly post-treatment as reflected on the CER Writing Self Confidence Survey, although comments to the reflective questions indicate that 84% of the students found the CER framework helpful in writing short answer questions. The Researcher reflective journal noted before the treatment that "Students have a much higher confidence about writing short answer responses than expected," after the initial interviews. I was confused by their positivity when I had seen the low quality of their pre-treatment writing samples and had been

witness to multiple teachers' comments lamenting the issue. As the treatment began, there was a definite dampening of confidence as they became aware of the expectations of eighth grade-level short answer responses. The researcher reflective journal notes that "students are reluctant to be held to the higher accountability involved in writing a full claim, evidence, reasoning response." This is supported by McNeill & Krajcik (2008) when they propose that the most challenging component of teaching this skill to students is impressing upon them the necessity of a practice that does not come naturally. This high initial confidence followed by disillusionment noted in the classroom accounts for the lack of apparent increase in post-treatment confidence levels. The evidence is encouraging because it indicates that the students rose to the challenge of these new expectations in all subject areas and were confident in their ability to achieve the necessary mastery post-treatment.

Instruction in the CER framework in the English classroom increased student ability to write well-reasoned arguments in science and other content areas. This was achieved by the simplification of the argumentation process to a level that middle school students can use to scaffold the reasoning process, as they develop their formal operational metacognitive abilities. The students were able to successfully transfer their acquired argumentation skills from English to apply them in science and other content areas.

Reflection on Methodology

Overall, the implementation of the instruction of the Claim, Evidence, Reasoning (CER) framework was well placed in the English language arts classroom and is ideal to

support the Writing Across the Curriculum initiative. The weaknesses in the study lie with lack of support from other content areas. Originally, math was also included in the methodology but due to the lack of support for writing in the math classroom and the time restrictions due to the global pandemic, it was removed from the results. In addition, science did little to no writing as part of their planned lessons and did not benefit from the CER framework quite as much as the content areas that were actively engaged in holding their students accountable for learning to write well-reasoned arguments.

This lesson set would also be much better placed at the beginning of the first nine weeks and supported throughout the year in all subject areas to achieve maximum growth. The students needed constant reminders to implement the CER framework throughout the treatment and afterward. The longer students are held accountable for these strategies the stronger their argumentative writing and reasoning abilities will become. This quote from Horace Mann, the father of public schools, holds as true today as it did in the early 1800s, “Habit is a cable; we weave a thread each day, and at last we can not break it.”

The limitations of the study must also be considered due to the low sample size and short duration of the post-treatment sample period, and more conclusive results could be attained by increasing both.

Value of the Study and Consideration for Future Research

To be effective researchers we must not only communicate and defend our discoveries to the scientific community but also evaluate their value and validity in our own environment. This is particularly important for educational research as no two

students or classes are exactly alike. Without this self-evaluation, we would never grow into a fuller understanding of what our students need or design new and innovative lessons (Toulmin, 2003).

Value

The implementation of the Claim, Evidence, Reasoning (CER) framework has impacted my students and my teaching in numerous ways this year. My primary focus was to improve my students' ability to write well-reasoned arguments across the curriculum. They had struggled for years with gaps in their education due to the teacher shortages here in New Mexico and needed to build a solid foundation for future growth in their writing. The CER framework developed by McNeill et al. (2006) provided the precise scaffolding they needed to simplify the process to make learning accessible for every student. The more advanced students were delighted to have a clear plan to organize their thoughts in a way that was concise and easily understandable by their teachers. The lower students thrived with the use of the graphic organizer that visually allowed them to connect the evidence and reasoning to their claim and encouraged greater independence in writing their short answer responses in all content areas. In addition, the students were well prepared to apply their CER skills to New Mexico's new science standardized test, New Mexico Assessment of Science Readiness, that is aligned to the Next Generation Science Standards and contained a sizeable amount of short answer questions. I was proud to watch my students take the new question format in stride and use their CER skills.

Future Research

McNeill et al.(2006) stress that using the same framework across all domains will promote mastery in written explanations. As I move forward, I have begun to speak with my content level team about my data and how we can support the new science standards by vertically aligning our writing strategies by using the Claim, Evidence, Reasoning (CER) framework to teach all grade levels to prove their work, rather than each of us teaching a different strategy, like RACE or ACE DC. This increased sample size should give us more data with which to convince other departments to adopt the CER framework and unify our school's writing strategies.

Impact of Action Research on Author

Through this process of research and reflection, I have learned a great deal about my students and myself as a teacher. Data is an instrument through which I can understand what my students are trying to tell me. They told me that they were confident in their writing abilities, but the data revealed that they did not fully understand what well-reasoned arguments were. The data also has shown me the immense value of the right graphic organizer on equalizing the accessibility of education to all of my students that words just cannot convey.

This project has also impressed upon me the importance of not being an island within my school and the need for cross-curricular and vertical implementation of study strategies, like CER. Students learn more completely and adopt positive habits more quickly if their teachers collaborate and utilize the same strategies.

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APPENDICES

APPENDIX A

INSTITUTIONAL REVIEW BOARD EXEMPTION

MONTANA STATE UNIVERSITY

INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

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FAX: 406-994-4303
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Chair: Mark Quinn
406-994-4707
mquinn@montana.edu
Administrator:
Cheryl Johnson
406-994-4706
cherylj@montana.edu

MEMORANDUM

TO: Michelle Platt and John Graves

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

DATE: November 13, 2019

RE: *"Impact of Claim, Evidence, Reasoning Instruction in the English Classroom on Argumentative Writing Across the Curriculum" [MP111319-EX]*

The above research, described in your submission of November 13, 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 B

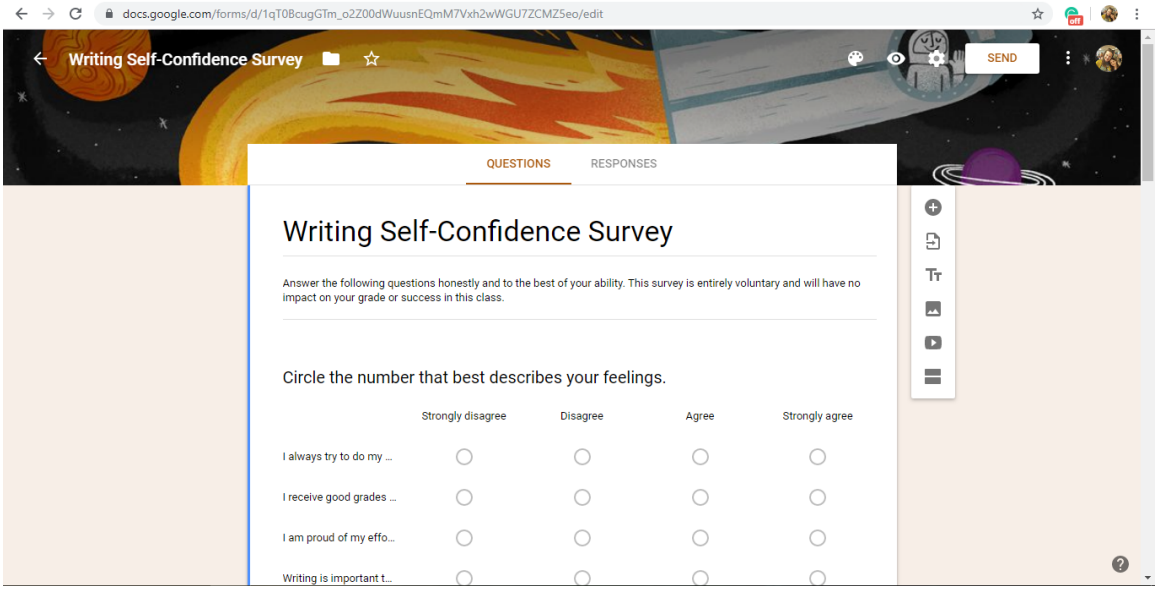
CER EXPLANATIONS RUBRIC

Claims, Evidence and Reasoning – Explanations Rubric

	4	3	2	1	0
Claim – a conclusion that answers the original question	• Scientifically/Content accurate • Completely answers the question • Common inaccurate claim(s) are clearly addressed.	• Scientifically/Content accurate • Nearly completely answers the question • Inaccurate claim(s) are only generally addressed, no specifics	• Partially scientifically/Content accurate • Partially answers the question • Inaccurate claim(s) are not addressed	• Is not scientifically/Content accurate overall • Does not adequately answer the question	No claim
Evidence – scientific data that supports the claim	• The data are scientifically /content appropriate to support the claim. • The data are thorough and convincing – enough details and evidence provided. • Proper units are used in data • Shows with evidence why alternate claims do not work	• The data are scientifically /content appropriate to support the claim • The data are basically sufficient and convincing, but tend to be more general and not as specific and in depth • Does not address why alternate claims do not work • Evidence may be repetitive	• The data relate to the claim, but are not entirely scientifically/content appropriate • The data are not sufficient, though generally support the claim	• There is some evidence provided, but it is not logically linked to the claim or scientifically /content appropriate	No evidence provided
Reasoning – a justification that links the claim and evidence	• Reasoning clearly links evidence to claim • Shows why the data count as evidence by using appropriate scientific principles/content evidence • There are sufficient scientific principles/content evidence to make links clear between claim and evidence	• Reasoning adequately links claim to evidence • Includes related scientific principles/content evidence, but only passably clarifies why this data count as evidence • Reasoning tends to be more general and shows only partial depth of content understanding	• Reasoning does not adequately link claim to evidence, or clarify why data count as evidence • Includes related and non-related scientific principles/content evidence, and shows little depth of content understanding	• Reasoning is clearly insufficient and relates only tangentially to question and claim at hand • Scientific/Content understanding is very limited	Does not provide reasoning
Language and Vocabulary	• Response clearly and effectively expresses ideas using precise, scientifically/content appropriate descriptions and vocabulary	• Response adequately expresses ideas and scientifically/content appropriate descriptions and vocabulary, but they are more general than specific	• Response inconsistently and sometimes inappropriately expresses ideas or scientific/content descriptions and vocabulary	• Scientific/content language and vocabulary are not precise or appropriate	Not under-standable
Focus and Organization	• Focus only on question at hand • Logical progression of ideas • Clearly stated and focused claim that is strongly maintained	• Focus mainly on question at hand, some loosely connected material present • Logical progression of ideas • Clearly stated and focused claim that is adequately maintained	• Focus not consistent on question at hand • Progression of ideas not entirely logical • Have a claim, but it's not entirely clear or maintained	• Focus not at all consistent • Progression of ideas not logical • Have an unclear claim that is not maintained	No clear focus or organiza-tion

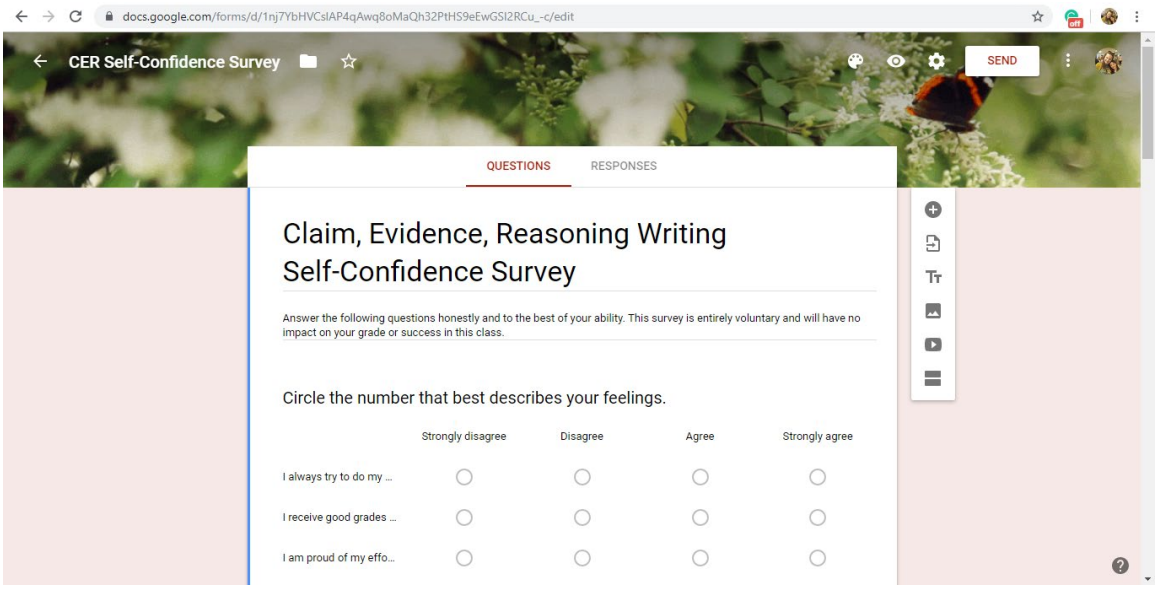
APPENDIX C

WRITING SELF-CONFIDENCE SURVEY


docs.google.com/forms/d/1qT0BcugGTm_o2Z00dWuusnEQmM7Vxh2wWGU7ZCMZ5eo/edit
Writing Self-Confidence Survey
SEND
QUESTIONS
RESPONSES
Writing Self-Confidence Survey
Answer the following questions honestly and to the best of your ability. This survey is entirely voluntary and will have no impact on your grade or success in this class.
Circle the number that best describes your feelings.
Strongly disagree
Disagree
Agree
Strongly agree
I always try to do my ...
I receive good grades ...
I am proud of my effo...
Writing is important t...

APPENDIX D

CER SELF-CONFIDENCE SURVEY


docs.google.com/forms/d/1nj7YbHVCsIAP4qAwq8oMaQh32PtHS9eEwGSI2RCu_-c/edit
CER Self-Confidence Survey
SEND
QUESTIONS
RESPONSES
Claim, Evidence, Reasoning Writing Self-Confidence Survey
Answer the following questions honestly and to the best of your ability. This survey is entirely voluntary and will have no impact on your grade or success in this class.
Circle the number that best describes your feelings.
Strongly disagree
Disagree
Agree
Strongly agree
I always try to do my ...
I receive good grades ...
I am proud of my effo...

APPENDIX E

STUDENT PRE AND POST-TREATMENT INTERVIEW QUESTIONS

Participation in this interview is voluntary and participation or non-participation will not affect a student's grades or class standing in anyway.

You will be asked questions about short answer questions as compared to multiple choice. These answers require you to construct your responses in writing.

1. How do you feel about answering short response questions?
2. Are there a subject(s) that you are more comfortable answering short response questions for than others? What makes you feel that way? What would help you feel more prepared to answer short response questions?
3. What is the most difficult part of answering a short response question? Why do you feel that is the most difficult?
4. What is the easiest part of answering a short response question? Why do you feel that is the easiest?
5. Is there anything else you would like to share?

Questions to add after Treatment:

1. Do you think learning the CER framework has helped you write better answers?
2. What part of the CER framework do you think helped you the most? What makes you feel this way?
3. Do you think the CER framework helps you answer questions in all your classes? Which class does it help the most?
4. Will you keep using the CER framework?

APPENDIX F

CLAIM EVIDENCE REASONING GRAPHIC ORGANIZER

Name: Class Period: Date:

Claim Evidence Reasoning: _____

Claim: State your answer to the question. (1-2 sentences)	
Evidence: Support your claim with evidence. -This may include data or text/content evidence from readings. -Evidence should be appropriate (relate to your point) and sufficient (fully explain your claim).	**Reasoning:** Explain why you think this. -Demonstrate why your evidence supports your claim with content knowledge, principles, laws, etc. Be sure to address any possible rebuttals (questions/arguments) your classmates/teacher may have to your claim.
•	• .
•	• .
•	• .
•	• .
•	•

APPENDIX G

CLAIM EVIDENCE REASONING GRAPHIC ORGANIZER

AUDI ALIEN SCAFFOLDING

Name: Class Period: Date:

Claim Evidence Reasoning: ***Audi Advertisement***

Claim: Who is my dad? (1-2 sentences)	
Evidence: **Support your claim with evidence.** -This may include data or text/content evidence from readings. -Evidence should be appropriate (relate to your point) and sufficient (fully explain your claim).	**Reasoning:** -Demonstrate why your evidence supports your claim with content knowledge, principles, laws, etc. Be sure to address any possible rebuttals (questions/arguments) your classmates/teacher may have to your claim.
• He speaks a weird language • He's from Albuquerque • He drinks green liquids • He dresses funny • He drives a spaceship	• . • . • . • . •

APPENDIX H

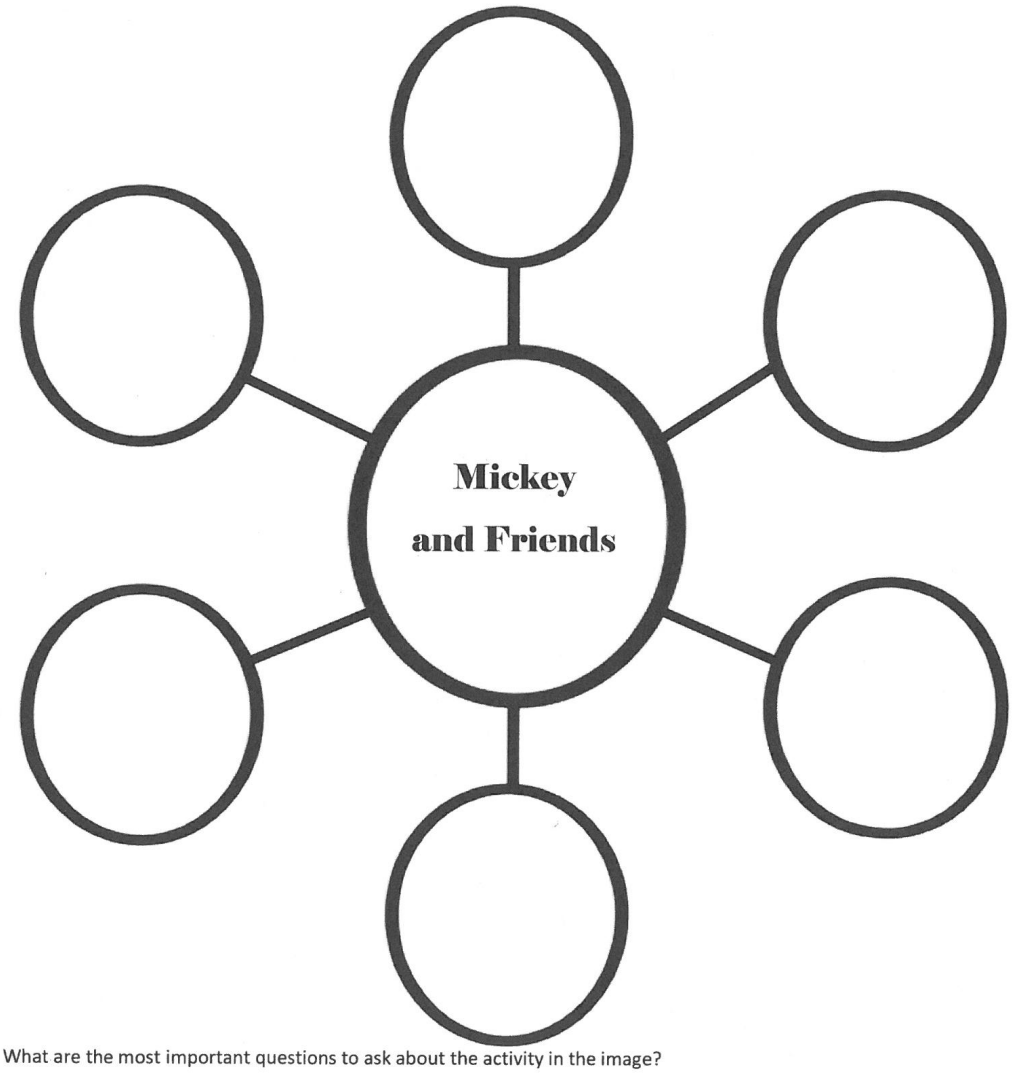
CLAIM EVIDENCE REASONING ACTIVITY

MICKEY AND FRIENDS PUZZLE ORGANIZER

Name: Class Period: Date:

Claim Evidence Reasoning Activity

Brainstorm what you already know.



What are the most important questions to ask about the activity in the image?

Evidence: What do you see in your clues?	Claim: What does that tell you about your image?	Reasoning: What background knowledge do you have that proves that the evidence leads to this claim.

Name: Class Period: Date:

Claim Evidence Reasoning: ***Mickey and Friends Puzzle Activity***

Claim: Who is participating in the activity in the image? **State your answer to the question.** (1-2 sentences)	
Evidence: Support your claim with evidence. - This is what you see in your puzzle piece. - Evidence should be appropriate (relate to your point) and sufficient (fully explain your claim).	**Reasoning: Explain why you think this.** - Use background knowledge about Mickey and Friends. - Be sure to address any possible rebuttals (questions/arguments) your classmates/teacher may have to your claim.
•	• .
•	• .
•	• .
•	• .
•	•