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EFFECTIVENESS OF CLAIM, EVIDENCE AND REASONING AS AN INNOVATION TO DEVELOP STUDENTS' SCIENTIFIC ARGUMENTATIVE WRITING SKILLS

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Abstract:

This study focused on inquiry necessities on the students' use of argument, particularly in writing, that is, to communicate their knowledge and scientific findings and develop an understanding of scientific practice/s. The purpose of this action research is to evaluate the effectiveness of Claim, Evidence and Reasoning as an innovation to develop students' argumentative writing skills in the senior high school classrooms. The CER Framework, while extensive and complex, shows promise building both argumentative writing skills and science content knowledge of the learners. The results of this study demonstrated that modified iterations of this model should include data sets that are personally meaningful to students, writing tasks scaffolded to areas of students' need, attitude and comfort, and clear communication of feedback, from both peers and teacher - focused on all three areas of scientific arguments: claim, evidence, and reasoning. Information gained from this study will benefit science educators by yielding information about how scientific argumentative writing can be most effectively implemented in the science classroom to yield the maximum benefit for literacy in the science curriculum.

Keywords: Claim, Evidence, and Reasoning; Attitudes; Comfort

INTRODUCTION

Writing is one of the most important skills that educators can teach in the high school classroom today (Srougi et al., 2014). Wheeler–Topin (2012) writes that writing stretches across almost all professions, plays a vital role in communication, and is present in everyday life. In the classroom, writing forces students to organize their thoughts and find relationships. In the fast paced world, writing also holds ideas long enough for students to think about them, evaluate them, and assess them (Wheeler –Topin, 2012). Compared to discussions, writing enables all students to participate. Written responses also help teachers discover misconceptions and what prior knowledge students are bringing to the classroom (Wheeler –Topin, 2012).

In the Philippine, K to 12 Science Curriculum it is stated that high school students should be able to conduct scientific argumentation and explain the results of an investigation based on evidence and support with scientific reasons, use evidence and conduct research to collect more evidence in order to accept or reject existing knowledge or idea. In contradiction, the struggle with writing argumentation that contains evidence and reasoning was seen among Senior High School in Graceville National High School during the Biology Class based on the previous mean percentage score in biology in the School Year 2018-2019, are below 50%.

Development of scientific argumentation and writing skills is important as well as development of proper scientific attitude and values. Science Education aims to train students to think like scientists and emphasis would be expected on the development of attitude that good scientists are able to display (Opulencia, 2011). One of the purpose of teaching is inculcation of desirable attitudes and values (Pacia, 2014). Shaping students' attitudes, behaviors, and motivations is necessary today for without these broader skills and strengths, students will be unprepared for the challenges they, and their world, will face (Miller, 2017).

On the other hand, positive attitude toward science is very essential. Students with positive attitude toward science tend to have higher scores on the achievement measures (Weinburgh, 1995).

Students' achievement is positively related to learning goal orientation, self-efficacy and meaningful learning (Hacieminoglu, 2015).

Scientific argumentation is defined as one of the essential practices in science education and served as fundamental knowledge and skills in scientific inquiry. Students engaging in scientific explanation not only promote their understanding of science, but also the nature of science. Since scientific knowledge is an explanation of natural phenomena acquired by scientists using evidence they explored, and supporting with scientific reasoning. There are three components of good scientific explanation including claim, evidence, and scientific reasoning; also the argumentation should provide enough valid evidence and reasoning to support the precise claim. Not only in science, could scientific argumentation be adapted across a variety of contexts. In the rapid growth of information technology, people should be able to criticize whether the claims presented in news, articles, fact sheets, or magazine are well supported with reliable evidence and reasoning. Thus, scientific argumentation could be claimed as an essential knowledge and skill for 21st century era citizens. In science learning, students should be able to (i) give priority to evidence when developing or evaluating scientific explanations, (ii) formulate scientific argumentation from evidence to address scientifically oriented questions, (iii) formulate and revise scientific argumentation using logic and evidence, and (iv) have a clear understanding that scientific argumentations emphasize evidence. Although engaging scientific explanations is an important learning goal for students, they often have difficulty constructing and connecting their claim and evidence.

Scientific argumentation is an attempt to validate or refute a claim based on evidence and reasoning. (Sampson & Schleigh, 2016, p.ix) A claim is defined as an explanation or conclusion that provides an answer to a question in research. Evidence represents the data or findings in an investigation, while the reasoning refers to the support that is offered for the claim.

A comprehensive review of literature investigated the development of argumentation skills and asserts that the lack of argumentation practice, along with the lack of proper pedagogical strategies by teachers for organizing argumentation skills is making progression in the scientific field difficult (Driver, Newton & Osborne, 2008). This study maintained the position that argument in science is a central skill that is socially constructed and that scientific knowledge is gained through argumentation of claims rather than through the scientific method approach seen in many science classrooms. It is clear that argumentative writing is both a crucial skill and one that has room for improvement in the science classroom.

Teachers play an important role in the development of the difficult skill of argumentative writing. A study of secondary science teachers was done over the course of a year in which they attended workshops that developed materials and strategies for augmentation in the classroom. By examining video and audio lessons from the beginning and end of the school year, researchers determined that professional development of argumentation skills does increase exposure to argumentation practice in the classroom (Simon & Osborne, 2008).

The study also indicated that teacher included higher-order processes had students with the best argumentation skills. For teachers to support the writing of scientific explanations, researchers point to five strategies that should be implemented into the classroom. "Make the framework explicit, model and critique explanations, provide a rationale for creating explanations, connect to everyday explanations, and assess and provide feedback to students." (McNeill & Krajcik, 2008, p.125).

It can often be assumed by teachers that students understand what it means to write a scientific argument. To approach the first strategy of making the framework explicit, educators have broken down argumentative practices into a framework that includes three components: claim, evidence, and reasoning. (McNeill & Martin, 2011, p.53) After establishing a clear understanding of claim, evidence, and reasoning, this framework provides students with structure that can help communicate their ideas.

Claim, evidence and reasoning are an effective writing strategy that targets evidence– based writing. Students should be able to voice well - informed opinions based on a deep understanding of the scientific concepts, demonstrate reasoning, and support their argument with evidence (Srougi et al., 2014). Reasoning is used to answer open-ended problems with no definitive, right answers that have many resources from which to draw support from (Kuhn, 1991). To underscore the importance of developing reasoning skills, a growing body of researchers concludes that these critical reasoning skills are more important for high school and college students than specific science content knowledge (Heller and Hallabaugh, 1992; Heller, Keith, and Anderson, 1992; University of Minnesota Physics Education Research and Development, nd). Fenci (2010) conducted a study in a general education course comparing the development of critical reasoning skills in a class that explicitly developed these versus a control class. The class that developed those skills showed significant gains in reasoning and were better able to give a sound argument rooted in evidence after reading a scientific article.

The framework of claim, evidence and reasoning is an instructional approach to writing a scientific argument. It includes three components: a claim, evidence, and reasoning (Venville and Dawson, 2010). "The claim makes an assertion or conclusion that addresses the original question or problem about a phenomenon. The evidence supports the student's claim using scientific data (McNeill, and Krajcik, 2008b, p 123)." McNeill and Krajcik go on to say, "The reasoning links the claim and evidence and shows why the data count as evidence to support the claim" and adds that the reasoning nearly always explains a scientific principle (2008b, p 102).

Students need more opportunities to analyze and reflect on the thinking processes and analyze viewpoints of other students. This must take place in a safe environment of respect, a place that nurtures a diversity of ideas and facilitates collaboration between classmates (Liftig, 2013). The term "argue" should be understood in the correct context. In a science classroom, an argument should model a process that might be used by the scientific community. This process of argumentation is different from conventional arguments. Llewellyn (2013) explains scientific argumentation as a higher-level, critical thinking science skill, used to propose, support, critique, refine, justify, and defend ones position about a specific issue. The goal of a confrontational dispute is for one viewpoint to "win" over another's. Llewellyn clarifies scientific argumentation as different because as explanations are discussed, new ideas are generated, verified, communicated, debated, and modified in a way that is ultimately "win-win" because the goal in scientific arguments is to refine and build consensus for scientific ideas. This collaborative nature leads towards ever developing understanding of scientific phenomenon.

The research documented in this paper is based on the Science and Engineering Practices (SEP) of the Next Generation Science Standards (NGSS), specifically, engaging in argument from evidence. The National Research Council (2012) contends that "learning to argue scientifically offers students not only an opportunity to use their scientific knowledge in justifying an explanation and in identifying the weaknesses in others' arguments but also to build their own knowledge and understanding".Therefore, the theoretical basis of social interaction and argumentation in the classroom can serve as a foundation for this research study.

According to Vygotsky (1978), learning and its social context are inextricably linked. He theorized that "all the higher functions emerge as actual relationships between individuals," and that learning was the process of integrating into a "knowledge community" (Vygotsky, 1978). Vygotsky's theory of social constructivism emphasizes the importance of the "more knowledgeable other", which is someone with more knowledge and experience than the learner. Communication with this "more knowledgeable other" can help solidify understanding of a particular concept, which leads to learning. This concept is the theoretical foundation of the increased emphasis on collaboration and communication in the classroom. The goal is for students to discuss content with peers or teachers. In the case of science classrooms, this happens whenever students are asked to provide evidence or communicate their findings. Therefore, when the NGSS specify that students are expected to use evidence to construct arguments within their science classrooms, these arguments, as means of communication between peers or with the teacher, can be used as a tool to build overall scientific inquiry and literacy skills.

Enabling students to become scientists and engineers in the classroom requires more than simply giving them the opportunity to experiment with and build things. It requires teaching them the real-world practices (skills) that scientists, who discover knowledge, and engineers, who solve problems, use to answer questions and solve problems objectively.

These are vital skills that every student needs to engage the world around them and to succeed in the career or college of their choice.

Part of successfully instilling science and engineering mindsets into students is helping them to understand that the conclusions they come to at the end of a scientific experiment or an engineering design solution must be based not on hope, supposition, or clever rhetoric, but on objective evidence. This is where claim-evidence-reasoning as innovation (CERI) comes in, a model in which students offer claims about their hypothesis or prototype, using the evidence available from their experiment or prototype testing to support their reasoning, just as a scientist or engineer would.

At present, the researcher, as a Science teacher in Senior high school department in Graceville National High School, is experiencing the above-mentioned scenario in science education. If not dealt with properly, it might result to poor performance in science laboratory activities. It is in this light that this research were conducted to the effectiveness of Claim - Evidence - Reasoning framework on Student's scientific argumentation writing skills.

To improve the performance of science teachers, which will result to improved student scientific argumentative writing skills and a positive impact on school effectiveness.

RESEARCH QUESTIONS

This study determine the effectiveness of Claim - Evidence – Reasoning innovation on Student's scientific argumentation and writing skills in teaching bioenergetics.

Specifically, the research tries to answer the following questions:

1. What is level of the scientific argumentative writing skills of the students after using the CER innovation as described in the following variables?
    a) Claim
    b) Evidence
    c) Reasoning
2. How effective that CER innovation on students' scientific argumentation and writing skills during the experiment?
3. What is the attitude and comfort level of the respondents who have exposed to the CER innovation?
4. Is there a significance difference between the pretest and posttest scores of the students' scientific argumentative writing skills that was exposed to C-E-R innovation?

METHODS

The researcher employed triangulation design. According to Fraenkel and Wallen (2010), it uses both quantitative and qualitative methods to study the same phenomenon in to determine if the two converge upon a single understanding of research problem investigated. In this design quantitative and qualitative methods are given equal priority, and all data are collected simultaneously.

More so, the subjects of the experiment are 20 Grade 11 Accountancy, Business and Management (ABM) Students from Graceville National High School in School Division of San Jose del Monte City, Bulacan. The researcher used purposive sampling. Under this method of drawing the sample, researcher selects the sampling units that meet the purpose or objective of the study.

To assess the effectiveness of the treatment in which the Claim - Evidence - Reasoning Framework is implemented, the researcher used several adapted instruments:

Online Evaluation Resource Library (2013) served as models for Likert survey. Specifically, some questions on survey were modified from three different instruments developed for Course, Curriculum, and Laboratory Improvement (CCLI)(2013) and Innovative Technology Experience for Students and Teachers (ITEST) (2013) and Computer Applications to Enhance Inquiry-Oriented Library Instruction in Biology at a 2-Year College (2013).

To gather the confidence of the student in writing CER, the research adapted the pre and post-intervention survey of Dr. Quinten Loch from Montana State University

Chapter tests was used to assess students' content knowledge. These tests, created using a test bank, included multiple choice questions, and paragraph length essay questions. Open ended essay questions on tests included questions designed to assess content learned without using the C-E-R framework as well as questions to assess content learned through use of the C-E-R framework. In addition to tests, student writing samples completed as part of the treatment were collected and scored using the rubric. The writing samples of students used to assess any changes in the quality of students' scientific argumentation prior to and during the treatment period.

Students interviews it involves a process where a researcher solicits information from respondents through verbal interaction. A researcher would have previously prepared a schedule list of structured questions pertinent to the study before meeting subjects for their opinions on a subject matter. The researcher poses questions to the subjects and the answers are recorded by the researcher.

The researcher utilized the weighted mean using a "five – point – scales or Likert Scale of Attitude Survey and the pre-post intervention survey and given weight as follows:

Rate	Verbal Interpretation		Interval Range
	Attitude Survey	Pre-post intervention survey	
5	Very Low Positive (VP)	Very comfortable (VC)	4.51– 5.00
4	Low positive (LP)	Comfortable (C)	3.51 – 4.50
3	Neutral (N)	Somewhat comfortable (SM)	2.51 – 3.50
2	Positive attitude (PA)	Not very comfortable (NVC)	1.51 – 2.50
1	High positive attitude (HPA)	Not comfortable (NC)	1.00 – 1.50

These were used to determine the student confidence and attitudes toward writing in science and learning in science, and the nature of science using CER Innovation.

To identify the level of of the scientific argumentative writing skills of the students, the researcher will utilize the weighted mean using a four– point – rating scale rubric adapted from McNeill and Krajcik (2008) and given weight as follows:

Rate	Interval Range	Level
4	3.50 – 4.00	Excelling (E)
3	2.50 – 3.49	Proficient (P)
2	1.50 – 2. 49	Developing (D)
1	1.00 – 1.49	Not demonstrating (NT)

To determine whether there are significant differences in the pre-test and post-test scores, the t test for mean difference were utilized.

The participants' interviews were transcribed, coded, and analyzed to identify the perspectives/ themes and their categorization. Furthermore, the qualitative data, thematic analysis will be used following the 6 phases which was proposed by Clarke and Brawn (2006) as cited by Prieto et. al (2017). These six phases are as follows: Phase 1. Familiarizing oneself with the data gathered; Phase 2. Generating initial codes that involve the production of initial codes from the data; Phase 3. Searching for themes which re-focuses on the analyses at the broader level of themes and collating all the relevant coded extracts within the identified themes; Phase Reviewing themes which involve two levels of reviewing themes; Phase 5. Defining and naming the themes and involves the themes to be presented for analysis; and Phase 6. Producing the report which involves the final analysis and writes up of the report.

RESULTS AND DISCUSSIONS

The data collected in this study were comprehensively, analyzed and interpreted to established clarity and consistency

Table 1: Level of the Scientific Argumentation and Writing Skills of the students

Big Questions	Claim	VI	Evidence	VI	Reasoning	VI
Activity 1: How cells carry out functions required for life?	**2.60**	**P**	**2.50**	**P**	**3.45**	**P**
Activity 2: How photosynthetic organisms use light energy to combine carbon dioxide and water to form energy- rich compounds?	**3.70**	**E**	**3.75**	**E**	**3.52**	**E**
Activity 3: How organisms obtain and utilize energy?	**3.79**	**E**	**3.87**	**E**	**3.90**	**E**
Overall	**3.36**	**P**	**3.37**	**P**	**3.62**	**E**

The abovementioned tabulated data showed the level of the scientific argumentation and writing skills of the students in different laboratory activities. In the activity 1(how cells carry out functions required for life?), the students exhibit the proficient level on writing the claim (X = 2.60), evidence (X= 2.50) and reasoning (X= 3.45). In the activity 2 (How photosynthetic organisms use light energy to combine carbon dioxide and water to form energy-rich compounds?) the students exhibit the excelling level on writing the claim (X = 3.70), evidence (X= 3.75) and reasoning (X= 3.52). In the activity 3 (How organisms obtain and utilize energy?) the students exhibit the excelling level on writing the claim (X = 3.79), evidence (X= 3.87) and reasoning (X= 3.90). Thus mean that the students are continuously improved their level of the scientific argumentation and writing skills in using the claim, evidence reasoning.

Overall	**1.69**	**PA**	**1.50**	**HPA**
Overall	**1.69**	**PA**	**1.50**	**HPA**

Tomas and Ritchie (2015) supported the results of the findings on how incorporating writing using CER into the science curriculum can be used as a tool for making meaning of science concepts. Analysis of the writing tasks revealed an improvement in scientific literacy, which indicated that participation in the writing tasks yielded a positive impact on learning, with 19 of 24 students in the case study demonstrating deep levels of conceptual understanding. This study indicates that writing itself can assist students with acquisition of content knowledge. Writing does not necessarily need to be kept separate from scientific content knowledge, but can be used as a tool to build this knowledge.

The study also supports the findings of Cavagnetto (2010) that argument within the science classroom is essential for students to transfer an understanding of scientific practice. Through argument, a student's overall scientific literacy can be supported as this understanding of scientific practice and norms merges with content knowledge.

Sampson, et al. (2013) conducted a study to evaluate the effectiveness of the CER model in science classrooms. They found that students' ability to write scientifically and to understand science content showed a significantly large improvement when implemented consistent.

Table 2.1: Mean Attitude Score of the students towards Nature of Science.

Statement	Pre- attitude Survey		Post – attitude Survey	
	Mean	VI	Mean	VI
Science is essentially an accumulation of facts to be memorized.	1.95	PA	1.35	HPA
Science is essentially about explaining the world around us	1.60	PA	1.63	PA
Science is actually based on the best available evidence at the time; it may change with new evidence.	1.80	PA	1.73	PA
Trustworthy scientific claims are supported with evidence and reasoning	1.85	PA	1.32	HPA
Overall	**1.69**	**PA**	**1.50**	**HPA**

Table 2.1 shows that all the five indicators resulted to positive attitude (X= 1.69) in the pre- attitude survey on nature of science. Moreover, after the students exposed on the claim, evidence and reasoning framework the students are improve their appreciation in nature of science into high positive attitude (X= 1.50) based on the five indicators. The data may imply that students know the importance of nature of science. They also that Science play an important role in our everyday lives. Students value Science as a very important subject that develops their ability to explained and accumulated knowledge about the natural world. When writing our first C-E-R using a science topic, "How cells carry out functions required for life?" gave opportunity to address the nature of science. "A student… asked me what she should write because she doesn't believe any of these theories because she is a Christian. I instructed her to look at the evidence and decided if the evidence supports or refutes that theory. I told her that it was okay if she believed something different, but that in science, we have to look at the scientific evidence from the natural world to support or refute claims. I addressed this with the class, reminding them that science is about explaining the natural world using only evidence that we observe and measure from nature. I said that for this reason, they could not, for example, use the Bible as evidence against or for a [scientific] theory." I found that use of the framework helped focus instruction on evidence which was reflected in the gain in students' high positive attitudes toward the nature of science.

Table 2.2: Mean Attitude Score of the students towards Science.

Statement	Pre- attitude Survey		Post – attitude Survey	
	Mean	VI	Mean	VI
I am good at science.	2.65	N	1.65	PA
I enjoy learning science	2.00	PA	1.45	HPA
Science is dull and boring.	3.70	LPA	4.67	VLPA
Science is more interesting than most school subjects.	2.10	PA	1.74	PA
Overall	**2.61**	**N**	**2.37**	**PA**

Table 2.2 shows that all the four indicators resulted to neutral attitude (X= 2.61) in the pre- attitude toward learning science. The data may imply that students are moderately interested in Science activities. But after the students exposed on the claim, evidence and reasoning framework the students are improve their appreciation in learning of science into positive attitude (X= 1.50). The result is in line with Zeidan and Jayosi (2015), states that positive attitude toward science makes the students more interested in focusing on science process. In other words, when the students understand the scientific argumentation becomes more interesting to them, which increases the positive attitudes towards science. A highly motivated student is usually one with a positive attitude toward the subject s/he is learning. Therefore, in order to improve students' attitudes toward science, faculty must motivate students, which they can do through their innovative strategies and by showing them the relevance of the learning topics to their everyday lives. In addition, they must create the learning. Environment that helps motivate students not only to come to classes but also want to learn and enjoy learning (Movahedzadeh, 2011). With followed up with a second brief survey. One student responded, "Science [this school year] is way different now and that's good. We have more uses for the phone application and computer. Science is more interactive and newer. Other students mentioned the lack of experiments done last year in science as a cause of negative attitudes toward science, "I think it had to do with science class in previous years because the only thing we did [was] to remember things that were on a paper and we didn't do any fun experiments."

Table 2.3: Mean Attitude Score of the students towards Writing

Statement	Pre- attitude Survey		Post – attitude Survey	
	Mean	VI	Mean	VI
I like writing.	2.53	N	1.61	PA
I am good at writing.	3.23	N	1.68	PA
Writing in science class helps me to understand science better.	2.59	N	1.31	HPA
Overall	**1.80**	**N**	**1.53**	**PA**

Table 2.3 shows that all the three indicators resulted to neutral attitude (X= 1.80) in the pre- attitude toward writing. The data may imply that students are neutral interested in science writing. But after the students exposed on the claim, evidence and reasoning framework the students are improve their appreciation in science writing into positive attitude (X= 1.53). Responses from the students included, "I learn the best when I write words down on the paper, as it strongly helps me remember and it improves my knowledge of thinking!" Another stated, "Well writing in science class just helps the information to be glued into my head. It also helps me understand the subject more if I don't really understand it." A third student remarked, "I can look back on my thoughts and reflect on them."

Table 2.4: Mean Attitude Score of the students towards Thinking & Learning

Statement	Pre- attitude Survey		Post – attitude Survey	
	Mean	VI	Mean	VI
I can think like a scientist.	1.75	PA	1.48	HPA
Science helps me become a better critical thinker.	1.67	PA	1.25	HPA
Explaining scientific ideas helps me understand them better.	1.75	PA	1.49	HPA
Overall	**1.72**	**PA**	**1.41**	**HPA**

Table 2.4 shows that all the three indicators resulted to positive attitude (X= 1.72) in the pre- attitude toward thinking and learning. In addition, after the students exposed on the claim, evidence and reasoning framework the students are improve their appreciation in thinking and learning science into high positive attitude (X= 1.43). As mentioned in the study of Opulencia (2011) Science Education aims to train students to think like scientists and emphasis would be expected on the development of attitude that good scientists are able to display. The results of the survey conducted by Sanja et al. (2012) on student's attitudes towards science and mathematics indicated that students value demonstrations, applications and practical, hands-on experimentation, and that after these types of classroom activities they express positive attitude towards science and mathematics. For instance responses from the follow – up survey after the experiments students cited their ability to use science skills as a reason for thinking like a scientist that, "I'm just very curious and want to discover new things." Another student shared "Because, I like to find out new things, and I think about things logically." The data demonstrated an improvement in student attitudes toward thinking and learning in science, especially one quote in particular. In response to why she can think like a scientist, one student wrote, "I've learned the CER way of answering things which makes me think about evidence to back up my claim and then I give the scientific principle that also supports my claim. Scientists probably go through a process kind of like this in order to prove something."

To further assess student attitudes toward thinking and learning in science, a Likert survey prompt, "Explaining scientific ideas helps me understand them better" was followed up with an open-ended response. "I answered the way I did because it is said that if you can explain and teach what you learned you fully understand it. It also helps me understand scientific ideas better because I can hear other people's ideas and add them to my thinking or explain why their thinking is wrong." Following the treatment, many students specifically mentioned the use of the C-E-R framework, writing, "When I explain the reasoning behind scientific principles (sic) I can process the information better and writing CER's helps me understand the topics more." Another student mentioned, "It helps me decide why the evidence is trustworthy and supports the claim." In a similar statement, another student wrote, "When we explain experiments and other questions, the evidence and reasoning will help show how they work and why it is." To conclude, following the treatment more students agree that forming scientific explanations aids in greater understanding of science content.

Table 3: Student Comfort Level in Writing Claim, Evidence, and Reasoning Innovation.

Statement	Pre- Intervention Survey		Post – Intervention Survey	
	Mean	VI	Mean	VI
I am comfortable with my ability to write a claim in a scientific investigation	4.00	C	4.72	VC
I am comfortable in my ability to use evidence to support my claim in a scientific investigation (lab)	3.69	C	4.68	VC
I am comfortable in my ability to use reasoning that links my evidence to my claim in a scientific investigation (lab).	2.34	NVC	4.49	C
I am comfortable in my ability to include concepts learned in class as part of my reasoning in a scientific investigation (lab).	2.49	NVC	4.31	C
Overall	**3.13**	**SM**	**4.55**	**VC**

Table 3 shows that all the four indicators of levels of comfort in using CER, resulted to somewhat comfortable (*X= 3.13*) in the pre- intervention survey. In addition, after the students exposed on the claim, evidence and reasoning framework the students are improve their levels into very comfortable (*X= 4.55)*

Table 4: Test of Significance difference between pretest and posttest scores of the students' scientific argumentation and writing skills that was exposed to C-E-R innovation.

df	t– computed value	t– critical value	*p*-value	Decision	Probability Level	Verbal Interpretation
19	16.859	2.861	.000	Null hypothesis is rejected	P < 0.01	Significant

The abovementioned tabulated data showed the computed t –value obtained of 16.859 is statistically significant against the tabular value of 2.861 at 1 percent of level of probability with degrees of freedom of 19 (df =19). This means that there is a difference between pretest and posttest scores of the students' scientific argumentation and writing skills that exposed to C-E-R innovation. Thus, the null hypothesis (H_0) is rejected.

THEMATIC ANALYSIS DEDUCED FROM THE INTERVIEW

The following are the themes that are deducted from the interview on the effectiveness of the claim, evidence, reasoning as innovation to develop students' scientific argumentation and writing skills in the selected senior high school science classroom:

Theme 1: Claim, Evidence and Reasoning increases students' ability to identify, critique, and compare the quality of evidence in written arguments.

Prior to this sequence of instruction, students had received only cursory instruction on what constituted a "claim," "evidence," and "reasoning." Through the process of constructing lab reports, students had to create their own claims, collect their own evidence in the form of measurements, and supply reasoning in the form of data analysis and scientific facts. Activity 1 to 3 measured students' ability to identify, compare, and critique evidence. Two of these skills demonstrated statistically significant improvement – the ability to identify supporting evidence and to compare and critique the use of evidence between two arguments.

Furthermore, students, as a whole, were better able to compare and critique the use of evidence in multiple arguments. This may also be attributable to the picking and choosing of relevant evidence to include in their lab reports, and it may also be a result of the peer review process, where they had to critique a partner's use of supporting evidence. It might also be due to the increased use of evidence, itself, in their classroom activities. A common observation in Activity 1 was that, when students were comparing two arguments in the free response question, several students chose the wrong argument as more effective because the writing was more "specific" and "detailed." The use of evidence in their own lab reports may have allowed them to better interpret the quality of this evidence, rather than rely on their perception of the amount of detail or the quality of writing in the argument. Furthermore, though engaging in peer editing of their formative paragraphs, students were trained to examine the quality of evidence and writing used in other people's writing, which may have also supported this skill. It can be hypothesized that, as students are trained to choose between various data points to support claims, they will be better able to utilize this skill in novel situations. The ability to either critique an argument or compare and critique multiple arguments in the free response question showed a statistically significant increase, whereas the ability to critique in a multiple choice question did not. An interesting observation is that, in activity 1 far fewer students were able to either critique or compare and critique arguments in the free response question, whereas the trend reversed in activity 2, where more students were able to clearly write about their critique and comparison in the free response than convey a correct critique in the multiple choice question. This may have been due to the fact that, in activity 1 they did not have a full understanding of the significance and meaning of scientific evidence. By the time they took Assessment 2, they had been exposed to scientific evidence through the CER activities and lab reports in class. This practice with writing about their own evidence may have allowed them to express their ideas more clearly in words than through a multiple-choice question. Nevertheless, this data demonstrates an increase in students' ability to analyze the quality of the evidence used in an argument. These results demonstrate that the process of collecting and writing about data is helpful in helping students distinguish appropriate data to use in an argument, critique the quality of this data, and compare the quality of multiple arguments that utilize slightly different data. In the classroom lab activities, almost all data that students collected were relevant and appropriate to use as evidence in their lab reports. If this was to not be the case, and some student data were to be irrelevant to their arguments, it is unclear what impact this might have on the results. However, these results can conclude that the process of collecting and writing about data in lab reports positively impacts students' ability to identify evidence, as well as to critique evidence and compare and critique the quality of evidence in multiple arguments.

Theme 2: Participation in argumentative writing exercises helps to strengthen Students' scientific claims.

Students wrote a total of four separate paragraphs throughout this study. Activity 1 to 3 was summative tasks that measured students' ability to interpret data in writing, using claim, evidence, and reasoning, before and after the instructional sequence. Activity 1 to 3 were formative lab reports, written as part of the instructional sequence, where students were guided to write similar paragraphs that drew conclusions from their own data sets collected during labs. Paragraphs were graded on a rubric that measured the quality of students' use of claim, evidence, and reasoning. Each category was graded on a scale of 1 to 4, based on a set of rubric criteria. Although all three categories on the rubric demonstrate increases in student scores, only the claim category showed a statistically significant increase. Therefore, this is the only category that can be considered as having been impacted by the CER presented in the science classroom Part of the instructional sequence included an "argumentation session" that had been modified from the original CER framework. In this research, the argumentation session consisted of students being given time to silently draft a claim, described as an answer to the research question, in their science notebooks. Students were then given time to discuss their drafted claims with one another, by sharing their own claim, as well as at least one reason why they had arrived at this conclusion – either specific numbers from their data collection or scientific reasoning based on knowledge of the content material. Then, students were randomly called on to share both their claim and why they chose that claim. In this argumentation, students were required to enter the discussion with a strong, clear claim. This discussion helped to ensure that every student had a claim, and that each student was able to construct this claim as instructed – answering the question and taking a clear position, based on the data that they had collected. The discussion of the evidence and the reasoning were less structured. The focus of this argumentation session was to ensure that students had a claim, and some reason why they made that claim. Therefore, this argumentation session served as a check on the quality of the claim, rather than the evidence and reasoning behind it. If students had followed a similar discussion process addressing the use of evidence and reasoning, they may have been able to demonstrate this knowledge more effectively on assessments.

Theme 3: Students need continuous feedback in order to improve and to think- like- a scientist.

Student feedback on the peer editing process indicated the following: Overall, the process of peer editing is useful for most students. However, there were students who did not receive helpful feedback and were not able to incorporate it. Upon review of the comments on the peer editing process, peer editing seemed to be less helpful for students who were already proficient and/or confident in their own writing. Even for those students, correcting someone else's paragraph can give ideas on what can be added or changed to their own paragraph. However, in order for peer feedback to be more useful to all students, students may need some ideas on what to say to peers whose paragraphs seem "perfect" at first glance. This may involve some additional instruction on editing for ideas and their clarity, not just spelling and grammar. In addition, some accountability systems might need to be put into place for peer editing processes in order to ensure that students are putting their best effort into their feedback and taking received feedback into account. As several students said, the best way to ensure that all students receive helpful feedback on their writing is if the teacher provides this insight. This is often a logistical impossibility before a student turns in a final draft, so peer feedback can be put into place as a proxy, as long as students are given clear, detailed instruction on how to deliver the type of feedback that is desired, and possibly even held accountable for the quality of their feedback. However, there truly is no replacement for a set of experienced eyes that have a clear idea of the expectations for a piece of scientific writing. In order for students to improve their writing, continuous, thorough feedback must be given frequently in order for students to clearly identify what they are doing right or wrong, and to engage in the metacognitive processes necessary for continued growth as a scientist

CONCLUSIONS.

The research results of and discussion on the effectiveness of CER as innovation to develop students' scientific argumentative writing skills in Biology teaching draw several conclusions.

1. The students' scientific argumentative writing skills in biology learning after the CER framework application is found at the proficient in writing the claim, proficient in writing evidence and excelling in writing the reasoning. This research has implied that CER as innovation are effectively increased the components of writing the claim, evidence and reasoning in biology teaching.
2. The students have high positive attitude (X= 1.50) based on the five indicators toward nature of science after the CER framework application.
3. After the CER framework application, the students improved their appreciation in learning of science into positive attitude (X= 2.37).
4. It is evident that after the CER, students' appreciation in scientific writing improved into positive attitude (X= 1.53).
5. The students have high positive attitude (X= 1.41) based on the five indicators toward thinking and learning science after the CER framework application.
6. After the students are very comfortable (X= 4.55) in using CER as innovation to develop students' scientific argumentative writing skills.
7. The implementation of CER results is the significant improvement on students' scientific argumentative writing skills in biology teaching after the experiment which is statistically significant which computed value of 16.859 against the tabular value of 2.861 at 1 percent of level of probability with degrees of freedom of 3 (df =3).
8. Claim, Evidence and Reasoning increases students' ability to identify, critique, and compare the quality of evidence in written arguments.
9. Participation in argumentative writing exercises helps to strengthen Students' scientific claims.
10. Students need continuous feedback in order to improve and to think- like- a scientist

RECOMMENDATIONS.

Based on the findings of the study and the conclusion drawn, the following are recommended:

1. Further research is needed on possible connections between argumentative writing instruction in the science curriculum and the language arts curriculum, and how teachers can potentially collaborate and/or design curriculum to support this practice among the different content areas.
2. Utilize the used of the CER Framework in teaching science subjects for further research with bigger population.
3. Conduct a School – Based workshop on proper implementation of the CER as innovation to develop students' scientific argumentative writing skills.
4. For more comprehensive findings, further studies on the same area of concentration may be conducted for improving science education where the students will be benefited.

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