# SCIENTIFIC LITERACY IN A 5E SECONDARY SCIENCE CLASSROOM

by

Emily Martin Hall

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# ABSTRACT

As a secondary Earth Science teacher, I noticed my ninth-grade students focused on learning content but were less proficient reading and summarizing scientific articles, assessing scientific sources, and applying what they learned in the classroom to the real world. I wanted to prioritize these three foundational parts of scientific literacy in my ninth-grade Earth Science classroom. To focus on building scientific literacy, I conducted an action research project incorporating current events into the 5E instructional model in the ninth-grade Earth Science classes at Oceanside High School in Rockland, Maine. Throughout two 5E units, students watched news clips, read scientific articles, wrote minute papers, and connected what they were learning to what was happening in the real world. Lessons asked students to assess sources, summarize what they read, and learn about the scientific research related to the topics. I measured growth using interviews, surveys, assessments, and minute papers before and after the two 5E units. Students who attended at least 80% of classes were included in the data ($N$=46). The minute paper indicated medium growth in student ability to summarize sources. The Scientific Source Validity assessments showed an increase in the mean number of qualifications students used to assess source validity. Organizing interview responses by themes indicated 20.45% more students mentioned that current events helped them connect what they were learning to the real world and 8% more students expressed a desire to learn more after the two 5E units. At the end of my action research, there was positive growth in scientific literacy skills after incorporating current events into the 5E model. Students were more able to assess sources and understand the reason why, they were more specific in their summaries, and they were more excited to learn more about science and make connections.

# CHAPTER ONE

# INTRODUCTION AND BACKGROUND

## Context of the Study

In modern society, we are surrounded by science in the news, social media, and politics. The public makes decisions every day based on their scientific knowledge. While teaching ninth-grade Earth Science, I observed students learn the factual content but struggle to read scientific literature in the news, assess scientific sources, and apply the information to the real world. As a teacher, it felt like classroom assessments were focusing on the facts but not on helping students develop scientific literacy skills or applying their knowledge. Even with earth science news surrounding them in their daily lives, students could not apply what they learned in the classroom to what they read and observed in the world around them. There was an essential part of science missing in the classroom—application.

For the past six years, I have taught ninth-grade Earth Science at Oceanside High School in Rockland, Maine. In 2020-2021, Oceanside High School was part of the Regional School Unit 13 (RSU13) district (Powerschool, 2019). RSU 13 included the towns of Owls Head, Cushing, Rockland, Thomaston, and South Thomaston. Rockland, in midcoast Maine, had 7,219 year-round residents and its economy relied on tourism, lobstering, and waterfront industries (About Rockland, 2019). Surrounding towns in the RSU13 district had smaller populations and relied on the same industries. Oceanside High School had 524 students in ninth to twelfth grades during the 2020-2021 school year. The population was almost all Caucasian at 94.8%. The other 5.2% of students included three African-American, eight Hispanic, two American Indian, five other, and four unclassified students (Powerschool, 2020).

All freshmen were required to take Earth Science at Oceanside High School as their freshman science class. Students were either placed in College Prep or Honors. I selected six freshmen Earth Science classes: one freshman honors Earth Science class and five College Prep Earth Science classes. For the Capstone Action Research, I measured growth in all the students who completed 80% of their work and attended 80% of the classes.

During the 2020-2021 school year, Oceanside High school had block scheduling and alternated blue and white days. Each day students attended four classes in person or virtually and each block was 65 minutes. A normal five-day week would either include three blue days and two white days or two white days and three blue days, depending on the rotation. Due to COVID, students alternated whether they attended class in person or virtually.

At the beginning of the year, students were divided into two teams: Mariners and Compass. Each group attended two days in person and three days virtually. In a five-day week, Compass students attended school in person on Monday and Tuesday and Mariner students were virtual on those days. Then, Mariner students attended Thursday and Friday and Compass students attended virtually. If it was a week with three white day classes, on Monday, Compass students attended the four white day classes and on Tuesday, they attended their four blue day classes. The Mariner students attended white day classes on Monday and blue day classes on Tuesday. On Wednesday, all students would attend their white day classes virtually. Then, Mariner students were in person for their four blue day classes on Thursday and their four white day classes on Friday. Compass would be virtual during those days. The hybrid schedule started in September when school started and continued throughout this study.

Since I started teaching at Oceanside High School, I have tried to show students that science impacts and surrounds us in our everyday lives. Also, I have tried to show students the more we learn about science, the deeper our understanding and the more explanations we can give for the conditions and characteristics of the world around us. When I was in high school science, we focused more on the content and less on application. When I went to college, I began to study geology and saw how everything I learned told a story which could be applied to what I saw around me. I started teaching science, hoping to bring a real-world application, critical thinking, and scientific literacy into the classroom—ideas also emphasized in *The K-12 Framework*. The Framework states that science education requires students to learn from texts, assessing sources, and applying their knowledge. Scientific literacy is a main theme throughout the Framework (National Research Council, 2012).

After I observed the students in my classroom focus only on the factual content but not the sources, the application, or the research, it was evident I needed to teach more scientific literacy skills. As our science curricula began to incorporate the Next Generation Science Standards (NGSS), the content shifted to include the principles outlined in the Nature of Science (NGSS Lead States, 2013). With this shift, opportunities developed that enabled me to teach students to select and assess sources, apply their knowledge, connect concepts, and develop skills in scientific literacy.

Reflecting on NGSS, the Nature of Science, and my interests, it was evident I needed to focus on scientific literacy in my classroom. Since Earth Science provides topics that are frequently in the news, discussed in public, and present in the world around us, it could provide students with a platform to study current events. Current events could provide the opportunity to evaluate the validity of various sources, read literature, and apply what they learn in the classroom to what is happening in the real world and showing up in the news. My interest in incorporating scientific literacy into my curriculum led me to the focus question.

## Focus Question

My focus question was, How can incorporating current events into the 5E instructional model promote scientific literacy in a secondary Earth Science class?

My subquestions include the following:

1. Does incorporating current events into a 5E structure teach students to learn how to assess the validity of sources?
2. How does incorporating current events into a 5E structure impact students' science related attitudes?
3. Does incorporating current events into a 5E classroom help improve students' abilities to summarize scientific sources?

# CHAPTER TWO

# CONCEPTUAL FRAMEWORK

## Scientific Literacy

Science is a way of knowing, understanding, and describing the natural world (NGSS Lead States, 2013). Maine was one of 26 states to help draft Next Generation Science Standards (NGSS) and started incorporating NGSS into the state curriculum in 2013 (Maine Department of Education, n.d.). The state officially adopted the standards in 2019 (Maine Department of Education, 2019). With the adoption of the NGSS, science education has shifted away from a strict focus on content knowledge and towards a curriculum that includes the nature of science, the practical skills of scientists, and scientific literacy.

Incorporating the crosscutting concepts, disciplinary core ideas, and science and engineering practices outlined by NGSS, a more complete understanding of science is built (National Research Council, 2012). By applying a three-dimensional curriculum, students can learn how science is practiced, and apply the skills scientists use. Students can learn to conduct their own background research by reading primary and secondary sources, they can discuss their own research with their peers, and they can communicate their findings using scientific language and vocabulary (Grant, 2015).

Scientists spend considerable amounts of their time reading, writing, and discussing science. Therefore, when students learn to be scientists, teaching must include scientific literacy skills (Grant, 2015). While many educators agree that we need to include scientific literacy in science education, many disagree on an exact definition of scientific literacy. Scientific literacy is a term that has various meanings in different research and contexts. One resounding idea about scientific literacy that is often mentioned is that it is what the public should know about science (Laugksch, 2000).

There are three common themes in many of the definitions of scientific literacy, including gaining knowledge of the factual content, applying science to real-world situations, and understanding scientific practices. One definition of scientific literacy is the ability to use scientific knowledge for multiple purposes, to create explanations, and also to form conclusions (Van Rooy & Moore, 2012). Another definition states that scientific literacy means comprehending and understanding scientific topics and issues. More specifically, this definition means that a scientifically-literate person can apply scientific knowledge to real-world situations, explain the phenomenon, evaluate scientific research and investigations, and gather data (Organization for Economic Co-operation and Development, 2017). A third definition focuses on how society interacts with science, engineering, and technology. In this definition, a scientifically-literate citizen must know basic terms and concepts and also be able to identify and use scientific practices (Jarman & McClune, 2007).

## Scientific Literacy and NGSS

NGSS incorporates scientific knowledge, practices, and application into three dimensions and promotes scientific literacy throughout the standards. Since communication is essential to the nature of science and what scientists do, scientific literacy is present in the NGSS framework, its goals, and the science and engineering practices (SEPs). NGSS states that science education needs to not only teach the facts, but also spend time teaching students how to apply the scientific concepts to new situations, and using scientific methods and skills that scientists use to gain knowledge (NGSS Lead States, 2013).

The K-12 Framework outlined five goals, three of which focus on scientific literacy. One goal emphasizes the importance of students having enough knowledge to discuss scientific issues with others. Another goal states that students should have the adequate scientific knowledge to be engaged citizens and intelligent consumers. The third goal of science education is to engage students in learning science in and out of the classroom (National Research Council, 2012).

Scientific literacy is also present in the science and engineering practices, one of the three dimensions in NGSS. The two SEPs which incorporate scientific literacy the most are: asking questions and defining problems and obtaining, evaluating, and communicating information (National Research Council, 2012). Asking questions and defining problems includes forming conclusions about a phenomenon, using models, and reading texts. It also requires students to use the proper vocabulary, correctly format a claim, critically read the text, and be able to write a strong conclusion. The SEP, obtaining, evaluating, and communicating information specifically requires that students gather, read, and evaluate scientific information while also evaluating the sources' validity. These SEPs are based on the fundamental ideas present in the definitions of scientific literacy (NGSS Lead States, 2013).

## Common Core State Standards

Common Core State Standards (CCSS) were adopted by the state of Maine for English and Math in 2011 and implemented during the 2012-2013 school year. CCSS focuses on both content knowledge and the skills students need to attain that content knowledge. Many of the ninth and tenth grade standards focused on science content and include these skills: citing evidence, determining central ideas, determining the meaning of terms, analyzing an author's purpose, and comparing and contrasting the text (Common Core State Standards, n.d.).

One goal of CCSS is to encourage students to read complex texts. CCSS also focuses on preparing students for college and the workforce. While teachers know they need to teach complex texts, often they need some guidance when learning to teach using complex texts and using CCSS. One study focused on five factors that make a text complex. These include specialized vocabulary, grammatical metaphors, expanded nominal groups, intricate sentences, and pronoun use. When designing learning experiences, teachers need to consider which of these five factors is present, as well as the readers' backgrounds and what is being asked of the readers.

The same study suggested teachers approach complex texts in four stages. Initially, students should read, take notes, and question independently before group and class discussions. Once they have developed a basic understanding, they can move to the next phase, focusing on a complex part of the text. Focusing on a small part allows students to take it apart and gain a better understanding of the meaning. The third phase focuses on the language the author uses including vocabulary, the author's voice, how information is presented, and the academic language. After a basic understanding, an examination of a part of the text, analyzing the language, students can move to a fourth phase. They use the information they read about to write their text. By this point, they should understand the main ideas, details on a section, and the language used. In the end, the study concludes that students must be supported in developing these skills. Teachers must look at a text, decide what makes it complex, consider the audience, and design an appropriate task to teach complex texts, a major idea behind CCSS (Fang, 2016).

## Current Events and Scientific Literacy

NGSS promotes scientific literacy but leaves it up to the teachers to decide and plan how to incorporate NGSS into their curriculum. While scientific literacy is the goal, there are challenges when it comes to reading different texts in the science classroom. Students often struggle reading scientific texts due to their depth, complex nature, and vocabulary. As one study explained, to teach scientific literacy, teachers need to provide support in both literacy and content. Teachers need to teach the science background and build vocabulary, while also helping students learn to summarize, model reading and questioning skills, and use graphic organizers. Students need frequent feedback in both literacy strategies and science knowledge. They also need opportunities to work independently, in small groups, and as a class. The study shadowed a group of teachers and the data showed that most teachers know what they should teach when it comes to content reading but do not always include these methods in their classrooms (Wexler et al., 2016).

One pedagogical practice which teachers can use to include literacy skills and promote scientific literacy in their classroom is to incorporate current events into their curriculum. A common way that the public interacts with science in their lives is through the news. Therefore, it is logical to use current events found in print and online sources to help develop scientific literacy skills. Using the news as a platform, teachers can help students make sense of what they read, evaluate the evidence and data, and discuss current topics that are relevant to their own lives. Stories in the news focus on science and society, a major component of scientific literacy, and can serve as a successful platform for students to learn the importance of science, engage with the content, and improve scientific literacy (Jarman & McClune, 2010).

In another study, using newspapers in the science classroom promoted active learning, allowed student choice, and provided flexibility in the curriculum. Basing the curriculum on newspapers at a college level was a successful platform for college-age students to read, discuss, question, and explain the content. In using newspapers, students were more engaged and were able to see how science plays a role in their own lives (Mysliwiec et al., 2003).

In an eighth-grade science classroom, one study focused on scientific literacy by teaching and measuring four factors: skeptical thinking, current event analysis, literature summaries, and long-term data collection based on observations. The four-part approach allowed the researchers to teach students to evaluate sources, locate articles, read critically, respond accurately and completely, and develop scientific literacy skills. The researchers noted that the students regularly cited the news in class discussions, were more interested in scientific writing, observed the outside world more effectively, and skeptically evaluated evidence throughout the year (LoGiudici & Ende, 2010). As science, technology, and engineering become more present in our daily lives, current events can help engage students in the content and promote scientific literacy (VanRooy & Moore, 2012).

## Pedagogy, Types of Questions, and Scaffolding

Teaching current events in the classroom is not only about the article, event, or story, it is also about the learning experience. Teachers plan lessons based on student goals, classroom goals, and their own teaching style. Once students are engaged in learning, students often become the decision-makers and shape their own experience. They decide whether to do be engaged, complete their work, and whether or not to participate (Mork, 2011).

One study promoting critical reading used Bloom's Taxonomy to create a plan to teach critical reading and develop higher-order thinking skills. The study had four main goals: to increase higher order thinking, to build participation, to provide opportunities for feedback, and to make the first three goals attainable for teachers. The researchers created a structure based on Bloom's Taxonomy. Students first defined themes, then started to make the connection, next, they explored multiple texts, and finally evaluated the author's claim and evidence. The study used a flipped model. Since the researchers wanted students to be able to compare ideas, transfer their understanding of certain concepts to new situations, and evaluate arguments, these skills were better developed in the classroom with the support of the teacher. The flipped model allowed students to read and define themes at home and discuss and collaborate in the classroom. This encouraged higher-order thinking (Mulcare & Shwedel, 2016).

Another study explored multimodal scaffolding in an English class. The goal of the teacher was to help students engage in the content and develop a deeper understanding of the content. The study took place in an interdisciplinary, environmental studies, high school's English classroom. The study was split into trimesters. The teacher started off using a movie clip and a non-fiction article. She provided a lot of support when she identified the questions students needed to answer and stated the themes. As the year went on, she incorporated books, articles, and encouraged students to make comparisons. By the end of the year, students were researching ideas on their own with less guidance and scaffolding. By stating and explaining the different modes, questions, and themes early, the students were able to develop connections and find their sources later on in the year (Boche & Henning, 2015).

A third study explored how using active learning to explore current events can help improve students' content understanding. Students were initially asked to investigate an event/issue that was discussed in the last year and present it to their peers. Then, they submitted the topic to who then assigned topics based on preference and curriculum coverage. Once topics were assigned, each group had to write and submit a summary that was less than one page and included an exam question, create a PowerPoint for their final presentation, and eventually present the article to their class in five minutes. Students agreed with the data that they were more aware of current events. While data showed students were better able to analyze information and arrange the information into a written report, students were unsure if this happened. Overall, the researchers noted that using current events and these strategies made a more positive learning and teaching environment (Kelsch & Werremeyer, 2010).

As stated before, a primary goal of scientific literacy is to help students become well-informed citizens who can make decisions and engage in a discussion based on scientific evidence. Scientific literacy includes debate, decisions, and research (Van Eijck & Roth, 2010). When designing learning experiences, there is never one approach or one curriculum, instead, teachers must always adapt and customize their lessons based on that year, group of students, and content (Mork, 2011).

## The 5E Model

In the science classroom, teachers use a variety of methods and the order in which students learn matters. The 5E model creates a structure of learning that is supported by data and educational research. The model of learning incorporates the way students learn and provides structure to lessons and units that help students better understand the content. When creating the 5E model, researchers determined the learner must be interested, active, and have an opportunity for application. To ensure lessons had these three characteristics, the 5E model includes five stages – engage, explore, explain, elaborate, and evaluate (Tanner, 2010) (Figure1).

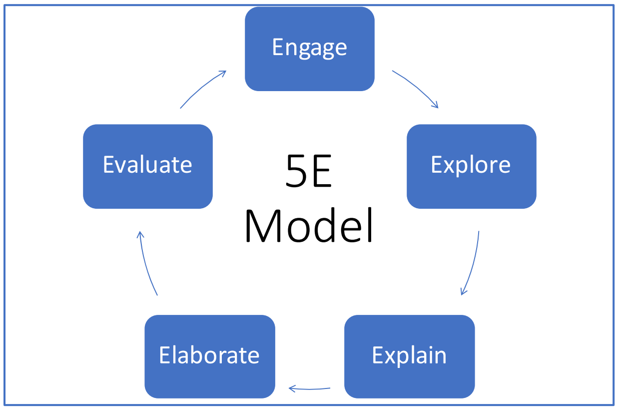


Figure 1. The 5E Model. This diagram shows stages and the cyclical nature (Adapted from Llewellyn, 2013).

The 5E model uses a constructivist philosophy to engage students immediately and provide them with a goal for the lesson or unit. The engage stage is focused on getting students interested in the topic, but also allows teachers to determine what students already know about the topic, identifying misconceptions, and showing the students the purpose of the upcoming lesson or unit. Next, students need the opportunity to explore. This stage continues to engage students but also allows them to explore their knowledge through collaboration, discussion, and testing of hypotheses. Students should have time to explore so they can move on to the next stage: explanation, when students find scientific context for what they just observed. They learn vocabulary, theories, and ideas that help them link what they already know to their observations. Without application, students do not have the same depth of understanding; the elaborate stage provides students with the opportunity to apply what they learned. Finally, at the end of the lesson or unit, students need an opportunity to form conclusions, ask more questions, and evaluate their own knowledge. This final evaluate stage concludes the unit and gives students that closure (Llewellyn, 2013).

# CHAPTER THREE

# METHODOLOGY

## Demographics

This study focused on using current events within a 5E model to help students develop scientific literacy skills. I broke down scientific literacy into three main themes: assessing source validity, science related attitudes, and comprehension. To determine if there was student growth over the treatment period, I gathered qualitative and quantitative data before, during, and after the units. I incorporated current events, real world places and ideas, and news articles into the preexisting 5E curriculum. The research methodology for this project received an exemption from Montana State University's Institutional Review Board and compliance for work with human subjects was maintained (Appendix A).

The treatment period lasted from February 5, 2021, until April 16, 2021, and all 91 of my Earth Science students participated in the 5E lessons. Out of the 91 ninth-grade students in my Earth Science classes, I selected students who attended 80 percent of the classes during the treatment period. With COVID during the 2020-2021 school year, attendance was down. In the end, from the 91 students, 15 ninth-grade Honors Earth Science students and 31 ninth-grade College Preparation level Earth Science students attended at least 80 percent of the classes. Out of these 46 students, seven students had Individual Education Plans, three students had a 504, and one student was part of our

English Language Learners program. The 504 plans were plans created by the school and the district to support students with a disability (Understood, 2011).

While I started to incorporate news stories and current events into units starting at the beginning of the year, the treatment period included two units. The first unit focused on oceanic and continental geologic features and covered NGSS HS-ESS2-1. The second unit looked at how variations in energy change Earth's climate, and covered NGSS HS-ESS2-4. I used the 5E model as a structure for the lessons and units since it was already in place in my classroom. As a student teacher and during my past six years of teaching, I used the 5E model to develop and plan curriculum. The order of how students receive instruction matters and the 5E model created an effective learning structure and outline while leaving flexibility in what I teach. In my classroom, the 5E model has promoted student engagement, student-led inquiry, and works well with Next Generation Science Standards (NGSS). Using the existing 5E model, I incorporated current events into at least two, sometimes three portions of the 5E model.

## Treatment

After administering the TOSRA pre-assessment, Source Validity pre-assessment, the Initial Scientific Literacy Interview, and the Scientific Literacy Survey, I began to incorporate scientific literacy skills into the curriculum. I started the treatment period by discussing and evaluating source validity. I brought up the two sources used in the pre-assessment. As a class, we looked at these sources and discussed what characteristics students use to determine if a source is valid. After the discussion, we came up with a checklist of characteristics to assess a source's validity (Appendix B). This list was adapted from a lesson I had previously used when teaching climate change (Sherwood & Tucker, 2019). By starting with this theme, we were able to revisit the idea of assessing source validity throughout the entire treatment period. Students used the checklist throughout the various units when finding, reading, searching, and using different sources.

After the class focused on the validity of sources, we moved on to the first treatment unit on geologic features. There were four different lessons in this unit. Each of these lessons was created as a Google Doc. Each assignment had 5 parts to correspond with the sections of the 5E structure. Throughout the lessons, there were links to news videos, articles, simulations, demonstrations, and connections to real situations. The first assignment focused on Iceland as a divergent plate boundary and hotspot. The next lesson focused on the East African rift valley. Then, students learned about the 2011 Japanese tsunami to better understand convergent plate boundaries (Appendix C). The final lesson explored transform plate boundaries using the San Andreas fault. Each lesson started with a short news story video to engage students. Then, students explored the motion of the plate boundary with demonstration videos, data exploration, and digital simulations. Once they completed those sections, they watched a video explanation I created about the plate boundary. Students moved on to read a news article about the area and finished with a 3-minute minute paper summarizing what they learned or answering a focus question from the lesson.

For the final assessment, students picked a geologic feature that was at either a hotspot or a plate boundary. Students explored their selected feature to explain how it formed, how it changed over time, drew a model, and then, found a geologic event that had recently happened there, such as an earthquake, volcanic eruption, or tsunami. The project was structured to provide students the opportunity to find and assess sources, summarize what they learned, and connect it to the world and current events. For the project, students were asked to find at least three sources. I reminded them of the checklist for source validity and asked them to assess all sources for validity. In the end, the unit emphasized choosing and assessing valid sources, summarizing different resources while making connections, and the value of science to society.

For the next unit, we focused on factors that impact climate. I incorporated current events, data, and real-world situations throughout the unit to engage students. With a shorter amount of time and seeing students infrequently due to COVID, students have done better and been more engaged with shorter units where I alternate between a project, test, or Claim Evidence Reasoning (CER) for their summative assessments. For this reason, I divided climate unit into two shorter units and only one unit was incorporated into this action research project. For the climate unit, I focused on how volcanoes, mountains, and the oceans impact climate. An example of a lesson on how oceans impact the climate is included in Appendix D. As students used new resources, I asked them to assess the validity of these sources, investigate the science behind what they learned, and summarize the content on a variety of levels. Incorporating current events, current science, and real situations allowed students to learn about and explain topics, observe the role of science in society, and learn about new topics from new sources.

In the past, I have tried to emphasize the importance of what students learn in the classroom and how it impacts their lives. While I have tried to bring current events into the classroom, this project allowed me to deliberately plan to incorporate current events and research into the classroom. For each unit, students were asked to identify real science, research the topics, assess the validity, summarize the material and make connections.

## Data Collection and Analysis Strategies

All of the instruments, except for the minute papers, were implemented through Google Forms. With the shifting from fully in-person to hybrid and potentially to remote, this method of administering the assessments ensured that I reached all students, whether they were present in class, working from home due to quarantine, or absent. It also allowed me to shift to a paperless system which enabled me to continue to socially distance when communicating with students.

### Test of Science Related Attitudes (TOSRA)

I also collected quantitative data on science-related attitudes by using a shortened version of the Test of Science Related Attitudes (TOSRA) (Appendix G). I administered this survey before the treatment period and at the end of the treatment period. I used the scoring system provided in the TOSRA. Numbers 1, 3, 5, 6, 7, and 9 all had regular scoring. Strongly agree received 1 point and strongly disagree received 5 points. Certain questions (2, 4, 6, 8, and 10) had a reverse scoring. This meant strongly disagree received

5 points and strongly agree received 1 point. If a student skipped a question, they received 3 points. Higher scores meant students had better attitudes about science.

In the end, I compared the individual scores and the average scores from before the treatment to the scores after the treatment to determine whether there was positive or negative growth. By looking at individual growth, I could calculate the percentage of students who saw positive growth and the percentage of students who indicated negative growth (Appendix E) (Fraser, 1978).

### Source Validity Pre-assessment and a Source Validity Post-assessment

Students completed a Source Validity Pre-assessment and a Source Validity Post-assessment where they were asked to summarize and assess the validity of two different sources (Appendices F & G). For the pre-assessment, students read one invalid source and watched another valid source before answering four questions. For each of the sources, they were asked to identify the claim, list three pieces of evidence, assess the validity, and explain why they thought the source was valid or not. From this pre-assessment, I compiled quantitative data about whether students were able to identify the claim correctly, if they could highlight the evidence, and whether they properly assessed the source. The pre-assessment also provided qualitative data when asking how students assessed sources. I compiled a list of the characteristics which students used to assess source validity. After the entire treatment period, students were given two different sources, again one valid and one not valid. Students were again asked the same four questions and I compiled the quantitative data and qualitative data to compare to the pre-assessment. For the quantitative data, I used a normalized gain to measure the growth.

In the end, I was able to determine if there was positive or negative growth in students' skills in identifying the claim, listing evidence, and assessing source validity. I was also able to use the quantitative data to compare how they assessed source validity before the treatment period to how they assessed source validity after the treatment period. This allowed me to determine how students changed in their ability to assess the validity of sources.

Scientific Literacy Initial and Final Interviews

The last instruments used were the Scientific Literacy Initial and Final Interviews (Appendices H & I). The initial interview and the final interview both had similar questions but phrased differently. There was a total of six questions in each of the interviews. The first two asked students how and why we should assess the validity of sources. The next one asked about what helps understand science content in the initial interview and asked if current events help with comprehension in the final interview. The fourth question in both interviews asked why it is important to read about science in the world. The next question in the initial interview asked about whether current events fostered curiosity and in the final interview asked how current events helped. The final question in both interviews asked if there was anything else to share. By analyzing and reflecting on these answers, I was able to determine how students grew negatively or positively in their scientific literacy skills, their understanding of the content, their ability to assess sources, and their feeling about science.

Conducting this study allowed me to make a deliberate effort to use current events to help students look at science differently, understand the content better, and be able to determine the validity of sources they see in their daily lives.

Scientific Literacy Survey

To collect quantitative data about all three parts of scientific literacy assessed in this study, I used the Scientific Literacy Survey (Appendix J). Three questions asked students about source validity. The first three questions asked if students could determine if an article was supported by science, whether it used scientific evidence, and whether they felt comfortable assessing the validity. The next three questions asked about highlighting the main points, summarizing content, and making connections. The final three questions focused on students' attitudes toward science. It specifically asked about hearing other views, learning about the world, and hearing new topics. By asking students both before and after the treatment whether they strongly agree, agree, disagree, or strongly disagree, I was able to determine if scientific literacy in the student body saw positive growth or negative growth. I assigned 2 points to strongly agree, 1 to agree, -1 to disagree, and -2 to strongly disagree. If the scores were negative, there was a decline in how students felt about their scientific literacy skills. If the scores were positive, there was positive growth in how they felt and if the score was 0, there was no growth. This evaluated how students felt about their scientific literacy skills while assigning quantitative data to the statements.

Minute Papers

Throughout the units, I used minute papers to evaluate student comprehension. I used a rubric to provide quantitative data about student understanding and used the papers themselves for qualitative data about student understanding. During the unit, I administered minute papers at the beginning of the unit, throughout the unit, and at the end of the unit. Throughout the other unit, I used minute papers to assess growth both within the unit and between the units. I used the Minute Paper Rubric to score each paper on a scale of 0-5. Each point represented a level of thinking - knowledge, comprehension, application, analysis, and evaluation. Higher scores indicated students addressed various levels of thinking in the minute paper and to collect quantitative data to indicate positive or negative growth over time (Appendix K).

Table 1. Data Triangulation Matrix.

| Focus Question: How can incorporating current events into the 5E instructional model promote scientific literacy in a secondary Earth Science class? | | | | | |
|---|---|---|---|---|---|
| Sub-questions | TOSRA | Scientific Source Validity Pre- and Post-assessment | Scientific Literacy Initial and Final Interview | Scientific Literacy Survey | Minute Papers |
| Did students improve at evaluating the scientific validity of sources after reading current events throughout the unit? | | X | X | X | |
| Did students develop a better understanding of science related attitudes after studying current events within the unit? | X | | X | X | |
| Were student responses more complete and more accurate when they summarized scientific literature after an Earth Science unit that incorporated current events? | | X | X | | X |

# CHAPTER FOUR

## DATA ANALYSIS

After using current events in two 5E units, the Scientific Literacy Survey indicated 70% positive growth in student scores (*n*=20)(Figure 2). Interview responses showed an increase in the desire to learn and make connections between what students learned in the classroom and the outside world. One student explained, "Well, sometimes I learn something in science then I see it actually happening in the real world and I'm like, 'Wow I just learned all about that.'"

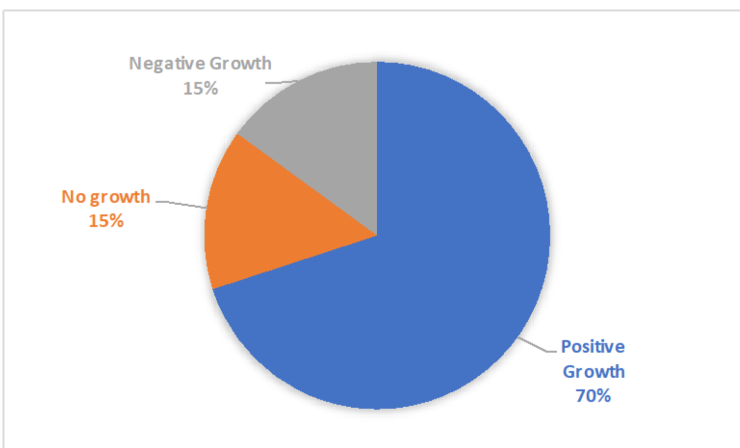


Figure 2. Scientific Literacy Survey Percentages. Percentages of student growth from initial survey to final survey. Survey included statements regarding assessing source validity, summarizing scientific sources, and science related attitudes, (*n*=20).

### <u>Summarizing Scientific Sources</u>

The minute papers indicated a normalized gain of 0.33, showing students demonstrated medium growth in their ability to summarize scientific sources (Figure 3)(Hake, 1998). For each minute paper, students responded to a question that asked them to reflect on a news article about a specific place or event which incorporated a theme from class. Using the minute paper rubric to assign a score of 0-5, the scores indicated the level of student understanding shown in their minute paper responses (Appendix K). The mean score of the first paper was 2.35 and the mean score of the final paper was 2.88.

All three mean scores from the minute papers showed growth and had relatively small standard errors. The scores increased by 0.37 points or 7.4% between the first and second paper and then 0.16 or 3.2% between the second and final minute paper (Figure 3). Between the first and final minute paper, student scores showed an overall increase of 10.6% growth, demonstrating improvement in their ability to summarize scientific sources and ideas.

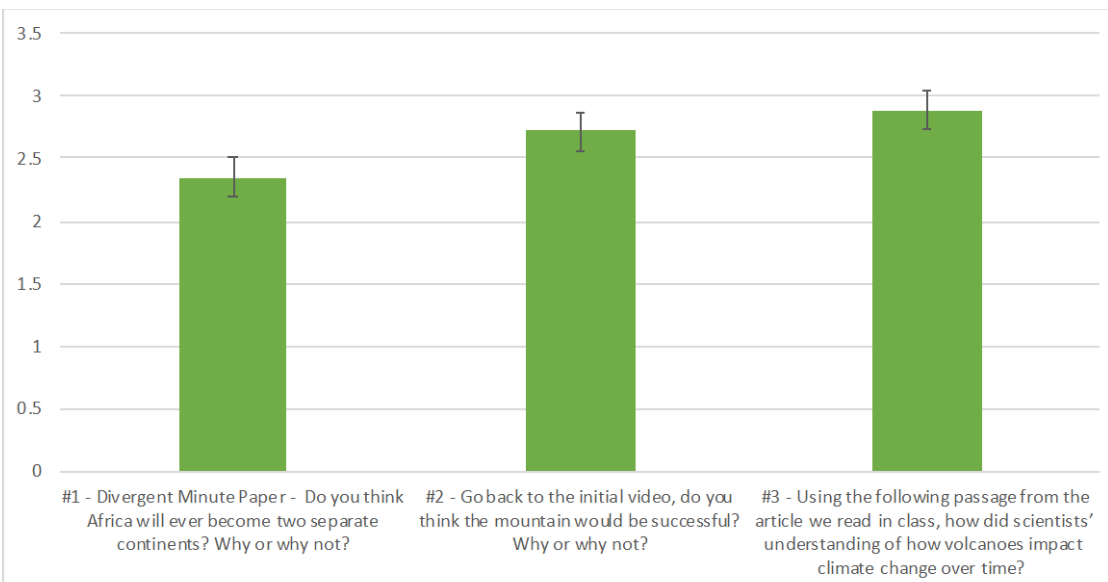


Figure 3. Mean Minute Paper Scores. Above are the means scores of the three-minute papers and standard error mean bars for three separate minute papers. The first minute paper asked about divergent plate boundaries (*n*=40). The second paper asked about how mountains impact precipitation (*n*=40). The third paper asked students how volcanoes impact climate, (*n*=41).

Reading through the Minute Paper responses showed growth in how students summarized. Students used more specific evidence and more direct claims. One student responded to the question about whether Africa would be two continents in the future with, “Yes at some point it will become two separate continents because at some point a small ocean.” After reading more articles and using minute papers to summarize throughout the two 5E units, the same student responded to the final question about how scientists over time changed their understanding of how volcanoes impact climate by stating, “In 1980 Mt. St. Helen’s erupted and it released incredible amounts of ash and dropped global temperatures by 0.1C. But two years later when El Chichon erupted and released much less ash but more than 40 times the sulfur gas causing temperature to drop 5x as much as MSH. This caused scientists to realize that sulfur made the temperatures drop more than ash.” In the second response, he used dates, specific places, quantities, and made a specific claim.

Finding patterns in the minute papers also showed that in the first minute paper, 52.5% students started their minute papers with, “I think” or “I believe.” In the final minute paper, no one started their answer with those statements. Students made a clear and specific claim. Students also used evidence more frequently to support their claim. In the initial minute paper, 32.5% incorporated specific evidence while in the final minute paper 85.7% included specific evidence. When asked in the interview why students should learn about science in the real world, one student responded that current events in their learning encouraged them to look at science, “More in depth, to receive facts, interesting news from people who are more experienced with science.”

When students were asked in the Scientific Literacy Survey about their ability to summarize topics, current events, and key points, the responses indicated a positive shift. The data showed a shift to the agree/strongly agree categories, while the number of students who strongly agreed decreased and the number of students who agreed increased. When students were asked in the Scientific Literacy Survey to strongly disagree, disagree, agree, or strongly agree with whether they could highlight the main points of summarize the content after reading current events, data showed 3% growth, where more students agreed or strongly agreed. One student explained that looking at evidence helped them understand the topic, "when the evidence is very well described, I understand it." Another student explained, "reading about current events in class and breaking them down helped me understand more of the content."

Looking at student responses to the other statements showed a higher percentage of students, 14% more, agreed or strongly agreed they used current events to make connections between the world and what they learned in class. Initially, 86% agreed or strongly agreed when reading current events, they could make connections between current events and what they learned in class but in the end, 100% of students agreed or strongly agreed they could do this. This statement also indicated that the students shifted from agree to strongly agree. This data was supported by the Scientific Literacy Final Interview responses after the two 5E units. The students more frequently mentioned that when reading current events, they often were more able to make classroom and real-world connections (Figure 4).

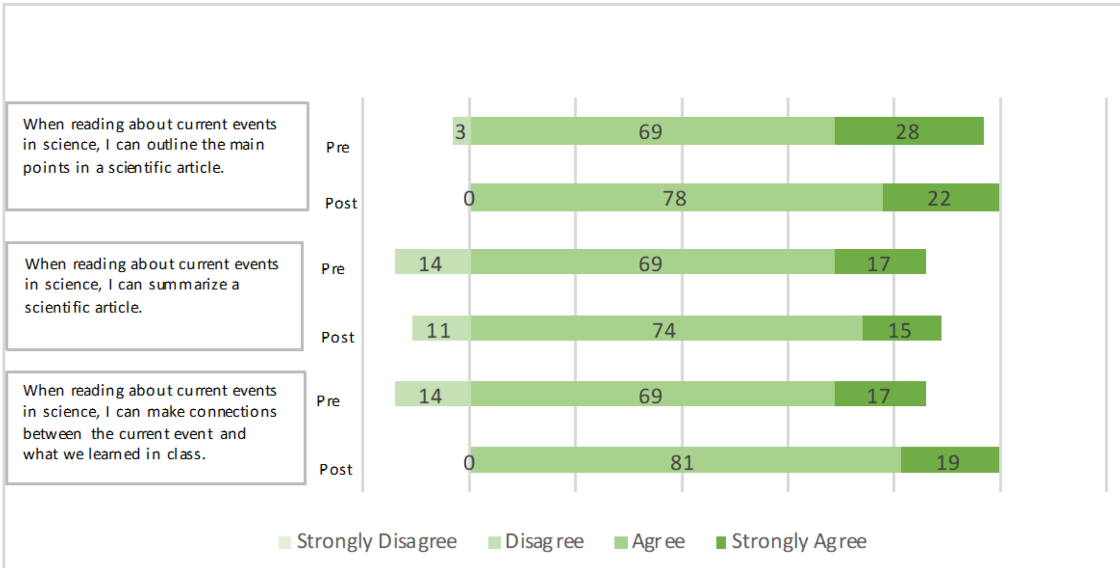


Figure 4. Scientific Literacy Survey – Summarizing Sources. The Initial and Final Survey statements focusing on how students summarize scientific articles and events. The Pre-treatment survey and Post-treatment survey asked students to reflect on outlining main ideas, summarizing, and making connections, (Pre-, *n*=29), (Post-, *n*=27).

A major theme throughout the Scientific Literacy Final Interview was making connections to help students understand the content. Looking through student responses to the question asking students how they thought current events helped them become more curious, the responses more frequently mentioned making connections in the Scientific Literacy Final Interview. One student explained, “This happened here, how did it affect over there? …just a spider web of different events and science.” Initially, 4.5% of students referred to making connections in their interview responses but after the two units, 25% of students mentioned that using real places and situations in the lessons helped them be more curious. One student summarized these thoughts up in the interview saying, “It made me more curious because it’s interesting to actually know what’s happening in places that I don’t live or haven’t even hear of.” (Figures 5).

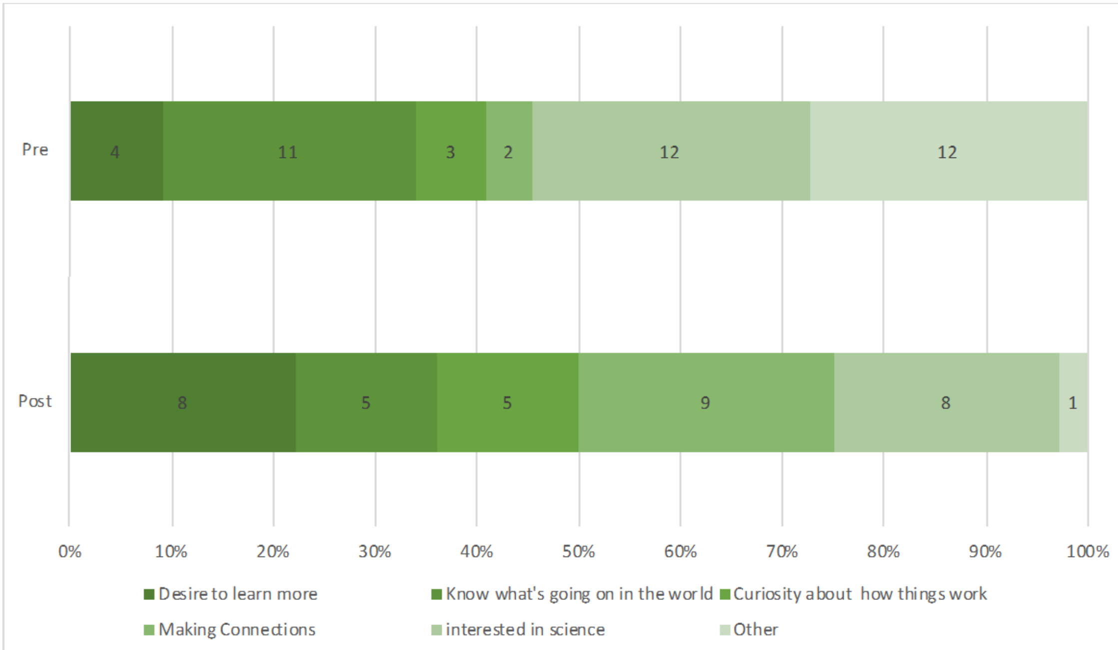


Figure 5. Pre- and Post-unit Interviews – Current Events and Curiosity. Student responses when asked about how current events helped students become more curious about science in the real world in the initial interview, (Pre-, *n*=44), (Post-, *n*=36).

Students practiced identifying the claim and evidence to help students identify key points, understand, and summarize articles throughout the two 5E units. Using the Scientific Source Pre-assessments and Post-assessments, I collected data on how students developed these skills. In the Scientific Source Pre-assessments, students looked at two different sources to identify the claim, three pieces of evidence, whether or not the source was valid, and how they decided if it was valid. They completed two more Scientific Source Post-assessments after the two 5E units asking the same questions but using different sources. As seen in Figures 6 and 7, comparing the data from the Scientific Source Pre-assessments to the Scientific Source Post-assessments, data showed students identified and summarized the claim and evidence in a scientific article after the two 5E units. In the two Scientific Source Pre-assessments, a mean of 32.43% of students identified the claim correctly and a mean of 31.43% of students identified the correct evidence (Figure 7). After the two 5E units, in the Scientific Source Post-assessments, 41.54% of students identified the claim correctly and 63.50% identified the evidence correctly (Figure 6).

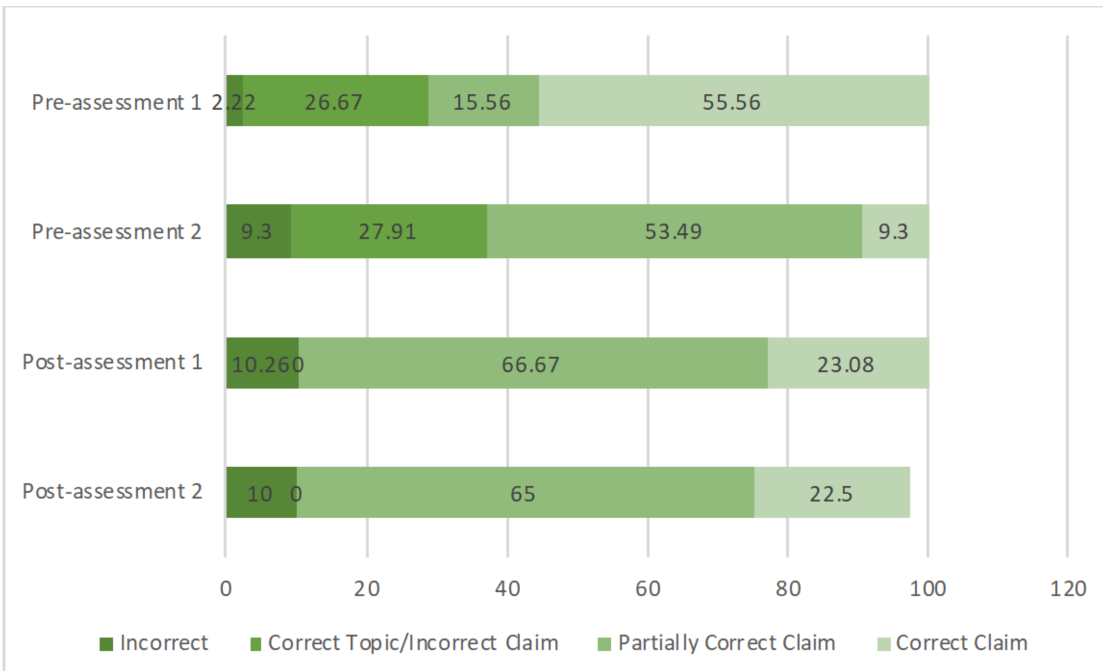


Figure 6. Scientific Source Validity- Identifying the Claim. A comparison of student claim identification in the two Scientific Source Validity Pre-assessments and two Post-assessments, (Pre- 1, *n*=46; Pre- 2, *n*=43), (Post- 1 and 2, *n*= 40).

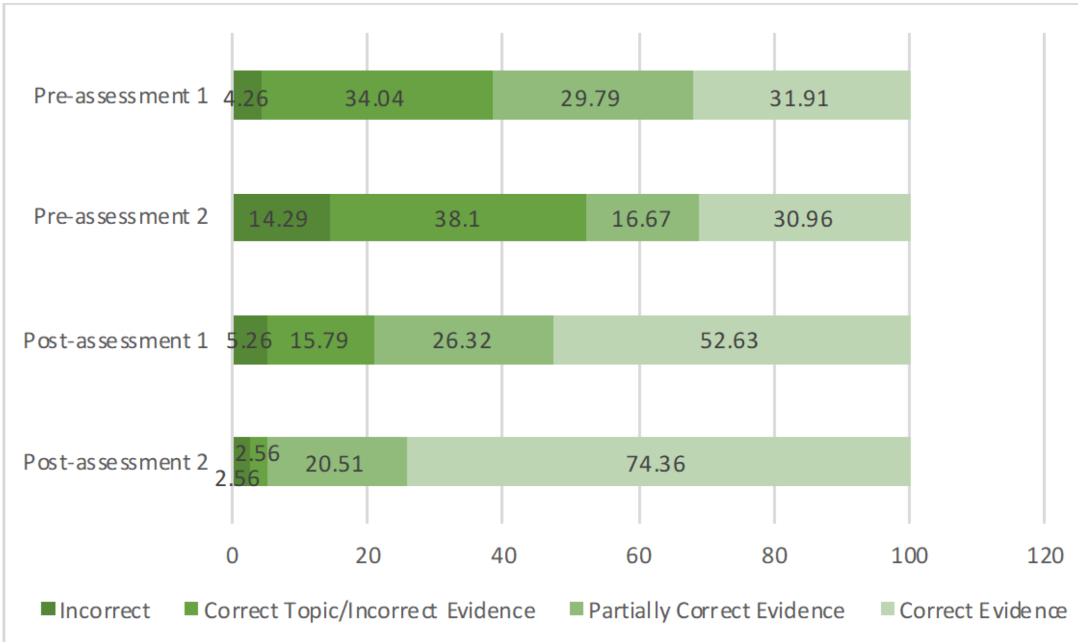


Figure 7. Scientific Source Validity – Identifying the Evidence. Comparison of student evidence identification in the two Scientific Source Validity Pre-assessments and two Post-assessments, (Pre- 1-, *n*=46; Pre- 2, *n*=43), (Post- 1 and 2, *n*= 40).

Comparing data from initial and final minute papers, Pre- and Post-Scientific Literacy Surveys, and Scientific Source Pre- and Post-assessments indicated growth in students' ability to identify the claim, use evidence, and summarize an article. The responses to the final minute papers reinforced student growth in evidence use to completely summarize what they learned. The interview responses focused on making connections between the classroom and the real world to help students understand the content. Students need to understand the topics to accurately and completely summarize. One student agreed in their interview by stating, "I think it helps to connect current events with science for a better understanding of how they occur…"

Scientific Source Validity

Another core piece of scientific literacy is the ability to assess source validity. The data from the Scientific Literacy Interviews, Scientific Source Pre-assessments and Post-assessments, and the Scientific Literacy surveys all indicated positive growth in how students assess source validity and the number of qualifications they use in their assessments. The Scientific Source Pre-assessments showed that when assessing whether or not a source was valid, students used a mean of 1.00 qualification to determine if a source was valid before the two 5E units. When asked how students assess source validity before the units, 20.93% of students explained they do not assess sources or that they don't know how. Other students stated they determined validity by figuring out, "If its Wikipedia or not," "If it's from a reliable source," or if they "read the whole thing."

Student responses from the final interviews all included some qualification instead of I don't know, or that they do not assess sources. In the Post-assessment, students used a mean of 2.7 qualifications. One student summarized how they assess a source by saying they, "…check if what they are claiming is true, if they back up their claim with scientific evidence. If their facts and sources are legit…You should also look into where the article is being published and if that site is reliable. Look into the authors credentials and experience."

When using current events, articles, and finding sources during the two 5E units, students used a Source Validity Checklist to assess if the source was valid (Appendix B). To stay consistent with what they learned in class, I used the checklist as a scoring sheet in the Scientific Source Pre and Post-assessments. Students received a point for each characteristic they used from the checklist to assess the validity. With this system, students on average, used a mean 1.7 more characteristics from the Source Validity Checklist to assess source validity after the two 5E units (Table 2).

Table 2. Source Validity Tallies. Number of times each student used a specific qualification to assess Source Validity in the two Scientific Source Validity Pre-assessments and two Post-assessments, (Pre- 1-, *n*=46; Pre- 2, *n*=43), (Post- 1 and 2, *n*= 40).

| | Pre- 1 | Pre- 2 | Post- 1 | Post- 2 |
|---|---|---|---|---|
| URL | 12 | 12 | 1 | 4 |
| Author | 1 | 1 | 4 | 17 |
| Hard to believe or seems real? | 17 | 7 | 21 | 5 |
| Photos | 4 | 0 | 0 | 2 |
| References and Reputable sources | 7 | 12 | 12 | 15 |
| Evidence supports claim and title | 8 | 7 | 2 | 19 |
| Quotations | 0 | 12 | 0 | 0 |
| Fact Checking Site or heard if from other source | 3 | 4 | 1 | 3 |
| Recent Publication/ Year | 0 | 1 | 13 | 9 |

The Scientific Literacy Survey data indicated that after the two 5E units, more students agreed or strongly agreed they could list ways to determine if a source was supported by science, assess whether a source was valid, and evaluate an article with scientific evidence. There was a shift from disagree/strongly disagree to agree/strongly agree. For these three statements, there was also a positive shift to strongly agree. When reading about current events, 10% more students agreed or strongly agreed they could list ways to assess whether a source was supported by science, while the number of students who strongly agreed increased by 22%. When asked if students could evaluate if an article used scientific evidence, 17% more students agreed or strongly agreed they could after the two 5E units, while 5% more students strongly agreed. When asked if students felt they could assess source validity after reading current events, there was a 14% increase after both 5E units, and in the end 100% of students agreed or strongly agreed they could assess validity (Figure 8).

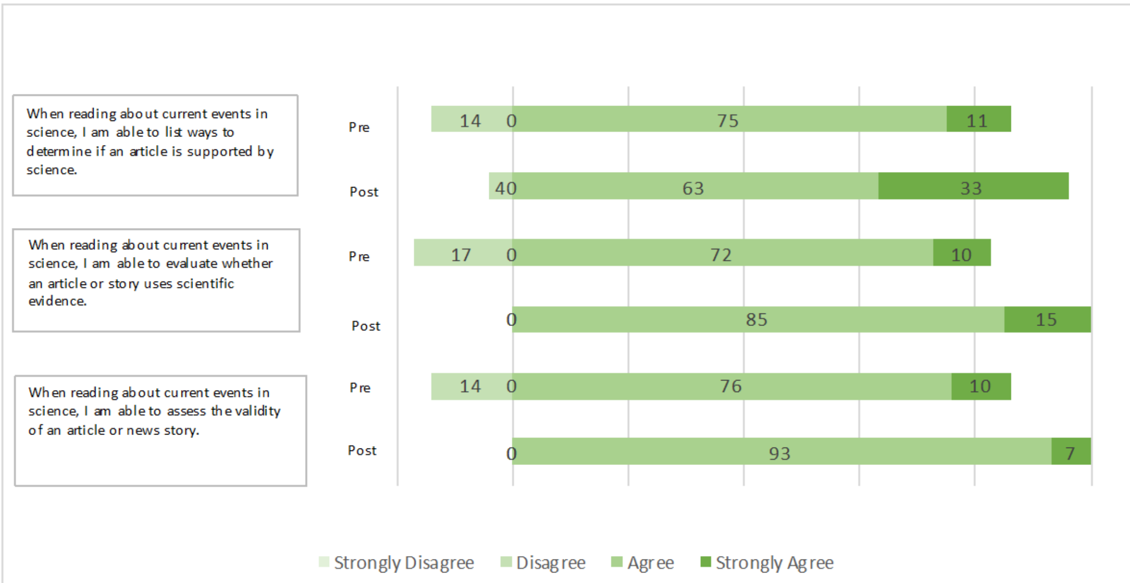


Figure 8. Scientific Literacy Survey – Assessing Source Validity. Initial and Final Survey statements focusing on how students assess source validity. The Pre-treatment survey and Post-treatment survey asked students to reflect on how to know if an article is supported by science, uses scientific evidence, or assesses source validity, (Pre-, *n*=29), (Post-, *n*=27).

Overall, the Scientific Literacy Initial Interview indicated before the two 5E units, students focused on using false information and not spreading misinformation. One student summarized why it was necessary to assess sources, “We should do this because if you don’t you could possibly be getting false information.” The Scientific Literacy Final Interview responses showed that after the two 5E units, students incorporated the need for evidence more often, “So you don’t go through life believing in things that aren't factual or supported by any evidence." Another student explained, "chances are their claim isn't correct if it's not backed up by legit science."

## Science Related Attitudes

Data from Scientific Literacy Interviews, the TOSRA, and the Scientific Literacy Growth Survey all indicated positive growth in students' science related attitudes. Throughout the units, students learned about new places and topics and read scientific articles. Before and after the 5E units, students were asked in the Scientific Literacy Interview why it is important to read about science in the real world. To identify patterns in the data from the interview responses, I looked for themes in the responses. Before the two 5E units, 4.76% of students mentioned that learning about science in the real world helped them want to learn more (Figure 9). After the two units, 8.33% of students mentioned this desire to learn more. Another area of growth was their interest in science. Before the unit, 16.67% of students mentioned that reading about real science made them more interested in science. After the two units, 27.78% of students mentioned an increased interest in science (Figure 10). These shifts in perspective from before and after the two 5E units can be seen in Figures 9 and 10 below. In the final interview, one student explained their shift in outlook by stating it was, "important to read about science in the real world because it can sometimes seem that science has no real application." Another student responded by making connections to how we respond, "If you don't have an example from something in real life, it can be harder to find a solution for something like that." Interview responses showed a change in how students looked at learning and at science.

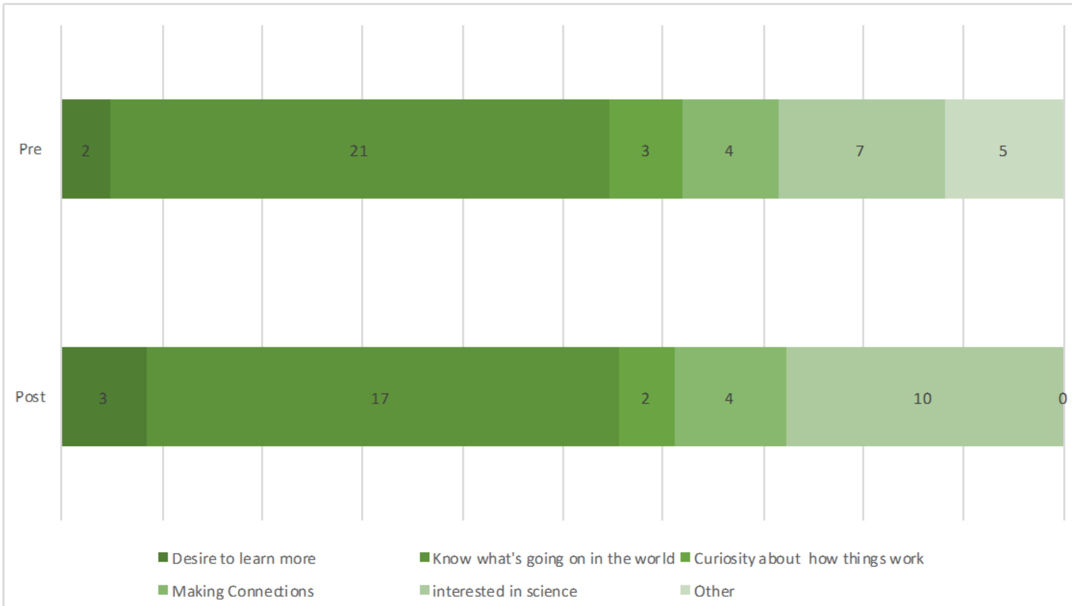


Figure 9. Pre- and Post-units Interviews – Importance of Learning Science in the Real World. Student responses by category when asked why it is important to learn about science in the real world. Data is organized by themes and from the initial interview, (Pre-, $n$=32), (Post-, $n$=36).

When asked how current events made students more curious about science in the real world, students grew again in their desire to learn, their curiosity about the real world, and their inclination to make connections. Before the two units, 4.55% of students felt that using current events made them more curious about science in the real world. After the units, 25% mentioned current events helped them make more connections (Figure 9).

The TOSRA data showed some growth and had a relatively small standard error. Using the instructions provided by the TOSRA, I calculated the scores for the initial and final TOSRA (Fraser, 1978). The initial TOSRA mean score was 28.88, while the final TOSRA mean score was 29.53. This data indicated a 1.63% growth in students' science related attitudes (Figure 10).

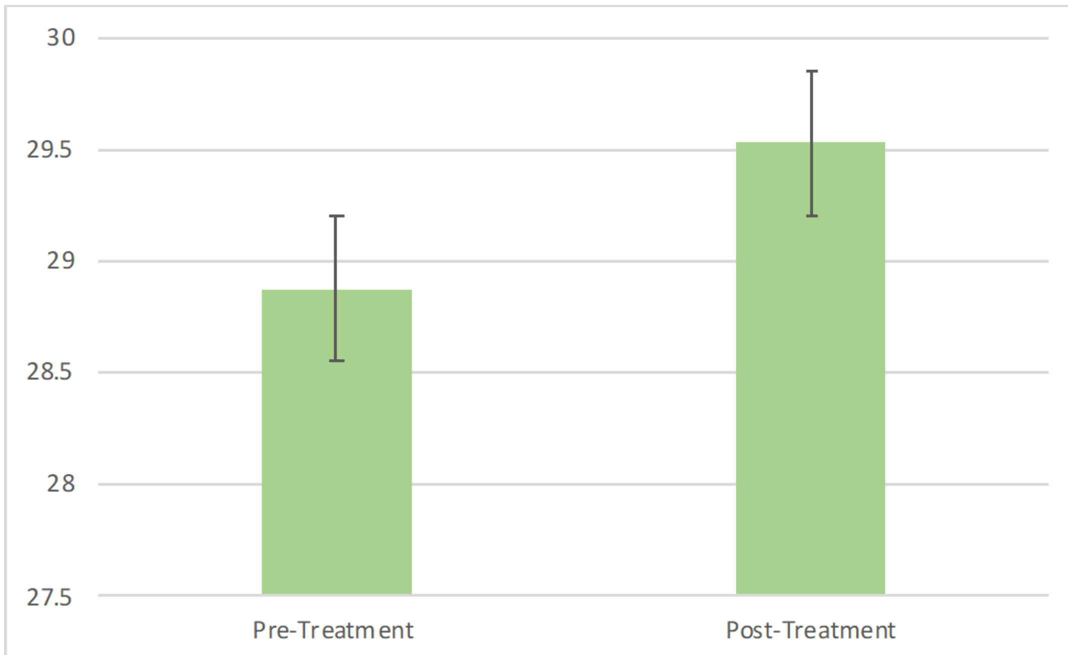


Figure 10. TOSRA Scores. Mean scores and standard error means for Test of Science Related Attitudes. Calculated using the Fraser Test, 1978, (Pre-, *n*=32; Post-, *n*=36).

Another chance for students to respond to their science related attitudes about science was the Scientific Literacy Survey, which included three questions focused on science related attitudes. Similar to my descriptions of the Scientific Literacy Survey in the sections above, students were asked to reflect on how reading current events in science impacted their science related attitudes by choosing strongly disagree, disagree, agree, or strongly agree to three statements. The first statement focused on curiosity, the next was focused on hearing other opinions and views, and the final focused on hearing new ideas and new topics. For all three statements, there were more students who agreed and strongly agreed after the two 5E units but two out of three showed a shift from strongly agree to agree. In the final Scientific Literacy Survey, 3% more students agree or strongly agreed that reading current events in science made them more curious about the world around them, 3% more enjoyed hearing other opinions and views, and 14% more liked to hear new ideas and new topics. This final statement also showed 2% more students strongly agreed than agreed after the two 5E units (Figure 11).

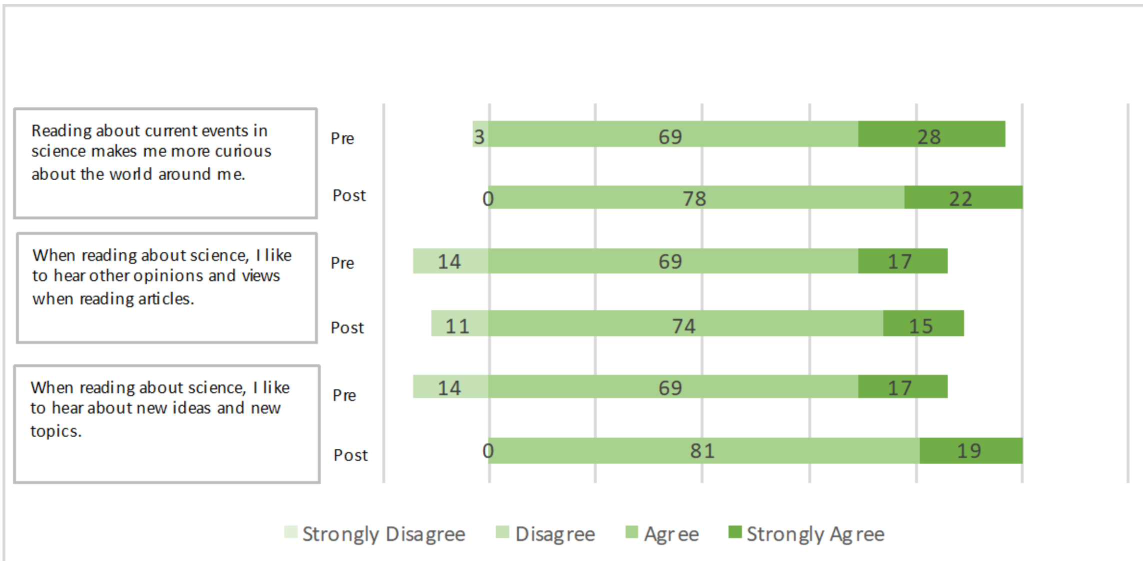


Figure 11. Scientific Literacy Survey – Science Related Attitudes. Initial and Final Survey statements focusing on science related attitudes. The Pre-treatment survey and Post-treatment survey asked students to reflect on how current events make students more curious, how it helped them hear other opinions, and how it helped them hear about new topics, (Pre-, *n*=29), (Post-, *n*=27).

While the Scientific Literacy and TOSRA both showed some growth, the Scientific Literacy Interviews showed a shift in perspectives. When asked why it was important to read about science in the real world, 3.57% more students expressed a desire to learn more and 11.11% more were interested in science. When asked how current events made them more curious, 20.45% more students mentioned making connections. One student explained, "…I wanted to know more about the current world of science and not find it boring."

# CHAPTER FIVE

# CLAIM, EVIDENCE, REASONING

## Claims From the Study

Incorporating current events into the 5E model had a positive impact on students' scientific literacy. Students improved in their ability to assess sources, became more interested in science, and were more comprehensive and detailed in their summaries of scientific sources. As the Scientific Literacy Survey indicated, 70% of students agreed or strongly agreed to more of nine statements on assessing source validity, summarizing sources, and science related attitudes.

Students were more aware of the importance of assessing source validity and more able to assess the sources multiple ways after deliberately including assessing sources as part of the curriculum. Before the two 5E units, 21% of students saying they did not know how or did not assess sources for validity. Meanwhile after the units, 100% could state why they assess the validity of sources. Students also used more qualifications to assess validity after the two 5E units, a mean of 1.00 qualification before and 2.70 qualifications after the units.

Student engagement improved as their desire to learn, interest in science, and ability to make connections improved. The Scientific Literacy Final Interview responses indicated this shift as well as the Scientific Literacy Survey. I also saw this in my classroom and, unexpectedly, during parent teacher conferences. During the spring conferences, one mother told me her son came home and asked about careers in Earth

Science. He has continued this discussion with his mother throughout the year. Another father told me he bonded with his son over the San Andreas fault and his experience during the earthquake in 1989. While students showed more engagement in their survey and interview responses, parents showed me that students were bringing home this eagerness to learn and form connections using what they learned in Earth Science. Students also showed their science enthusiasm in the classroom when we arrived at the Plate Tectonics summative. They were eager to pick a geologic feature and were more able to find valid sources and identify key points in their research.

Reading through the short answers on the final test and the final minute papers, students wrote more detailed and comprehensive summaries of scientific sources after the two units. They were better able to answer questions more clearly, use scientific evidence, and identify the claim. Students formed their own claims, supported these claims with evidence from the reading, and made connections or identified the significance of the topic they were learning. Students improved in their ability to identify the claim, find scientific evidence, and make connections to what they were learning in class.

Reading science in real world situations allowed students to see how science is done, learn about new places, and become more interested in science. One student explained, “I think current events got me into thinking more about our world and how it works, it’s interesting how much there is to learn.”

## Value of the Study and Consideration for Future Research

Overall, this was an unusual year with COVID, hybrid learning, and constant uncertainty for students and teachers. The 5E structure and current events created structure, consistency, and a way to engage students when they were not always in the classroom. I used news stories to engage, simulations and demonstrations to explore, scientific articles to explain, and stories to elaborate. Finding structure this year through the 5E structure allowed students to know what to expect and be able to work at home on their own when they were not in class.

Students were also more engaged in class. They explored current events, real places, and real-world science woven into the lessons. Between quarantines, inconsistent attendance, social distancing, and the structure of hybrid learning, COVID made it difficult to conduct labs in class. Incorporating current events allowed students to explore new places and new situations without using labs. One student explained it as, "They showed that there's a bunch of cool stuff happening out there that I'd love to see up close (like a volcano)." Using current events, links, videos, and real places, created a platform for students to learn and interact with the content wherever they were.

Incorporating current events into the curriculum increased students' scientific literacy skills. Students became more familiar in assessing source validity and understood why they needed to look at sources critically. Initially, it was simply about fake news and misinformation but in the end, they explained that it was about understanding science. Regularly incorporating current events also helped students interact with scientific sources more and better understand how to read and summarize these sources. While the surveys were not always representative of the growth I saw, students were more eager to make connections to the real world. They often told me about a volcanic eruption they read about, a tsunami warning they read about, or asked me how a certain rock formed. There was more curiosity in the classroom, more connections made, and more interest in science.

## Impact of Action Research on the Author

Conducting action research provided me with two major lessons in my teaching career, one future goal, and a question to ponder. This project created a foundation and reason to collaborate more with my peers both within my department and outside of my department. Intentionally incorporating current events into my teaching while following a 5E structure gave me a consistent curriculum to where I could regularly collect and compare data and the data gave me an opportunity to reflect on my own teaching. Throughout my project, I was concerned that the structure I used to incorporate current events increased screen time for my students and decreased hands-on time. In the future, I would focus on finding balance and incorporating more hands-on opportunities into the 5E structure alongside the current events. One question I was left wondering was how students would have responded to this method in a more traditional year.

While deciding on my topic, conducting the action research, and analyzing the data, the project encouraged me to collaborate with my peers. I worked closely with the ninth grade English teacher, who acted as my mentor. We discussed barriers to comprehension and literacy strategies to help me structure the lessons and reflect on my own pedagogy. When created instruments for data collection, she and I discussed how to collect data, how to write and ask effective questions, and tips for writing simpler scoring rubrics to help assess the depth of student thinking. As I worked through the action research, she prompted me with questions so I could reflect on lessons I learned, how I adapted my teaching, and the ways I gathered data. After the data collection, I shared some of my data with the tenth-grade science teacher who was eager to hear about my research. When we started to discuss data, he asked if he could make a copy of my spreadsheets to try to work with the data on his own. He had never graphed Likert data and was interested in using my results to explore how he would present the data. I shared the graphs I was making and he shared tips he learned while researching. Throughout the Analysis section, I found myself asking him for feedback on my graphs and on how I presented my data. He helped me think about which graphs I should use to indicate the data patterns and relationships.

As I completed this action research project, I made plans to share my data, my results, and the lessons I learned with the science department and with the Freshman Academy teachers, the two groups of teachers I work with closely. Within our department, we frequently use the Claim Evidence Reasoning (CER) structure for lab write-ups. Sharing student progress in identifying an author's claim and evidence or finding evidence to support their own claims was beneficial for the entire science department. Since I am the only full time ninth-grade science teacher, sharing student responses, data, and my action research helped the department see students strengths and challenges and their scientific literacy skills as freshmen.

Focusing on a specific action research project allowed me to stay focused and conduct research that intentionally incorporated a specific method into my teaching, while also collecting data. In the past, I have used student responses, normalized gains, and open-ended responses to help understand student progress more than what the grades alone showed. However, this project allowed me to use a variety of methods for data collection. The process of action research gave me time to compare and contrast the quantitative and qualitative data, look for trends, and form conclusions. Having a structure and time to study the data, reflect on my own teaching methods, and analyze student responses allowed me to recognize what worked and what did not. The balance of qualitative and quantitative data also helped me to see how the 5E model was benefiting students in my classroom and how current events were essential in teaching science.

Throughout the units, I noticed that by incorporating current events into my curriculum and only focusing on one structure, sometimes students had too much screen time. I am not sure if this was because of the structure I used or because of COVID. As I move forward and incorporate current events into my curriculum, I would like to focus on finding a balance between screen time and hands-on exploration. Of course, in the end, the big question I am left with is how would this research be different without COVID, seeing students more frequently, and incorporating more hands-on exploration? Would students become more engaged or less engaged seeing current events more regularly?

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# APPENDICES

# APPENDIX A

IRB EXEMPTION

INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

MONTANA STATE UNIVERSITY

2155 Analysis Drive
c/o Microbiology & Immunology
Montana State University
Bozeman, MT 59718
Telephone: 406-994-4706
FAX: 406-994-4303
E-mail: cherylj@montana.edu

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

**MEMORANDUM**

**TO:** Emily Hall and John Graves

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

**DATE:** November 5, 2020

**RE:** *"Incorporating Current Events in a 5E Model to Promote Scientific Literacy in a Secondary Classroom" [EH110520-EX]*

The above research, described in your submission of November 5, 2020, 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

## SOURCE VALIDITY CHECKLIST

| Is the source valid? CHECKLIST |
|---|
| Check the web address. Is it .gov or .edu? |
| Who is the author? |
| Who is the source? |
| Is it published recently? |
| Does the main idea support the title/headline? |
| Does it provide information from reputable sources? |
| Check a quote. Does it match an actual event? |
| Check a fact-checking website. |
| Is it hard to believe or ridiculous sounding? |

(Sherwood and Tucker, 2019)

# APPENDIX C

## JAPANESE TSUNAMI 5E LESSON

## Plate Tectonics
## How are tsunamis formed?

Part 1: Engage - watch this video: https://youtu.be/oWzdgBNfhQU

1. What did they feel? (include magnitude).
2. How far away was the earthquake?
3. What was significant about the earthquake?
4. What happens to the speed and height of the tsunami as it approaches the shoreline?
5. What did you find to be the most interesting or surprising part of the video?

Part 2: Explore these simulations.

6. Watch: https://youtu.be/xyKgamjegtQ
    a. What do you observe in this demonstration?
    b. What happened to the motion of the water?

Part 3: Explain VIDEO

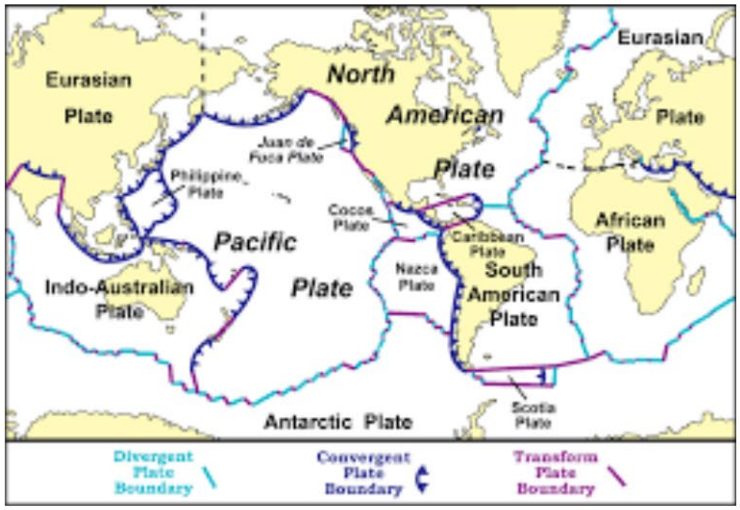
https://drive.google.com/file/d/1EW5Zm70zpbwViFfLjFsAkJ3AQ6FsD8My/view?usp=sharing

7. What plates were involved?
8. Why was there an earthquake?
9. How did the land change? (name at least one way.)
10. Create a model of the plate boundary where the tsunami occurred. Paste the picture below. This can be on paper and simple.

Part 4: Elaborate

Read this article: https://www.nbcnews.com/mach/science/what-tsunami-ncna943571

11. The article gives examples of other tsunamis. List these below.
12. Use the plate boundary map below and the video to identify which plates are interacting and how near where the tsunami formed.




Part 5: Evaluate

3 minute paper: What did you learn about how the tsunami in Japan formed? Be specific and include plate boundaries, plate names, initial cause, etc.

# APPENDIX D

# MARITIME AND CONTINENTAL CLIMATES

# How does the geosphere impact climate?

Maritime/Oceanic and Continental Climates

*Performance Expectation: Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. (HS-ESS2-4)*

Part 1: Engage - Look at local climates.
Climate Data for Augusta and Port Clyde.

- Augusta:
https://www.usclimatedata.com/climate/augusta/maine/united-states/usme0013
- Port Clyde:
https://www.usclimatedata.com/climate/port-clyde/maine/united-states/usme0325

1. Using the data in the link, compare the two places month to month. Is one hotter, colder, more extreme, or have more precipitation?

2. Fill out the table below using the two links.

| Town | Average High Temperature | Average Low Temperature | Difference between High and Low (High-Low = This number) |
|---|---|---|---|
| Augusta | | | |
| Port Clyde | | | |

3. Using the data table above, make a claim about the climate of Augusta compared to Port Cycle.

Part 2: Explore

4. The figure below shows the temperatures of an inland location and a coastal location. Pick two of the cities near the same latitude and fill out the table below. (You may need to look up where they are on a map to figure out which one is inland and which one is coastal.)

**Highs and lows, coastal vs. inland §**

| City | (low) Jan | (high) July | (*N) latitude |
|---|---|---|---|
| 1) Los Angeles | 64*F<br>18*C | 81*F<br>27*C | 34.0 |
| 2) Little Rock | 50*F<br>10*C | 90*F<br>32*C | 34.5 |
| 3) Seattle | 4*F<br>7*C | 72*F<br>22*C | 47.5 |
| 4) Bismarck | 18*F<br>-8*C | 82*F<br>28*C | 47.0 |
| 5) London | 45*F<br>7*C | 73*F<br>23*C | 51.5 |
| 6) Warsaw | 32*F<br>7*C | 75*F<br>24*F | 52.5 |
| 7) Belfast | 43*F<br>6*C | 64*F<br>18*C | 54.0 |
| 8) Moscow | 16*F<br>-9*C | 73*F<br>23*C | 56.0 |
| 9) Tokyo | 46*F<br>8*C | 82*F<br>28*C | 35.0 |
| 10) Kabul | 36*F<br>2*C | 88*F<br>31*C | 35.0 |
| 11) Beirut | 63*F<br>17*C | 90*F<br>32*C | 34.0 |

(https://seawifs.gsfc.nasa.gov/OCEAN_PLANET/HTML/oceanography_currents_4.html)

5. Fill out the table below with data from the cities you chose.

| Town | Average High Temperature | Average Low Temperature | Difference between High and Low (High-Low = This number) |
|---|---|---|---|
| City 1 - Inland | | | |
| City 2 - Coastal | | | |

6. Compare your findings in this table to the one above. Did you notice similar patterns in your data for the cities you chose compared to Port Clyde and Augusta?

Part 3 Explain

7. Read the following: (It's a really short reading.) https://seawifs.gsfc.nasa.gov/OCEAN_PLANET/HTML/oceanography_currents_4.html

8. Using the terms from the reading, state why you saw one pattern along the coast and one pattern inland? Be specific.

Part 4: Elaborate

9. Watch: https://www.cbsnews.com/news/climate-change-atlantic-ocean-gulf-stream-system-amoc-weakest-1600-years/

10. What does the video explain about the currents in the Atlantic?

11. What observations have scientists made about the Gulf Stream?

12. How has the current changed over time?

13. What is one way a changing Gulf Stream could impact life in Maine.

Part 5: Evaluate

Next class, you will be asked to write a 3 minute paper about how oceans impact climate. Remember to use evidence, specific examples, and patterns observed in the data.

# APPENDIX E

## TEST OF SCIENCE RELATED ATTITUDES

# Test of Science Related Attitudes

Using the survey, identify whether you strongly agree, agree, feel neutral, disagree, or strongly disagree with the 10 statements below.

Your participation does not hurt your grade or impact it at all. Participation in this research is voluntary and participation or non-participation will not affect class standing in any way.

Statements and the survey taken from the following source:
Fraser, B.J. (1981). Test of science-related attitudes (TOSRA). Retrieved from https://t7-livecyfar.nyc3.cdn.digitaloceanspaces.com/cyfar.org/files/Attitude%20Towards%20Science%20(middle%20school%20and%20high%20school).pdf
* Required

1. Name *

2. I enjoy reading about things that disagree with my previous ideas *

*Mark only one oval.*

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

3. I dislike repeating experiments to check that I get the same results. *

*Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

4. I am curious about the world in which we live. *

*Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

5. Finding out about new things is unimportant. *

*Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

6. I like to listen to people whose opinions are different from mine. *

*Mark only one oval.*

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

7. I find it boring to hear about new ideas. *

*Mark only one oval.*

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

8. In science experiments, I like to use new methods which I have not used before. *

*Mark only one oval.*

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

9. I am unwilling to change my ideas when evidence shows that the ideas are poor. *

*Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

10. In science experiments, I report unexpected results as well as expected ones. *

*Mark only one oval.*

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

11. I dislike other peoples' opinions. *

*Mark only one oval.*

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

# APPENDIX F

## SCIENTIFIC SOURCE VALIDITY PRE-ASSESSMENTS

# Scientific Source Validity Pre-Assessment #1

I am going to provide 5 minutes for you to look at the following article. I have posted it on Google Classroom as well. Spend some time, read the article, and then for the last 5-10 minutes shift to answering the questions below,

https://zapatopi.net/treeoctopus/

1. What claim is the author making?

2. List at least three pieces of evidence that support the claim.

3. Does the author's claim seem valid?

   *Mark only one oval.*

   - Yes
   - No
   - Maybe

4. 4. List how you assessed the validity of the source. Be specific.

# Scientific Source Validity Pre-Assessment #2

I am going to provide 5 minutes for you to look at the following article. I have posted it on Google Classroom as well. Spend some time, read the article, and then for the last 5-10 minutes shift to answering the questions below,

https://www.sciencenewsforstudents.org/article/what-you-need-to-know-about-murder-hornets

1. What claim is the author making?

2. List at least three pieces of evidence that support the claim.

3. Does the author's claim seem valid?

   *Mark only one oval.*

   - Yes
   - No
   - Maybe

4. 4. List how you assessed the validity of the source. Be specific.

# APPENDIX G

## SCIENTIFIC SOURCE VALIDITY POST-ASSESSMENTS

# Scientific Source Validity Post-Assessment #1

I am going to provide 5 minutes for you to look at the following article. I have posted it on Google Classroom as well. Spend some time, read the article, and then for the last 5-10 minutes shift to answering the questions below,

https://youtu.be/tVo_wkxH9dU

1. What claim is the author making?

2. List at least three pieces of evidence that support the claim.

3. Does the author's claim seem valid?

   *Mark only one oval.*

   ◯ Yes
   ◯ No
   ◯ Maybe

4. 4. List how you assessed the validity of the source. Be specific.

# Scientific Source Validity Post-Assessment #2

I am going to provide 5 minutes for you to look at the following article. I have posted it on Google Classroom as well. Spend some time, read the article, and then for the last 5-10 minutes shift to answering the questions below,

https://www.nytimes.com/video/science/100000004177295/sciencetake-plants-can-count.html/

1. What claim is the author making?

2. List at least three pieces of evidence that support the claim.

3. Does the author's claim seem valid?

   *Mark only one oval.*

   - Yes
   - No
   - Maybe

4. 4. List how you assessed the validity of the source. Be specific.

# APPENDIX H

SCIENTIFIC LITERACY INITIAL INTERVIEW

# Scientific Literacy Initial Interview

Answer the questions below as honestly as you can.

Your participation does not hurt your grade or impact it at all. Participation in this research is voluntary and participation or non-participation will not affect class standing in any way.

1. How do you evaluate whether an article or new story is valid or not?

2. Why should we evaluate if an article or story in the news is valid?

3. What ways helps you better understand science content in class?

4. Why is it important to read about science in the real world?

5. How do you think the current events can help make you more curious about science in the real world?

6. Is there anything else you would like to share with me?

# APPENDIX I

## SCIENTIFIC LITERACY FINAL INTERVIEW

# Scientific Literacy Final Interview

Answer the questions below as honestly as you can.

Your participation does not hurt your grade or impact it at all. Participation in this research is voluntary and participation or non-participation will not affect class standing in any way.

1. How do you evaluate whether an article or news story is valid or not?

2. Why is it important to evaluate whether an article uses scientific evidence or not?

3. How do you think bringing current events into the classroom helped you better understand the subject matter?

4. Why is it important to read about science in the real world?

5. How do you think the current events helped you become more curious about science in the real world?

6. Is there anything else you would like to share with me?

# APPENDIX J

## SCIENTIFIC LITERACY SURVEY

# Scientific Literacy Survey

Using the survey, identify whether you strongly agree, agree, disagree, or strongly disagree with the 9 statements below.

Your participation does not hurt your grade or impact it at all. Participation in this research is voluntary and participation or non-participation will not affect class standing in any way.

1. Name

________________________________________

2. When reading about current events in science, I am able to list ways to determine if an article is supported by science.

   *Mark only one oval.*

   - Strongly Agree
   - Agree
   - Disagree
   - Strongly Disagree

---

3. When reading about current events in science, I am able to evaluate whether an article or story uses scientific evidence.

   *Mark only one oval.*

   - Strongly agree
   - Agree
   - Disagree
   - Strongly Disagree

4. When reading about current events in science, I am able to assess the validity of an article or news story.

   *Mark only one oval.*

   - Strongly Agree
   - Agree
   - Disagree
   - Strongly Disagree

5. When reading about current events in science, I can outline the main points in a scientific article.

*Mark only one oval.*

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

6. When reading about current events in science, I can summarize a scientific article.

*Mark only one oval.*

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

7. When reading about current events in science, I can make connections between the current event and what we learn in class.

*Mark only one oval.*

- Strongly Agree
- Option 2
- Disagree
- Strongly disagree

8. Reading about current events in science makes me more curious about the world around me.

*Mark only one oval.*

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

9. When reading about science, I like to hear other opinions and views when reading articles.

*Mark only one oval.*

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

10. When reading about science, I like to hear about new topics and hear new ideas.

*Mark only one oval.*

- Strongly Agree
- Agree
- Disagree
- Strongly Disagree

# APPENDIX K

MINUTE PAPER RUBRIC

| **Level of Understanding** | What does this mean? | **Yes. (1)** | **No. (0)** |
|---|---|---|---|
| **Knowledge/Remembering** | Does the student restate the main points or ask questions about the main points? | | |
| **Comprehension/Understanding** | Does the student summarize the main points or ask the question that brings in more than one main point? | | |
| **Application** | Does the student apply the topics they are learning to what they have learned before? | | |
| **Analysis** | Does the student compare, contrast, or question the topics they are learning? | | |
| **Evaluation** | Does the student assess the validity and importance of what they learn? | | |
| Notes | | | |