

THE EFFECTS OF USING A CURRICULUM PROGRAM WITH EMBEDDED
LITERACY ON MIDDLE SCHOOL STUDENTS' SCIENCE
PERFORMANCE AND CONFIDENCE

by

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ABSTRACT

Incorporating disciplinary literacy into content area instruction has been a focus of the district for several years. General strategies such as annotating text and note-taking were implemented with little success. The purchase of a new science curriculum program, Amplify Science, with embedded literacy strategies gave teachers the opportunity to teach students science content through embedded literacy strategies that utilize reading, writing, and communicating in science. The effectiveness of this program was measured by comparing students' pre- and post-unit assessment scores, ability to write science arguments using Amplify and non-Amplify prompts, reading comprehension, ability to annotate text, self-assessment of their reading abilities, and a survey of students' confidence in science. Students and the collaborating teacher were also interviewed to discuss specific areas of growth. Results indicate that Amplify Science has made a very significant, positive impact on this group of 6th grade students' performance and confidence in science, as well as their ability to read and write in science.

INTRODUCTION AND BACKGROUND

This Capstone Project was completed at C.R. Anderson Middle School in Helena, Montana. Helena is the state capital of Montana with a population of a little over 30,000. Most of the population, 93%, is Caucasian, with small percentages, close to 3%, of Hispanic and Native American populations. The median household income in Helena is \$56,221, which is almost \$4,000 more than the state median household income. The education level of the population (ages 25+) in Helena is that 95.1% have a high school diploma and 45.0% have a bachelor's degree or higher per (U.S. Census Bureau, 2018). Helena is unique in that while it is like many parts of Montana, where agriculture is a large part of the economy, it also has many state and federal employees. The Helena School District includes two high schools, two middle schools, and 11 elementary schools.

C.R. Anderson Middle School (CRA) is the largest middle school in the state of Montana, with 1,070 students, grades 6th-8th as of October 1, 2019. According to parent/guardian identification of the federal ethnicity status, 926 students are white, 20 students are American Indian/Alaska Native, 12 students are Asian, 5 students are African American, 37 students are Hispanic/Latino, 59 students are two or more races, and 11 are unspecified. Twenty-nine percent of students receive free reduced lunch. There are 161 students with active Individualized Education Plans (IEP's) and/or 504 Plans. There are six feeder elementary schools for C.R. Anderson, whose free reduced student lunch percentages range from 16% to 43% (PowerSchool, 2019).

CRA utilizes a schedule where students are randomly assigned to specific teams of teachers. Most of the students within these teams have the same science, English, and

social studies teachers. There are several different levels of math for each grade, so students from different advisor groups can be in the same math. The math classes are considered “off team.” The teachers on each team have an advisor section of students, whom they meet with for one shorter (30 minute) advisor period daily. The purpose of this advisor class is to provide students an opportunity to catch up on missing assignments, get extra help, receive services, such as speech, and various other things. There are 57 teachers, one principal, two assistant principals, and various other support staff at C.R. Anderson.

Various standardized assessments show that students in the district continually struggle with reading and science. Between 2015-2019, the percentage of students who score at or above the reading benchmark on the American College Testing (ACT) exam, ranges between 45.5%-49.7%, and the percentage of students who score at or above the science benchmark on the ACT ranges between 40.4%-45.6%. On the 2019 Smarter Balanced Assessment (SBA), 58% of 6th graders, 67% of 7th graders, and 59% of 8th graders scored proficient in English/Language Arts (ELA). The district also uses the ACT Aspire assessment for 7th-11th grades to monitor student progress. In the fall of 2019, 66% of 8th graders were on track for reading, 66% of 8th graders were on track for science, 56% of 7th graders were on track for reading, and 54% of 7th graders were on track for science (J. Chandler, personal communication, March 20, 2019).

Due to the ACT benchmark percentages, the district has been working on integrating content literacy strategies into all K-12 classrooms. According to Shanahan & Shanahan (2012), “Content area literacy focuses on study skills that can be used to help students learn from subject matter specific texts” (p. 8). The idea is that students will

learn a set of literacy strategies that they will then be able to apply across the disciplines as they move up through the grade levels. Shanahan & Shanahan explain this process as, “...the purpose of content area reading approaches is to provide students with a collection of generic reading strategies and study skills that will boost learning in all disciplines” (p. 12). In the district, success with implementing content area literacy strategies in all K-12 classrooms has been limited for various reasons, such as teacher resistance to the integration of the strategies and inconsistent teacher training due to teacher turnover.

Secondary, grades 6th-12th, content area teachers tend to be the most resistant to the integration of these content area literacy strategies. Potential reasons for content area teachers’ resistance are poor textbook quality and lack of quality reading materials, lack of educational background and training on literacy, and teachers feeling that teaching students to read isn’t their job. From my personal experience, as a previous high school science teacher in the district, I found that the content area literacy strategies felt like another “thing” that I needed to teach in conjunction with all the science content. Fang & Wei (2010) describe this exactly as, “The idea of allocating time for reading instruction may not sit well with some science teachers, who sometimes fail to see the usefulness of reading instruction for meeting their instructional goals...(p. 265)”.

At CRA, I am a second-year instructional coach, with the primary focus of helping teachers incorporate more literacy into their teaching. Prior to this position, I taught chemistry and physics at Helena High School, one of the high schools in the Helena Public Schools. Before teaching at Helena High School, I taught several different high school science classes in central Washington state. After spending nine years in the classroom, I felt the need for a change, so I applied for my current position within the

school district. This position, as an instructional coach, has reinvigorated me and renewed my love of education. It has allowed me to explore how students read, why they struggle, and disciplinary literacy. Before this job as an instructional coach, I was a content teacher who felt that teaching students to read wasn't within the purview of my job. I've had a complete pedagogical shift; in that I now believe that teaching skills, especially those related to disciplinary literacy, is critical in helping students access content in their lives beyond high school. In today's world, for students to be college and/or career-ready, they must have strong literacy skills.

Throughout my experience teaching high school science, I was consistently frustrated with students' inabilities and struggles with reading science texts, whether it was an article or a textbook. My teaching routine was to read through articles and textbooks to pull the information for students, and I then would deliver this information to students in lecture format, usually via PowerPoint. At the time, I felt that covering large amounts of science content was most important and this was the quickest way to do that.

My new position as an instructional coach led me to becoming fascinated with all aspects of reading, especially reading in content areas. I came to the realization that while as a science teacher, I was not specifically a reading teacher, but I was responsible for teaching students to read, write, and communicate like scientists. Upon a lot of reflection, I realized that I spent nine years teaching students a lot of science content, but not how to independently read the content, or engage in argument with the content through discussion and writing. In hindsight, I was teaching my students facts about science, not how to be actual scientists. My next thought was how do I help other teachers have this

same epiphany? And not only have this epiphany, but be willing to begin weaving literacy strategies into their own teaching?

Initially, I planned to find literacy strategies more specific to science, teach them to teachers, and that would be all that was necessary. After researching, I concluded that it's not that simple. It is very difficult to weave literacy strategies throughout science content, along with the three dimensions of the Next Generation Science Standards (NGSS). I realized that I had neither the time, nor the expertise. Lawrence Hall of Science (2019) at the University of California (UC), Berkeley, the country's only science center that is part of a top-tier, public research university, describes the importance of science literacy using a metaphor:

Professional musicians are not asked to demonstrate their expertise by designing and fabricating their instruments...Just like other professionals, teachers can and should be expert users of the highest quality instructional materials available. Better, more experienced teachers can use the materials they have at a higher, more sophisticated level, but do not need to build their materials from scratch any more than concert pianists need to build their pianos. (p. 1)

In other words, science teachers need excellent curricular resources to teach science in a way that teaches students how to be scientists, instead of teaching students science content facts.

My conundrum solved itself in March 2019, when the district chose to adopt a curriculum that not only is completely three dimensional in terms of the (NGSS), but also has embedded disciplinary literacy strategies tied to inquiry. The program, Amplify Science, is a three-dimensional NGSS aligned program authored by UC Berkeley's Lawrence Hall of Science. Inquiry, through the exploration of scientific phenomena and/or questions, drives each unit of the Amplify Science program. Each unit has a real-

world phenomenon and unit question, and each chapter within the units have a unit question. Students then “act like scientists” as they work toward answering the unit and chapter questions through disciplinary literacy strategies, experimentation, simulations, and modeling.

After exploring this new curriculum, I decided to investigate its impact on students’ ability to learn science concepts and develop disciplinary literacy skills specific to science, or in less formal terms, how to read and write like scientists. I also wondered if the program would make students more confident in their science skills and knowledge. This led to the development of the focus question for my project: To what extent does Amplify Science, which teaches science concepts through inquiry, with an emphasis on disciplinary literacy strategies, affect student performance and confidence in science? I am also interested in these related questions:

- (1) To what degree will the embedded disciplinary literacy strategies impact students’ abilities to actively read and comprehend science texts?
- (2) To what degree will the embedded disciplinary literacy strategies impact students’ ability to write scientific arguments?
- (3) To what extent does the use of disciplinary literacy strategies affect students’ confidence in reading and writing in science?

CONCEPTUAL FRAMEWORK

While learning oral language is a natural, developmental process for human brains, learning to read and write is not. Evolutionarily speaking, our brains are wired for oral communication, not necessarily for written communication. Therefore, specific literacy skills need to continue to be intentionally taught well past elementary school. For

students to develop strong literacy skills they must practice them at all grade levels and across all content areas. Learning to read and write begins with developing strong skills in phonics and phonemic awareness, transitions to comprehension development, and then reading and writing become methods students use to learn content. Once students are using reading and writing to learn, they need to learn how to increase the specificity of these skills for content areas, like science or social studies for example. This transition to specific literacy skills within content areas begins to occur around 6th grade when most students transition to an elementary model of instruction with one teacher per day, to a middle school or junior high model where students have multiple teachers per day that teach specific content areas.

Development of Literacy Skills

Development of literacy skills is a complex process and occurs in multiple phases. Shanahan & Shanahan (2008) describe the development of literacy as a three-step process that includes basic literacy, intermediate literacy, and disciplinary literacy. Basic literacy includes literacy skills like decoding and developing the knowledge of high frequency words. Intermediate literacy includes generic comprehension strategies, common word meanings, and fluency. Disciplinary literacy includes skills that are specific to a subject matter, like science (Shanahan & Shanahan, 2008, pp. 43-44). According to Shanahan & Shanahan (2008), “The majority of American students gain control of these intermediate reading tools by the end of middle school...” (p. 45). Meaning that as students begin transitioning to middle school, we need to begin teaching them literacy strategies that are specific to content areas, such as history/social studies, science and mathematics.

In a study conducted by Shanahan, Shanahan, & Misischia (2011), it was found that people who work within specific disciplines read text with different considerations in mind. In the study they observed and interviewed expert historians, chemists, and mathematicians to determine if they read text differently due to their differences in the tasks of their profession. Specifically they noted that scientists said: (1) that close reading was important and that the rereading of important information was critical, (2) they use text structure to support their understanding and to locate particular information, and (3) the graphic elements of text are critically important because they are alternative forms of overlapping information that has to be translated and compared (Shanahan, Shanahan, & Misischia, 2011, pp. 406-407). It is critically important that along with science content, we teach students how to specifically and intentionally read science texts, and not just science textbooks.

Disciplinary Literacy

To be scientifically literate citizens, students need to be able to comprehend and evaluate written scientific information that is not in textbook form. Since technology allows students an overabundance of information at their fingertips, one could argue that teaching students to critically read, write, and communicate in content areas is more essential now than ever. It is imperative for all students to be able to read articles critically to discern fact from fiction. Moje (2011) perfectly expresses the need for teaching disciplinary literacy:

...if society hopes to continue to populate disciplines and the professions that are framed by the disciplines (e.g., journalism, accounting, laboratory science, teaching), then students need the opportunity to apprentice into the ways of producing and communicating knowledge valued in the disciplines. In addition, if society hopes to generate thinking, productive citizens, then learners need the opportunity to participate in even

rudimentary forms of knowledge production, to ask questions of assumptions held by and in the disciplines, to understand how disciplines work, and to push back on the knowledge that is produced (p. 259).

A functional shift from focusing on teaching content in science to teaching science through inquiry, with an emphasis on disciplinary literacy skills, could yield more academic success for all students in science. According to Shanahan & Shanahan (2012), disciplinary literacy, "...is an emphasis on the knowledge and abilities possessed by those who create, communicate, and use knowledge within the disciplines" (p. 8). Specifically pertaining to science, for students to be successful in any science related field they must have more than just content knowledge, they must have the specific literacy skills that scientists use daily. Greenleaf, Pearson, and Moje (2010) iterate this importance as, "No scientist simply walks into a lab and starts manipulating materials, tools, and phenomena...Science literacy instruction should engage children and youth in making sense of scientific texts as one form of scientific literacy" (p. 460). If we want a more scientific literate world, we must begin teaching our students the necessary skills to read, write, and communicate scientifically.

Framing Disciplinary Literacy as Inquiry

Teaching students to read, write, and communicate scientifically is much easier said than done. Teachers want students to experience science with inquiry, so it does not feel natural to use limited classroom time to read and write when students could be investigating phenomena. Many science teachers constantly consider how to incorporate inquiry into the classroom. If students are working toward answering a question or discovering the reason for an action, they tend to be more engaged in the learning and therefore experience higher achievement. Moje (2015) suggests that we need to make

inquiry within a community of practice and discourse central to the learning of the literacy practices of a discipline. This approach to disciplinary literacy teaching includes four Es: engage, elicit/engineer, examine, and evaluate (Figure 1).

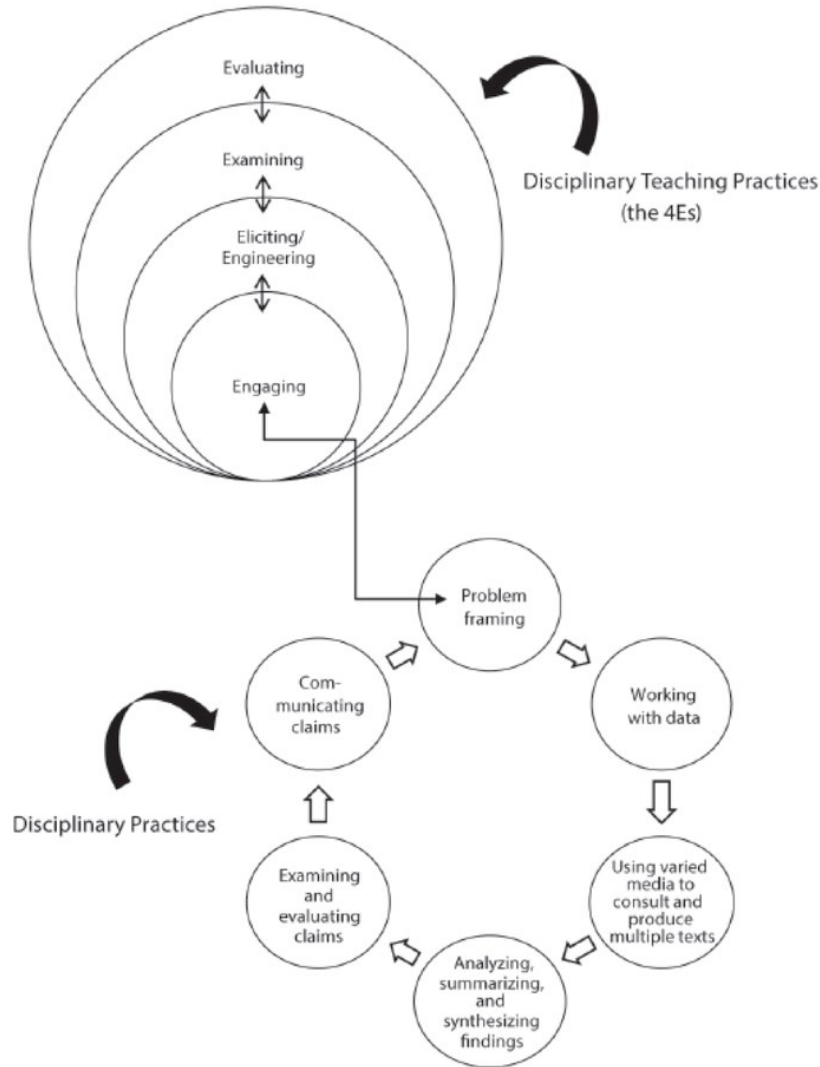


Figure 1: 4Es Heuristic Framework with Disciplinary Practices (Moje, 2015).

The first “E” (engage) is meant to remind teachers to engage in the practices of the discipline under study, or to ensure that they are using practices like those in the disciplines daily in the classroom. The second “E” (elicit/engineer) focuses on eliciting the knowledge and skills youth bring to the disciplinary inquiry and then engineering the necessary knowledge for engaging the students in the inquiry. The third “E” (examining)

serves as a prompt for getting students to closely examine words and ways with words. The fourth “E” (evaluating) asks students to evaluate the disciplinary language itself (Moje, 2015, p. 260).

Using Moje’s 4E framework seamlessly fits within the teaching of science. Moje gives more emphasis to the first “E” (engage) because it is the launch point and centerpiece of disciplinary literacy learning (Moje, 2015, p. 261). Inquiry methodologies, that are best practice in science instruction, very similar to the disciplinary practices embedded in the first “E” (engage). The disciplinary practices referred to in the first “E” are problem framing, working with data, using varied media to consult and produce multiple texts, analyzing summarizing, and synthesizing findings, examining and evaluating claims, and communicating these claims. These skills are akin to the Science & Engineering Practices from the Next Generation Science Standards (NGSS) and (NGSS Lead States, 2013; Appendix E).

The second “E” (elicit/engineer) includes the strategies that elicit and engineer adolescent students’ skills for engaging in disciplinary reading and writing (Moje, 2015, p. 267). An example would be teaching students text annotation strategies that would enable students to glean appropriate information from science texts. The third “E” (examine), would include helping students understand the technical language and discourse practices used in science. By examining language use closely within a discipline, students have an opportunity to learn about and question why members of a disciplinary discourse community read, write, and talk in particular ways (Moje, 2015, p. 268). For example, it is common for nominalization, the conversion of a verb to a noun, to be seen in science texts (Fang & Schleppegrell, 2010). The fourth “E” (evaluate)

requires students to consider how, when, and why to use particular words within science. For example, writing an article for the school newspaper on the importance of handwashing would include writing that is significantly different compared to writing a formal lab report on the findings of a hand washing experiment. Shifting from inquiry learning in science as being mostly hands-on investigations with limited reading and writing, to using reading and writing throughout as tools to help students improve their investigations and learning, could not only improve students' knowledge in science, but also their disciplinary literacy skills.

Disciplinary Literacy in Science

If we combine this idea that disciplines are cultures with specific ways of reading, writing, and communicating with an inquiry approach, then literacy can be used to help students effectively navigate and learn science. Moje (2015) argues that:

Disciplines are cultures in which certain kinds of texts are read and written for certain purposes and with or to certain audiences. As a result, the texts read or written in each disciplinary culture demand particular kinds of literacy practice relevant to the needs, goals, and conventions of those purposes and audiences (pp. 257-258).

In addition, Appendix M of the NGSS concisely summarizes the connections between the Science and Engineering Practices and the Standards for Literacy in Science and Technical Subjects from the Common Core State Standards (CCSS). For example, in connection to Reading Anchor Standard #1 from the CCSS it makes the connection to the use of asking and refining questions in order to answer them with evidence that is either explicitly stated or implied (NGSS Lead States, 2013; Appendix M). If, as teachers, we begin to conceptualize science literacy as a form of inquiry, then we can use reading and writing tasks as ways to improve upon that inquiry (Greenleaf, Pearson, & Moje, 2010).

Supporting Inquiry with Literacy Using Amplify Science

No longer can we continue to teach science as a series of discrete facts and investigative experiments, we must begin to use reading and writing in science as vehicles for inquiry and learning. Grant, Fisher, and Lapp (2015) say that

The science teacher has to provide students with opportunities to use language to learn science. Doing so supports students in becoming better readers and writers who have a much deeper understanding of science from being actively immersed in using the language of science so they can begin to think, read, and write like scientists (p. 18).

The Amplify Science program is designed to do just this, to use the language of science to support scientific inquiry. Amplify uses literacy to support the inquiry process that students take part in with each unit. The following are the guiding principles for disciplinary literacy in the Amplify Science program: (1) Students can acquire literacy expertise through the pursuit of science knowledge and by engaging in scientific and engineering practices. (2) Attention to disciplinary literacy instruction should begin as soon as students enter school and should continue throughout the grades. (3) Participation in a community is key to acquiring disciplinary expertise and literacy. (4) Argumentation and explanation are the central enterprises of science and, thus, these practices are the focus of reading, writing, and speaking in science (<https://my.amplify.com/programguide/content/national/an-integrated-science-and-literacy-program/integrated-model/>).

The inquiry process that students participate in with Amplify, incorporates the disciplinary practices emphasized in the first E (engage) of Moje's 4E Heuristic model (Figure 1). The first disciplinary practice is "problem framing" (Moje, 2015, p. 261). All Amplify units use "problem framing" as they have an overarching anchor phenomenon

and each chapter within the unit is focused on an investigative question. According to the NGSS Lead States (2016) science learning needs to be structured around phenomena that students must first investigate and then explain, shifting the focus from topics to how and why things occur. When students discover how a phenomenon occurs, they develop understanding of science concepts in a real-world context, leading to deeper, transferable knowledge and they begin to understand the social relevance of science (NGSS Lead States, 2016).

The second disciplinary practice in Moje's (2015) 4E model is "working with data," students work with data on multiple levels within the program (p. 263). Students work with prepared data, data they collect through their own experiments, and data they collect through online simulations. This constant interaction with data helps students understand that scientists use data, not just text, to communicate.

The third disciplinary practice, "using varied media to consult and produce multiple texts," is also incorporated in Amplify (Moje, 2015, p. 264). It contains a paper notebook and online resources that include simulations, videos, and other tools. This varied media allows students to interact with more realistic ways that scientists communicate, rather than textbooks.

The fourth disciplinary practice, "analyzing, summarizing, and synthesizing findings," also exists within the program (Moje, 2015, p. 264). Students use these skills to read the included articles, interact with the data, and develop scientific arguments. Analysis, summary writing, and synthesis are key skills that scientists use to communicate, and students will be able to transfer to other content areas as well.

The fifth disciplinary practice, “examining and evaluating claims,” occurs throughout the Amplify program (Moje, 2015, p. 265). Students deeply investigate a minimum of two claims in each unit that could be potential reasons as to why the unit’s phenomenon occurs. The curriculum also includes the last disciplinary practice from Moje’s (2015) 4E framework, “communicating claims,” as students frequently engage in discussing claims and writing scientific arguments that include a claim, evidence, and reasoning (p. 265). At the end of each unit students apply what they have learned to a new phenomenon by participating in a science seminar or other project where they must engage in argument with their peers. In these seminars or projects students must communicate their claim, evidence, and reasoning either orally or written. In summary, Amplify Science has the correct components necessary to meld inquiry and literacy when teaching science.

Disciplinary Literacy Components of Amplify Curriculum

There are five distinct disciplinary literacy components embedded within the Amplify Science program: reading, academic language and vocabulary, writing, listening and speaking, and visual representations. All the reading within the Amplify Science Program is approached from an inquiry perspective. Students use the program’s Active Reading Guidelines each time they read within the program. These guidelines include strategies like highlighting key concepts and vocabulary and recording questions as you read a piece of text. These guidelines force students to ask questions, make connections, evaluate information, search for evidence, and clarify difficult concepts as they read (<https://my.amplify.com/programguide/content/national/an-integrated-science-and-literacy-program/reading-in-amplify-science/integrated-model/>). In Active Reading, the

text is read twice. The first time, students annotate the text, take notes, and record questions as they read. The second time, students are given a particular purpose as they read, like finding evidence to support a specific claim (<https://my.amplify.com/programguide/content/national/an-integrated-science-and-literacy-program/reading-in-amplify-science/integrated-model/>). The program also encourages teachers to model the Active Reading Guidelines by thinking out loud as they read the text aloud. Amplify Science calls this metacognitive modeling.

The program divides the vocabulary words into two different groups: science content (i.e., mitochondria, atmosphere, proton) and science practice (i.e., evidence, constraint, solution). Students experience vocabulary words in the Amplify Science program through immersion, explicit instruction, and repeated practice (<https://my.amplify.com/programguide/content/national/an-integrated-science-and-literacy-program/academic-language-and-vocabulary/integrated-model/>). Within each unit students have multiple opportunities to interact with the vocabulary words. A few ways that students experience the vocabulary words within Amplify are as they read and annotate articles, write responses to questions, and in-class discussions.

The Amplify Science program utilizes writing as a critical component of students' learning. According to Robert Marzano (2012), "Writing to learn focuses on deepening understanding and improving retention of content" (pp. 82-83). Students write through warm-ups, annotation of text, answering short answer questions, explaining/creating diagrams and models, and the writing of scientific arguments and explanations (<https://my.amplify.com/programguide/content/national/an-integrated-science-and-literacy-program/writing/integrated-model/>.) The program also provides several

scaffolding tools to support students in their writing, such as the Reasoning Tool, which is a graphic organizer to help students organize the evidence and reasoning that support a claim, and sentence starters for discussion and argument writing. One example of a sentence starter is, “I think this evidence supports the claim because...”

Students engage in listening and speaking within the Amplify Science program daily. The program provides authentic opportunities for talking and listening as students, such as using discussion to construct explanations and join in oral argumentation (<https://my.amplify.com/programguide/content/national/an-integrated-science-and-literacy-program/listening-and-speaking/integrated-model/>). There are several types of discourse within the program that support students’ development of oral language and discussion skills, such as Write and Share, Think-Pair-Share, Word Relationships, and Evidence Circles (<https://my.amplify.com/programguide/content/national/an-integrated-science-and-literacy-program/listening-and-speaking/integrated-model/>). At the end of some units, students participate in whole class discussions through Science Seminars, where students collaboratively evaluate evidence and form strong oral arguments.

The Amplify Science program also explicitly teaches students how to read visual representations, such as charts, diagrams or pictures within text and the text features themselves (<https://my.amplify.com/programguide/content/national/an-integrated-science-and-literacy-program/visual-representations/integrated-model/>). Students also practice creating their own visual representations through drawing models and diagrams to explain science concepts and processes (<https://my.amplify.com/programguide/content/national/an-integrated-science-and-literacy-program/visual-representations/integrated-model/>).

As students begin middle school, we must be consciously incorporating disciplinary literacy into all content areas to ensure that students develop strong reading, writing, speaking, and listening skills. In science, this is critically important to help students become scientifically literate citizens who can weigh the impact of their actions and decisions. If we make learning disciplinary literacy skills part of the inquiry process, we can successfully help students develop the skills necessary to be scientifically literate citizens. Amplify Science provides teachers all the necessary tools to help students develop strong science literacy skills. After deeply exploring the program and its components, it appeared to me this curriculum included the components of Moje's 4E heuristic method of teaching literacy within a discipline. The next step was to determine how to measure how this program could impact students' performance and confidence in science, and their ability to read and write scientifically.

METHODOLOGY

This Capstone Project developed from my newfound interest of disciplinary literacy and what this looks like in science teaching. How does a teacher successfully teach students to read and write like scientists? This overarching question led to deep exploration and research into disciplinary literacy in a science classroom. This exploration and research, along with the district adoption of a new science curriculum program, led to this Capstone Project. My project involved measuring the impact of the new science curriculum program, Amplify Science, on students' performance and confidence in science and their abilities related to reading complex text and writing scientific arguments. This Capstone Project received exemption by the Montana State University Institutional Review Board in the Fall of 2019.

Participants

This project was completed collaboratively with one 6th grade science teacher at C.R. Anderson Middle School. In the Helena School District, 6th grade science is Earth and space science. The collaborating teacher is an enthusiastic, second-year teacher with very strong classroom management and instructional skills. I selected this teacher because he planned to use Amplify Science with fidelity for the entire school year and was also very interested in measuring the impact of Amplify Science on student learning in science.

The teacher had five sections of science, with class sizes that ranged from 20-28 students. There were 124 students who participated in the study, 22 of whom had an IEP and/or 504 Plan. Class periods were 51 minutes long and occur daily. Students sat at hexagon-shaped tables, with four to six students at each and the class has a cart of Chromebooks to access the program online. The collaborating teacher opted to have students keep their own paper science notebook as well to reduce the amount of screen time for students. In spring of 2018, the collaborating teacher and I created a concept map that students completed during each unit to help them organize the unit question, chapter questions, evidence, and key ideas (Appendix A). This graphic organizer was used for every unit and students used it on an almost daily basis.

Treatment

Amplify Science is a curriculum program that is aligned with the three dimensions of the NGSS. Each unit is developed around a phenomenon and unit and chapter question. Students explore and evaluate evidence related to the phenomenon and claims that answer the unit question through online simulations, hands on laboratory

activities, reading articles, group discussions, and other instructional activities. The program was developed with middle school students in mind and capitalizes on the age group's high level of social interaction. Students discuss and interact with each other daily to eventually decide which evidence best helps them determine the reason for a phenomenon and/or supports a claim. Amplify Science has embedded five distinct disciplinary literacy components: reading, academic language and vocabulary, writing, listening and speaking, and visual representations, that help students develop the disciplinary literacy skills necessary in science.

I observed at least one class period per week and met several times per week with the collaborating teacher to discuss the program and student progress. Data collection occurred from September 2019 until March of 2020. The main objectives of this project were to:

- (1) determine the extent of the impact Amplify Science has on student performance and confidence in science,
- (2) determine the degree that the disciplinary literacy strategies impact students' ability to actively read and comprehend science texts and write scientific arguments, and
- (3) determine the extent of the impact of the program on student's confidence in reading science texts and writing scientific arguments.

Table 1 summarizes the data sources used for this Capstone Project.

Table 1
Data Triangulation Matrix

Focus Question	Data Source 1	Data Source 2	Data Source 3
<i>Research Question:</i> To what extent does the use of Amplify Science, which teaches science concepts through inquiry, with an emphasis on disciplinary literacy strategies, affect student performance and confidence in science?	Amplify Pre- and Post- Unit Assessments	Collaborating Teacher Interview	Student Pre- and Post- Confidence Survey and Interviews
<i>Sub-Questions:</i> 1. To what degree will the embedded disciplinary literacy strategies impact students' abilities to actively read and comprehend science texts?	Non-Amplify Article Student Annotations	Non-Amplify Article Reading Questions	Collaborating Teacher Interview
2. To what degree will the embedded disciplinary literacy strategies impact students' abilities to write scientific arguments?	Student Scores on Amplify Argument	Student Scores on non-Amplify Argument	Collaborating Teacher Interview
3. To what extent does the use of disciplinary literacy strategies affect students' confidence in reading and writing in science?	Pre- and Post- Student Self-Assessment Reading Survey	Student interviews	Collaborating Teacher Interview

Objective 1 Data Collection Instruments

To determine the impact of the program on students' performance in science, I compared the Amplify Science pre- and post-unit assessment scores for three of the units taught. These units were: (1) Plate Motion, (2) Rock Transformations, and (3) Earth, Moon & Sun. The pre- and post-unit assessments were either identical or very similar and included 16-20 multiple choice questions and two short answer questions. The assessment questions require students to analyze and interpret data, evaluate evidence, construct explanations, and demonstrate knowledge of unit-specific science content concepts (i.e., standards) and crosscutting concepts, such as patterns. The teacher only required students to answer all the multiple-choice questions on the pre-assessments, so only the students' scores on the multiple-choice questions could

be compared. If the disciplinary practices from the 4E framework embedded within the program are effective, then a significant increase between the students' pre and post assessment scores should be seen. The pre- and post- assessment scores were compiled into an Excel spreadsheet for each unit. Excel formulas were used to calculate students' growth in score between the pre- and post- assessment, students' percent growth in score between the pre- and post- assessment, the normalized gain, and the average normalized gain. Normalized gains of less than 0.3 were considered low, gains 0.3 to 0.7 were considered a medium gain, and normalized gains greater than 0.7 were considered high (Hake, 1998). A box-whisker plot was also used to compare the students' scores on the pre- and post- assessment. The paired t-test function in Excel was used to determine a p-value.

To determine the impact of the program on students' confidence in science, I created a six-question survey for students that asked them questions related to their enjoyment of science, how difficult science is for them, and how confident they feel in learning science (Appendix B). If the disciplinary practices from the 4E framework embedded within Amplify improve students' performance in science, then an increase in confidence will likely follow. The survey included three Likert statements and three open-ended questions. A Likert statement, like "I enjoy science," where students either strongly disagree, disagree, neutral, agree, or strongly agree, was always asked before the open-ended question. The following open-ended question was related to the prior Likert question, like "What do you like/not like about science?" The purpose of these open-ended questions was to get more detail and clarification about students' Likert responses. To compare student responses, the survey was given twice during the school year. In the

fall, the purpose of the survey was to get a baseline of students' initial thoughts and opinions about whether they liked science, what they found difficult about science, and if they felt confident in learning science. In the spring, the purpose of the survey was to see if and how students' opinions about science had changed. If the disciplinary practices from the 4E framework that are embedded in the program are effective, then students should become more confident in science as they will not only have learned content more deeply, but they will have learned disciplinary literacy skills needed to read, write, and communicate in science.

This survey was administered to 19 students in the teacher's advisor class who also had the collaborating teacher for science in mid-September and the end of February. I opted for a smaller sample size here due to time constraints. Advisor is essentially a study hall for students, so they were easily surveyed without interrupting valuable class time. The survey was administered to students, in person, over several days. I met with each student, individually outside of the classroom and asked them the questions. I used Microsoft Forms to administer this survey to students. I asked students the Likert Questions and typed their verbal responses to the open-ended questions. Before beginning, students were informed that participation was not mandatory and that their participation, or lack thereof, would not impact their science grade.

The results from this survey were compiled in an Excel spreadsheet and a data table was created to demonstrate the differences between the pre and post Likert response results. The data analysis of this survey included the comparison of students' responses on the Likert questions between fall and spring, and the comparison of trends in students'

responses to the open-ended questions. For the open-ended responses, I looked for trends in students' responses. For example, did students have similar likes and/or dislikes about science? I compared these trends between fall and spring to see if the trends changed or remained the same. For example, did students have the same likes/dislikes, or have they changed? To track these trends, such as students expressing that they're more confident in science, I highlighted it a specific color to allow me to tally similar responses. I used a different color highlighter for and tallied each trend that I saw.

The last data collection instrument used to determine the effect on student performance and confidence in science, was an interview with the collaborating teacher conducted at the end of February. After analyzing the quantitative data from the other data collection tools, I created interview questions that helped me determine what the teacher believed the impact of the program to be on students (Appendix C). This interview was during the teacher's prep period and the conversation was recorded so that I could create a transcript. I then reviewed the transcript to find the most pertinent information the teacher shared with me regarding the impact of the program on student learning of science, their confidence, and their reading and writing skills. I used highlighters to select the best information provided by the teacher that was related to my research questions. Anything the teacher said that was pertinent to the main research question was highlighted in pink, information relating to sub-question #1 was blue, sub-question #2 was green, and sub-question #3 was yellow.

Objective 2 Data Collection Instruments

To determine the impact of Amplify Science on students' ability to actively read and comprehend science text, I compared students' use of the Amplify Active

Reading Guidelines, on articles that are not from the Amplify program that students completed in mid-September and the beginning of February. If students truly learned how to utilize disciplinary literacy strategies specific to science, then they should be able to apply these skills to other science text. Students read and annotated two articles that I compiled from the online resource, CommonLit. The articles on CommonLit provide a Lexile to ensure that the texts are grade level appropriate and Common Core State Standards aligned questions. The first article, “Voyage to Pluto,” was administered to students on September 19, 2019, and was related to the Geology on Mars unit they were studying at the time (Appendix D). In this unit, students explored the atmosphere, geosphere, biosphere, and hydrosphere of Mars to determine whether a geographic channel on Mars was created by flowing water or flowing lava. The CommonLit article, written by Ken Croswell, describes the New Horizons spacecraft’s voyage to Pluto and the geographic data that was collected (2016). The second article, “What is Earth?” was administered to students on February 2, 2020. In this unit, students were exploring the Earth, moon, and sun system (Appendix E). The CommonLit Article, written by the National Aeronautics and Space Administration (NASA), describes features of Earth, how it supports life, and its movement within our solar system. I selected this article because it was closely related to what students were currently studying in the class. To collect data on how students annotated these articles, I created an Annotation Tracker with a simple “yes” or “no” table for each specific Active Reading Guideline from Amplify Science to measure how many students were using annotation strategies while they read, and which annotation strategies were used most frequently(Appendix F). I reviewed the students’ annotations and compiled the results in an Excel spreadsheet. I

then calculated the number and percentage of students who used each annotation strategy on both articles. The percentage of students who used each strategy on both articles was graphed on the same bar graph to demonstrate the increase of frequency.

To measure students' reading comprehension of complex text, I opted to use two of the multiple-choice questions that came with the article. Question 1, "Which statement best expresses the central idea of the text?" is directly aligned with CCSS ELA Literacy Reading Standard 6-8.1, which is to, "Cite specific textual evidence to support analysis of science and technical texts (Common Core State Standards Initiative, 2019)." Question 2, "Which detail from the text best supports the answer to Question 1?" is directly aligned with CCSS ELA Literacy Reading Standard 6-8.2, which is to "Determine the central ideas or conclusions of a text (Common Core State Standards Initiative, 2019)." I compiled students' responses in an Excel spreadsheet. I then calculated the number and percentage of students who got each question correct on both articles. I created a bar graph for each question to represent the percentage of students who got each question correct on both articles to demonstrate the change in percentage.

To determine the impact of Amplify Science on students' ability to write scientific arguments, I looked at student argument writing work samples from the Amplify Science program itself and from a question on the CommonLit articles. During the time of this project, there were two units within the Amplify program that required students to write a formal scientific argument. I wrote one question for each CommonLit article, that was similar to the Amplify argument questions, that required students to answer by making a claim, providing evidence from the text, and connecting scientific reasoning to the evidence they chose.

Student responses to both types of arguments were scored using a rubric I created by combining claim-evidence-reasoning (CER) ideology and a rubric for scoring short-constructed responses on the Smarter Balanced Assessment (SBA) (Appendix G). The rubric used a five-point scale where a score of “0” meant that the response provided no evidence of the ability to answer the prompt and/or answered without relevant information. A score of “1” was considered “minimal” with the criteria of: (1) the response either lacked a claim or the claim didn’t answer the question, (2) lacked evidence or the evidence didn’t support the claim, (3) lacked scientific explanation(s) of evidence, and/or (4) was unorganized. A score of “2” was considered “partial” with the criteria of: (1) the claim insufficiently answered the question, (2) the response included general or not specific evidence from the text/unit, (3) the response did not provide adequate scientific explanation(s) of the evidence, and/or (4) was unorganized. A score of “3” was considered “adequate” with the criteria of: (1) the response included a sufficient claim that answered the question, (2) the response included one specific piece of evidence from the text/unit that supports the claim, (3) the response included adequate scientific reasoning of how the piece of evidence supported the claim, and/or (4) was organized with the writing in order of the claim, evidence, and then reasoning. A score of “4” was considered exemplary with the criteria being the same as a score of “3,” except that students needed to include at least two correct pieces of evidence from the text/unit and the correct scientific reasoning.

I hand scored the students’ responses to the CommonLit articles and then entered their scores into an Excel spreadsheet. I used formulas to calculate the frequency of the rubric scores on every argument question and used a bar graph to represent the

distribution of scores. The non-Amplify argument score distributions were organized on one bar graph and the Amplify argument score distributions were organized on a second bar graph to show the difference in distributions at the beginning and end of the data collection period.

The last instrument I used to measure the program's impact on students' abilities to actively read and comprehend complex texts and write arguments is an interview with the collaborating teacher (Appendix B). After looking at the quantitative data, I prepared interview questions that would help me get the teacher's view of students' growth in their writing. These questions were part of the same interview that occurred at the end of February.

Objective 3 Data Collection Instruments

To determine if students became more confident in their abilities to actively read and comprehend science texts, I created a Student Self-Assessment Reading Survey, using the Amplify Active Reading Guidelines. If the disciplinary practices from the 4E framework and embedded literacy strategies truly improve students' reading and writing skills in science, then they will naturally be more confident (Appendix H). The Amplify Active Reading Guidelines include strategies like making connections to your own experiences and/or knowledge, highlighting challenging words or phrases, and recording notes and/or questions while reading. I used Likert statements with first-person language that I found in another Capstone Project paper because I felt that the first-person language would be easily understood by 6th grade students (Chierici, 2012, p. 40). There were seven statements on the survey, such as, "When I read I make connections to my own

experiences and/or knowledge,” and the response choices were “very different from me,” “a little different from me,” “a little like me,” and “a lot like me.”

This survey was given before the collaborating teacher had begun teaching Amplify Science, at the beginning of September, to provide a baseline of students’ perceptions of their own Active Reading skills and again in mid-February to compare students’ perceptions after using Amplify Science. The survey was administered to four of the five class sections. One section did not take the survey in the fall due to a scheduling conflict with school picture day, so they did not take the survey in mid-February either. Overall, 94 students took this survey. I created a Microsoft Form for students to take this survey because it was easy for students to access via a website link and the data was easily downloaded as an Excel spreadsheet. In Excel, I created formulas to calculate the number and percentage of students’ responses to each Likert item. To easily compare the data collections of September and February, I compiled the percentages in stacked bar graphs for each collection period.

To determine the impact of the program on students’ confidence in writing scientific arguments and reading in science, I added additional interview questions at the end of the Student Confidence Survey (Appendix I). I used quantitative data from the other data collection instruments, my own personal observations, and input from the collaborating teacher to create these interview questions. These interviews were conducted one-on-one during the students’ advisor time. I conducted about four interviews during an advisor period, so it took a total of five days to complete these interviews. I sat in the hallway with students during these interviews so they would be comfortable that their teacher and peers could not hear their responses. I recorded

students' responses to questions by typing them into a Microsoft Form. This allowed me to easily organize their responses into a table in Excel. Data analysis of these responses included looking for common trends in students' responses, such as students' expressing that they feel that their reading and/or writing has improved, and then tallying these responses. These trends were marked and tracked using different color highlighters. For example, if students said they felt their reading in science was better it was highlighted in blue to make it easier to count and refer to when completing the data analysis section.

The last instrument I used to measure the program's impact on students' confidence in writing scientific arguments and reading in science was an interview with the collaborating teacher (Appendix B). These questions were part of the same interview that occurred at the end of February.

Table 2
Data Collection Timeline

Month	Data Collected
September	-Student Confidence Survey (Pre-treatment) -Student Self-Assessment Reading Survey (Pre-treatment) -Non-Amplify Article (Pre-treatment)
October	-Plate Motion Pre-Assessment
November	-Plate Motion Post-Assessment
December	-Rock Transformations Pre-Assessment
January	-Rock Transformations Post-Assessment -Earth, Moon, & Sun Pre-Assessment
February	-Student Confidence Survey (Post-treatment) -Student Self-Assessment Reading Survey (Post-treatment) -Non-Amplify Article (Post-treatment) -Final Collaborating Teacher Interview -Final Student Interviews
March	-Earth, Moon, & Sun Post-Assessment

Table 2 summarizes the data collection timeline. These data collection tools were carefully created and selected to ensure that I could measure the impacts on students' performance and confidence in science. I wanted to be able to see if it not only impacted

students' scientific abilities and confidence, but also their abilities and confidence associated with literacy in science. It is one thing to be able to learn science by memorizing a set of discrete facts, it's a completely different skill set to be able to analyze, synthesize, evaluate, and communicate scientific information.

DATA AND ANALYSIS

Data collection for this project was extensive. Data collection tools were a combination of items from the Amplify Science program and items that not from the program. They included pre- and post- unit assessments from the Amplify program, pre- and post- student confidence surveys, student scores on writing scientific arguments from Amplify, student scores on writing scientific arguments not from Amplify, pre- and post- student self-assessment reading surveys, student annotations and scores on questions from an article not from Amplify, collaborating teacher interviews, and student interviews.

The use of Amplify Science, a curriculum program that teaches science concepts through inquiry, with an emphasis on disciplinary literacy, positively affects student performance in science. Students made large growth between the pre- and post- unit assessments on each of the assessments, as demonstrated by the normalized gains for each assessment. The three pre- and post- assessments that were administered during the project timeline were, in chronological order: Plate Motion, Rock Transformations, and Earth, Moon, and Sun. The normalized gain for Plate Motion was 0.76 ($N=116$), the normalized gain for Rock Transformations was 0.71 ($N=109$), and the normalized gain for Earth, Moon, and Sun was 0.47 ($N=108$).

The median scores on these unit assessments also greatly increased between the pre- and post- assessments (Figure 2).

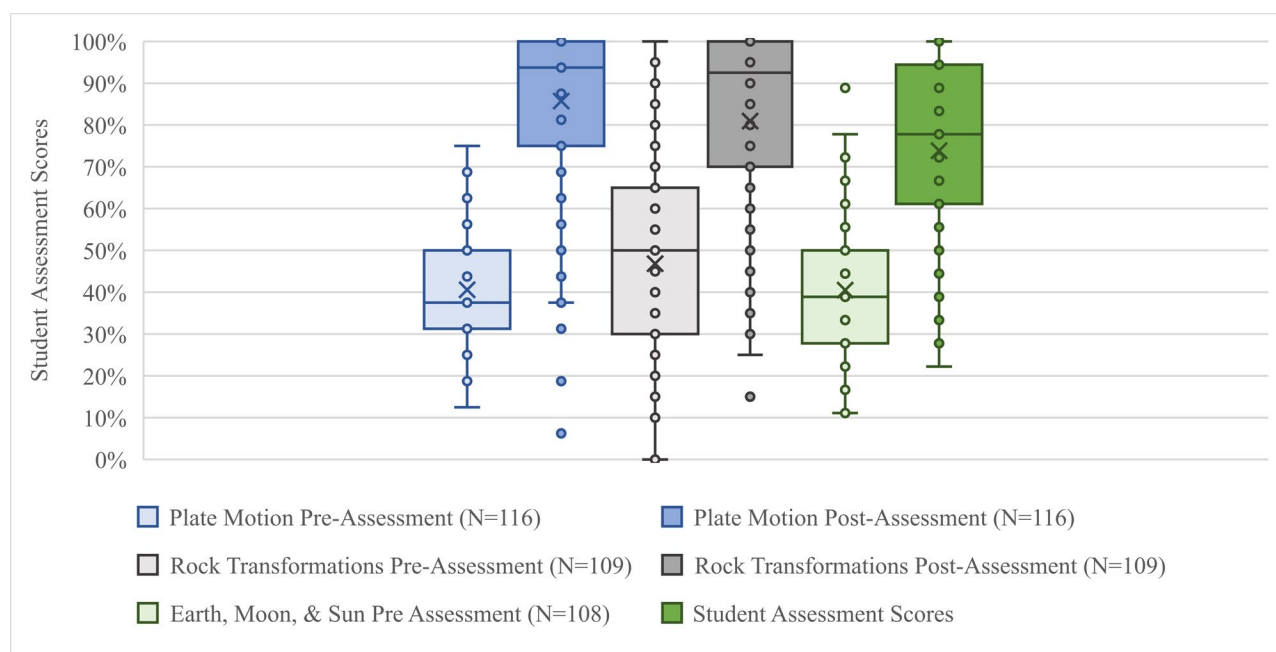


Figure 2. Pre- and Post- Unit Assessment Score Comparison for Amplify Units.

The median score on the Plate Motion pre-assessment was 41%, and the median score on the Plate Motion post-assessment increased to 86% ($N=116$). This improvement was statistically significant based on a paired t-test analysis ($p<0.001$). The maximum score on the Plate Motion assessment also increased from a 75% on the pre-assessment to 100% on the post-assessment ($N=116$). The median score on the Rock Transformations pre-assessment was 47%, and the median score on the Rock Transformations post-assessment increased to 81% ($N=109$). This improvement was statistically significant based on a paired t-test analysis ($p<0.001$). The minimum score on the Rock Transformation assessments also increased from a 0% on the pre-assessment to 15% on the post-assessment ($N=109$). The median score on the Earth, Moon, and Sun pre-assessment was a 40%, and the median score on the Earth, Moon, and Sun post-assessment increased to a 74% ($N=108$). This improvement was statistically significant

based on a paired t-test analysis ($p < 0.001$). The maximum score on the Earth, Moon, and Sun assessment also increased from an 89% on the pre-assessment to 100% on the post-assessment ($N=109$). When asked about the decrease in growth on the Earth, Moon, and Sun assessments in comparison to the other two units, the collaborating teacher said, “Spatially it’s difficult for students. They struggle with space, especially the moon phases. It’s not as concrete as our other units, like sedimentary rocks needing water to form and igneous rocks need lava to form. What students struggle with is that the moon is always half lit, we just don’t always see it. They want what’s scientifically true to be what they always see and they can’t differentiate the two. I think it’s just an extremely difficult thing for 6th graders to do.”

During the interview with the collaborating teacher it was obvious that he also felt the program has greatly impacted students’ performance in science. When asked, “How do you know that kids are learning content at a much deeper level?” he listed several pieces of evidence. First, he said, “Through their ability to verbalize their thinking. I knew right away their level of learning when we did the science seminars. Just sitting back and listening to them talk about key concepts and pulling in evidence to support their thinking. People can’t clearly verbalize concepts, or anything really, unless they know it deeply.” Second, he mentioned, “Test scores too! They have to read and analyze every single question and every single illustration or data/graph or anything that’s shown and have to read so much to be successful on these unit assessments. At first, we were worried about the amount of reading required on the assessments, but it’s turning out to not be an issue because kids know the concepts so well.”

The collaborating teacher also stated specific examples of students making great improvements on the science and engineering practices (SEPs) and crosscutting concepts (CCCs) from the NGSS. When I asked, “Are there skills you’ve seen your students develop this year that they didn’t last year? In terms of the SEPs and CCCs?” he said, “I hear students continuously use patterns when looking at maps and diagrams. I don’t have to ask them to use the word ‘patterns,’ they do it intuitively. They’re also able to look at a model now and just use it with very little explanation from me because they’re so familiar with using them.” He also said that students have greatly improved their ability to analyze and interpret data. He said, “Because the program wants you to describe in detail all the time and think deeper about the data, students have started to do this naturally. The other day students were talking about data in very specific qualitative and quantitative terms.”

The use of Amplify Science, a curriculum program that teaches science concepts through inquiry, with an emphasis on disciplinary literacy, also positively affects student confidence in science. Results from the Student Confidence Survey demonstrate that students are more confident in science (Appendix B) (Table 3).

Table 3

Results of the Fall (Sept. 2019) and Spring (Feb. 2020) Student Confidence Survey

	1		2		3		4		5	
	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring
I like science.	0	0	0	0	4	0	8	9	7	10
I find science difficult.	0	7	7	8	5	2	3	2	4	0
I am confident in my ability to learn science.	1	0	0	0	1	2	12	5	5	12

Note. 1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree. (N=19).

According to the survey results, there were slight increases in the “agree” and “strongly agree” categories for the statement, “I like science.” This is consistent with

students' responses on the open-ended question, "What do you like/not like about science?" During the interviews in the fall, 12 of the 19 students expressed that they like science, most of whom expressed the reason they like science is the experiments, activities, and/or projects. In the spring, the students were better able to articulate why they like science. For example, three of the 19 students expressed they liked science because they are learning science more deeply. Also, 13 of the 19 students expressed a specific activity, video, simulation, or hands-on experiment as the reason for liking science. In addition, three of the 19 students surveyed expressed they liked participating in the discussions. For example, one student said, "I like all the discussion time we get, it helps me understand the concepts." Last, two of the 19 students surveyed expressed they liked the reading the articles in Amplify, and three expressed they liked using Claim-Evidence-Reasoning. Students said things like, "I like writing claims," "I like...finding out about evidence," and "I like when we're finding out the evidence to support claims."

The survey results also show that the number of students that reported finding science difficult decreased. For example, in the fall zero students chose "strongly disagree" and four students chose "strongly agree" for the statement, "I find science difficult," and in the spring seven students chose "strongly disagree" and zero students chose "strongly agree ($N=19$)."

The student responses to the open-ended question, "What about science do you find difficult?" align with this survey data. In the fall, the students made much more generic statements about what was difficult for them in science. Students said things like, "Keeping up with the homework is hard or "It's difficult to work alone." In the spring students were able to articulate specifically what they found hard in science. For example, students said things like, "The argument writing is

difficult...choosing the right evidence is hard for me too,” and “It’s hard finding the evidence and proving that something is true.” Two of the 19 students were able to articulate that they struggle in the beginning of units but not at the end because they learn the concepts so well. One of these students said, “When we first start a chapter and we have to do the pre-assessment those are really hard because I don’t know exactly what is going on. When I take the assessment again at the end, I know what the answers are because we learned about it. I get a lot better from pre to post.” The other student said, “It’s difficult when I don’t necessarily know what I’m doing. When you like don’t know at the start but at the end you know. At the beginning of the unit it’s harder because we don’t know the concepts yet, at the end we do, so it’s easier.”

Last, the results of the survey also indicate that students are more confident in their ability to learn science. In the fall, one student selected “Strongly Disagree” to the statement, “I am confident in my ability to learn science,” while zero students selected “strongly disagree” in the spring ($N=19$). Also, in the fall five students selected “strongly agree” and in the spring 12 students selected strongly agree for this statement ($N=19$). Again, student specificity in their responses to the open-ended question, “Why do you feel confident/not confident in science?” increases from fall to spring. For example, in the fall students said things like, “I do science at home,” “I pay attention in science,” or “I listen and learn well and I’m very good at science.” In the spring, students were much more able to articulate why they were confident. Students said things like, “Learning Claim-Evidence-Reasoning has really helped me learn science better this year because I can explain what I have learned in a unit,” “I’m good at gathering evidence...,” and “I

feel confident because I know that I am going to get to interact with models and hands-on activities. This helps me remember things...”

The embedded disciplinary literacy strategies within Amplify Science greatly improved students’ abilities to actively read science texts. The percentage of students using each measured active reading (annotation) strategy increased for each of the measured strategies: highlighting challenging words/phrases, annotations to record thinking, thinking of questions while reading, and making connections to one’s own experiences (Figure 3).

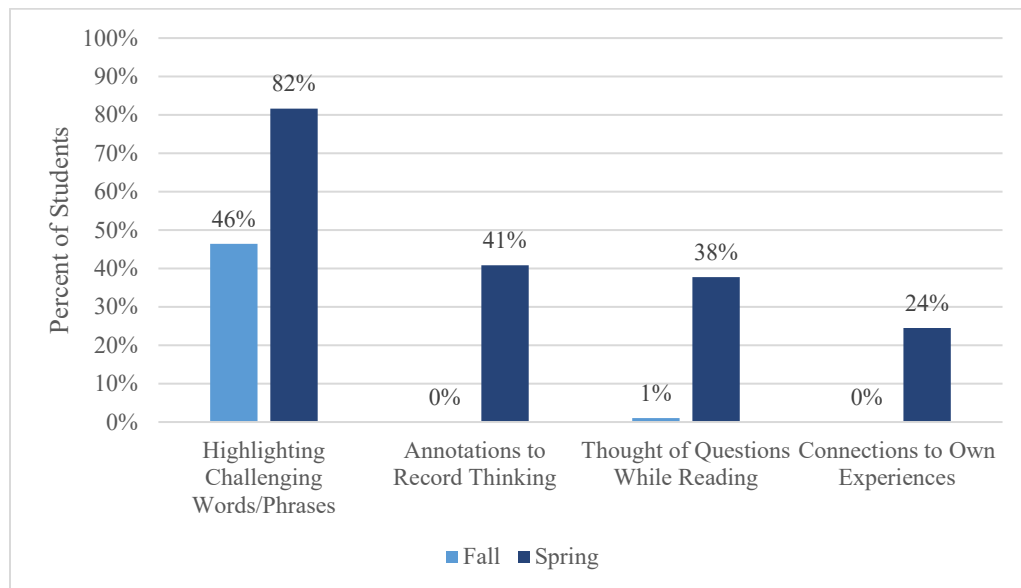


Figure 3. Percentage of Students Usage of the Active Reading Strategies in Non-Amplify articles, Fall ($N=97$), Spring ($N=98$).

The percentage of students who highlighted challenging words and phrases on the first non-Amplify article, “Voyage to Pluto,” was 46% ($N=97$), while on the second non-Amplify article, “What is Earth?” the percentage of students 82% ($N=98$) (Figure 3; Appendices D & E). This is an increase of 36%. Zero students ($N=97$) used annotations to record their thinking on the first non-Amplify article, on the second non-Amplify

article, this increased to 41% ($N=98$) (Figure 3). Only one percent students ($N=97$) recorded questions that they thought of while reading on the first non-Amplify article, but on the second non-Amplify article this number increased by 37% ($N=98$) (Figure 3). Last, zero percent of students ($N=97$) recorded connections to their own experiences on the first non-Amplify article. In the spring this percentage increased to 24% ($N=98$) (Figure 3). The growth in each percentage demonstrates how much more adept students are now when they read science articles.

The data from the students' annotations of the non-Amplify articles aligns with what the collaborating teacher said in the final interview (Appendix B). First, he noted that students are much better at using the active reading strategies. He said, "I see a lot of improvement, especially when I make sure to continue modeling [at the beginning] with each reading." He said, "The questions that they [students] ask in their article reading now are so much deeper than last year because they're constantly being put in a position where their questions can't just be 'Why?' or 'How?' They have to ask questions on a deeper level." He also added that this practice of asking deeper questions has led to students asking their peers deeper level questions in their discussions.

While I was scoring the students' annotations, I also noticed much more specificity in the students' annotations. Many students connected ideas in the text to concepts they had already learned by writing things like, "This is connected to our Mars unit," or "We learned this in the Earth, moon and sun unit." Students also wrote much more specific questions, such as "Do other planets have seasons like Earth?" Overall, the students were significantly better at highlighting specific sections of text, instead of highlighting entire paragraphs or even pages of the text.

When students were asked the question, “Are there certain strategies that you use to help you understand your reading?” in the final interviews it was remarkable how many students were able to articulate how they tackle science texts now (Appendix I). Eleven of the 19 students interviewed specifically used the word “annotate” or “annotations” when describing how they tackle science texts. Students said things like, “I finally understand the annotating” or “I highlight and annotate now.” Fourteen of the 19 students interviewed explained how they use highlighting to identify important concepts and things they’re unsure about. One student said, “I start highlighting the important parts and things I still don’t know.” Another student noted, “I feel like I finally know what I should be highlighting.” Also, 10 of the 19 students said that they now write questions they think of while reading next to the specific sections of text. One student said, “Writing questions that I have while reading has helped me learn more about the concepts.” Last, six of the 19 students said that they make connections from the text to themselves or concepts they’ve already learned. One student stated, “I remember if we did something already and then I annotate this connection.” Another student said, “I also connect things to what I already know.”

The embedded disciplinary literacy strategies within Amplify Science also improved students’ abilities to comprehend science texts. A larger percentage of students were able to identify the main idea from the non-Amplify articles in the spring than in the fall (Figure 4; Appendices D & E).

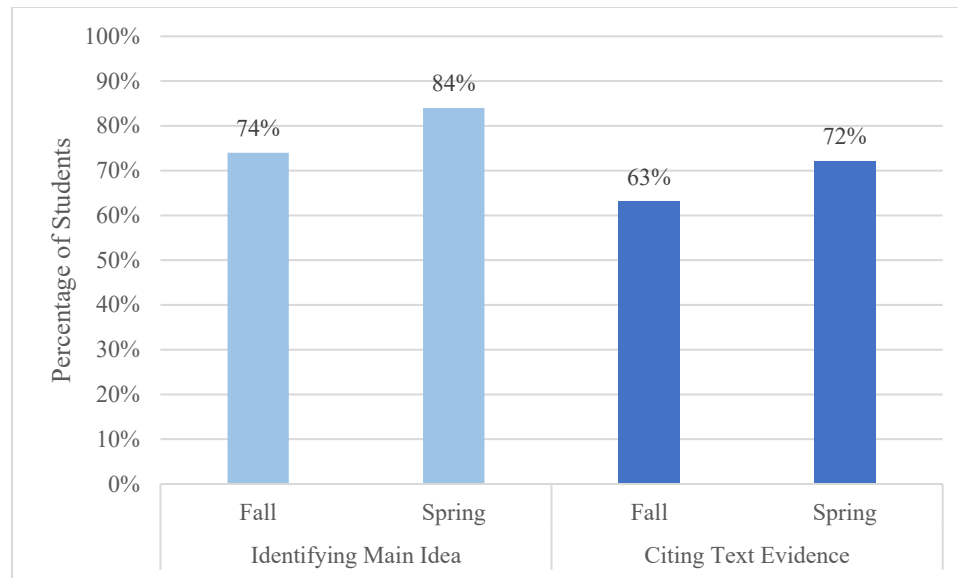


Figure 4. Percentage of students who correctly answered the main idea and text evidence questions on the non-Amplify articles, Fall ($N=97$), Spring ($N=98$).

In the fall, 74% of students ($N=97$) correctly answered the main idea multiple-choice question on the non-Amplify article, “Voyage to Mars” (Figure 4; Appendix D). In the spring, this percentage increased by 10%, as 84% of students ($N=98$) correctly answered the main idea multiple-choice question on the non-Amplify article, “What is Earth?” (Figure 4; Appendix E).

In the fall, 63% of students ($N=97$) correct answered the text evidence multiple-choice question on the non-Amplify article, “Voyage to Mars” (Figure 4; Appendix D). In the spring, this percentage increased by nine percent, as 72% of students ($N=98$) correctly answered the text evidence multiple-choice question on the non-Amplify article, “What is Earth?” (Appendix; Figure 4).

The teacher agreed that students’ reading comprehension skills have increased. In the final interview he explained that the fact that 70-80% of students demonstrating mastery on the assessments also provides evidence that students have better reading comprehension (Appendix B). He said, “We [6th grade science teachers] thought it

[assessments] were too much text, but if we hadn't actually given the assessments and provided students the opportunity, we would've confirmed our thoughts that it's too much text...they can do these hard assessments with a lot of reading.”

The embedded disciplinary literacy strategies within the Amplify program significantly improved students' writing of scientific arguments and students' writing skills overall. Students' argument writing scores improved greatly from the first argument they wrote in the Geology on Mars unit to the second argument they wrote in the Plate Motion unit (Figure 5).

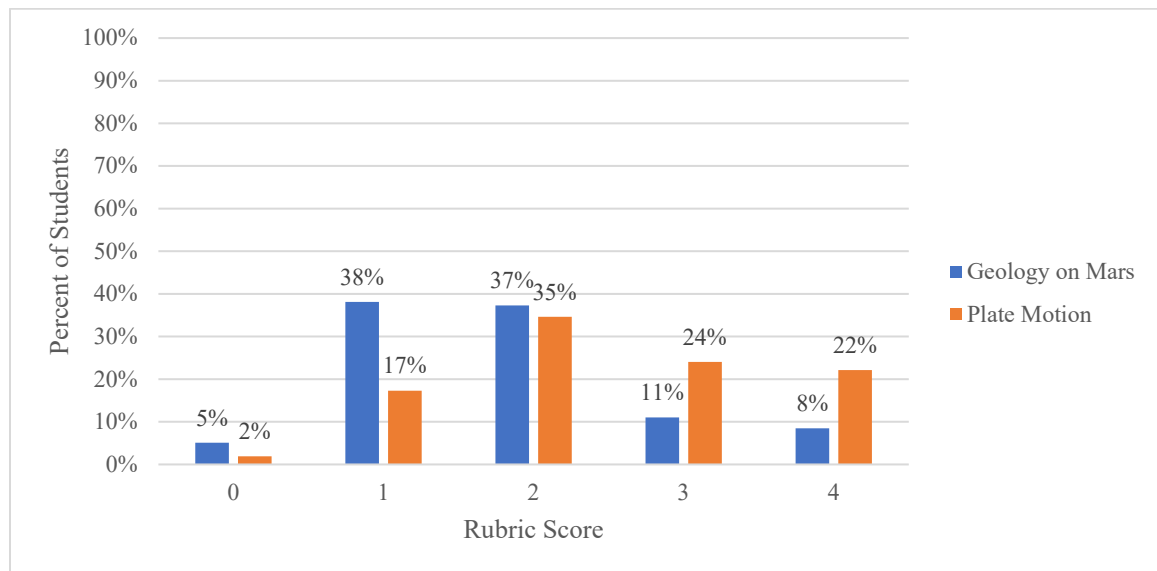


Figure 5. Rubric scores by percentage of students for the two Amplify arguments, Geology on Mars ($N=118$), Plate Motion ($N=104$).

On the first Amplify argument for the Geology on Mars Unit, 11% of students scored a three and eight percent scored a four, so overall only 19% of students scored proficient or above on the scoring rubric (Figure 5; Appendix F). On the second Amplify argument for the Plate Motion unit, 24% of students scored a three and 22% scored a four, so overall 46% of students scored proficient or above on the scoring rubric (Figure 5; Appendix F). This is a 27% increase in student proficiency. It should also be noticed

that the percent of students who scored a zero on the rubric decreased by three percent and the percentage of students who scored a one on the rubric decreased by 21% (Figure 5).

Student proficiency also increased on the two arguments that students wrote that were not from any Amplify unit (Figure 6). These arguments were questions from the “Voyage to Pluto” and “What is Earth?” Commonlit articles (Appendices D & E).

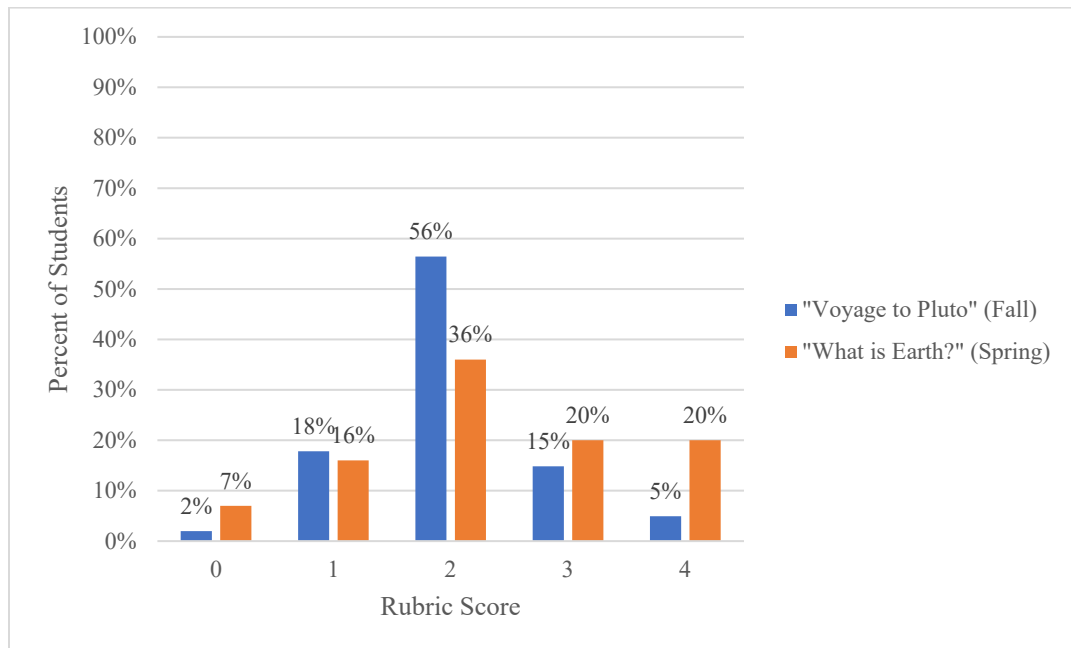


Figure 6. Rubric scores by percentage of students for the two non-Amplify arguments, “Voyage to Pluto” ($N=97$), “What is Earth?” ($N=98$).

On the first argument, for the article, “Voyage to Pluto,” 15% of students scored a three and five percent of students scored a four on the scoring rubric, so overall, only 20% of students were proficient (Figure 5; Appendices D & G). On the second argument, for the article, “What is Earth?”, 20% of students scored a three and 20% of students scored a four on the scoring rubric, so overall, 40% of students were proficient (Figure 6; Appendices E & G). This is an increase of student proficiency by 20%. It is also

important to note that 56% of students scored a two on the first argument and 36% scored a two on the second argument, a decrease of 20% (Figure 6).

In the final interview with the collaborating teacher, he echoed this improvement in student argument writing and overall writing skills (Appendix B). About their argument improvement in writing, he said:

Students are so much better at constructing explanations and arguments. This is way better than it was last year, just writing the scientific arguments especially...Today they [students] had to look at two different cities [Buenos Aires and Capetown] and look at the ocean currents. They then had to choose a claim and explain by supporting the claim that they selected. They all wrote the claim. Then students were pulling in evidence from the map...and reasoning it with energy transfers. Students writing and their explanations of learning have dramatically improved.

He also made sure to note that students overall writing has improved. He said:

The writing is unbelievable. I can start students on an argument and they just take off now. They sit for five minutes and write solid. Even if students are incorrect, I can tell what they're trying to describe. They're writing is improving because they're doing it so much...They give the appropriate amount of detail now in their responses.

In the final student interviews students were able to specifically articulate what strategies they used to help them write scientific arguments and identify what they found easy/difficult with the writing, indicating a deeper understanding of scientific writing (Appendix I). When asked, "Are there certain strategies you use to help yourself write these [scientific arguments]?" nine of the 19 students mentioned specific resources they use to help them identify the correct evidence and/or reasoning. One student identified four different resources, "I look back at the articles, lessons, my class notebook, and my learning map to find my evidence and reasoning." Another student noted using peers, "They help me organize my evidence and reasoning better." In the interviews, students were also able to specifically describe what was easy and/or difficult about writing

scientific arguments. One student said, “Gathering up all the evidence is a little hard, but I feel like the reasoning is the hardest part of it. You need to fit it in right, the organization is difficult. Claims are a little easier.” Another student said, “The reasoning is the hardest...the claim and evidence is pretty easy because you can go back to the articles, notes, and learning map to find what you need. The reasoning is hard to connect to the evidence.” Each of the 19 students interviewed used the terms “claims,” “evidence,” and/or “reasoning.” Eight of the 19 students said that writing the claim was the easiest. Fourteen of the 19 students said that reasoning was the most difficult part. Student responses about the evidence was most varied; some stated it was the easiest part and others stated it was the most difficult. The collaborating teacher echoed this sentiment in the final interview (Appendix B). He said, “They verbally understand what evidence is. They still struggle with understanding how to tie in the key concepts as reasoning. That reasoning is scientific principles, versus evidence being observations. They like to tie the two things in together still. For example, we did one the other day and students were writing the reasoning as evidence and not just listing the quantitative evidence. They especially struggle with qualitative evidence because it seems like reasoning because there aren’t numbers involved.”

The disciplinary literacy strategies within the Amplify program positively impacted students’ confidence in reading in science. The Student Self-Assessment Reading Survey that was administered in the fall and spring demonstrates this increase in confidence (Table 4; Appendix H). The statements on the survey directly align with the active reading strategies within the Amplify program.

Table 4

Student Reading Self-Assessment Survey Fall and Spring Results

	1		2		3		4	
	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring
When I read, I think about if I'm understanding what I'm reading.	9%	3%	19%	16%	48%	48%	24%	33%
When I read, I make connections to my own experiences and/or knowledge.	6%	4%	26%	26%	43%	40%	26%	30%
When I read, I take notes (annotate) about what I'm thinking.	49%	22%	20%	20%	22%	26%	9%	33%
When I read, I highlight challenging words or phrases.	57%	33%	26%	20%	10%	28%	7%	19%
When I read, I add my own notes and/or record any questions I have.	45%	24%	26%	28%	24%	28%	5%	22%
When I read, I look carefully at the visual representations (graphs, pictures, charts, diagrams, etc.).	10%	5%	14%	13%	26%	28%	51%	55%
After reading, I discuss what I read with someone else to check own understanding.	34%	35%	29%	27%	28%	25%	10%	14%

Note: 1=Very different from me, 2=A little different from me, 3=A little like me, 4=A lot like me, (N=94).

The results from the spring survey indicate that students feel significantly more confidence in their reading because the percentage of students that selected “Very different from me,” decreased for each statement while the percentage of students that selected “A lot like me” increased, indicating that they now feel they have the strategies necessary to read science text (Table 4). For example, on the fall survey 49% of students selected “Very different from me” and only nine percent of students selected, “A lot like

me,” for the statement, “When I read, I take notes (annotate) about what I’m thinking (Table 4).” When students took the survey again the spring for this statement the percentage of students who selected “Very different from me” decreased by 27% and the percentage of students who selected “A lot like me” increased by 24% (Table 4). Also, on the fall survey 57% of students selected “Very different from me” and only seven percent of students selected “A lot like me” for the statement, “When I read, I highlight challenging words or phrases (Table 4).” In the spring for this statement, 24% fewer students selected “Very different from me” and the percentage of students who selected “A lot like me” increased by 16% (Table 4). Last, on the fall survey, 45% of students selected, “Very different from me” and only five percent of students selected “A lot like me” for the statement, “When I read, I add my own notes and/or record any questions I have (Table 4). In the spring the percentage of “Very different from me” responses dropped to 24% and the “A lot like me” response percentage increased to 22% (Table 4).

The students’ verbal responses in the final interview mirror their responses to the Student Reading Self-Assessment Survey (Appendices I & G). When asked, “How do you feel about reading science articles now?” seven of the 19 students interviewed responded with some version of the language, “getting better,” and six of the 19 students responded with some version of “I feel pretty good.” For example, one student said, “I’m getting better at understanding what I’m reading.” Another student said, “I’m getting a lot better at recognizing things to highlight and annotate.” Students also said things like, “I feel pretty good about reading science stuff now,” and “I feel good and I feel like I’m getting better at annotations.”

When students were specifically asked, “Do you feel more confident in your ability to read in science? Why or why not?” during the final interviews, 17 of the 19 students reported that they were more confident (Appendix I). One student said, “I feel more confident because now I know how to attack science text.” Another student said, “I feel like I can do it without adding extra things that don’t really matter. I feel like my annotations are meaningful now.” Several students indicated that they are better readers overall. For example, one student mentioned, “I am a much better reader because I know how to annotate text correctly now.” One student said, “I feel better about doing this in other classes now because I really know how to annotate,” indicating that they are transferring the skills to other classes.

The disciplinary literacy strategies within the Amplify program also positively impacted students’ confidence in writing in science. When asked, “How do you feel about writing scientific arguments now?” in the final interview, 12 of the 19 students expressed either improvement or that the writing was getting easier (Appendix I). Students said things like, “I feel like I’m getting pretty good at writing scientific arguments,” “I feel good about writing them because I understand claim, evidence, and reasoning,” and “I feel like I’m getting a lot better.” When asked, “Do you feel more confident in your ability to write science arguments? Why or why not?” 15 of the 19 students expressed an increase in confidence. Additionally, 11 of the 19 students expressed that they’ve become better writers in other classes as well. In their verbal responses, the amount of specificity to this question was impressive. One student said, “I feel a lot more confident because when I’m writing about my evidence, I know how to add details and reasoning a lot better. It was a lot easier to write our essay in English on

Canada. I could actually structure my paragraphs!” Another student said, “I use some of what I learned in science I use in English class. It really helped me cite evidence in my English class when we did our research papers.” One student even mentioned that they feel their vocabulary and grammar are improving, “I feel like I'm getting more of the vocabulary into my writing. I also feel like my grammar is getting better through so much practice.”

The collaborating teacher echoed this increase in student confidence in our final interview by stating:

The confidence in writing is insane. I don't think that writing is a big struggle for these kids anymore, they just go do it. I also think they now feel safe to be wrong because they do it so much and they know it's not graded all the time. For what I can see, every student is now writing. They know they're not always right, but they still keep writing. I think this shows confidence because students are comfortable to write, knowing that they might be wrong. They can do it with the freedom of making a mistake, so their confidence level skyrockets.

The validity of these findings, due to the large sample size, indicate that Amplify science had a strong, positive impact on students' performance and confidence in science. Students made significant improvement between their pre- and post-assessments for the three Amplify units taught during the time of this project. Students also greatly improved their ability to write scientific arguments, as evidenced by the improvement of their scores on the Amplify and non-Amplify arguments. The number of students using the Active Reading strategies also greatly improved during the time of this study. Last, the specificity of students' responses during the final interviews, demonstrate that students have greatly increased confidence in science.

INTERPRETATION AND CONCLUSIONS

Impact on Students' Performance in Science

Amplify Science has made a very significant, positive impact on this group of 6th grade students' performance in science, largely due to the concepts being taught through inquiry and the amount of embedded disciplinary literacy. Evidence of the impact include the normalized gains on the unit assessments and the student and collaborating teacher interviews.

Two of the normalized gains were values of 0.71 and 0.76, so they fell into the “high” range. The third unit assessment had a normalized gain of 0.47, which is considered medium (Hake, 1998). The collaborating teacher felt that a large part of students' increase in performance was that they were doing most of the work through investigation. He said, “They arrive at an answer through discovery, this is what Amplify does. We release students to make mistakes and to discover the concepts on their own, they just have to work through it. When you take the discovery out and you just dictate answers, I don't think it connects... We pull more kids into mastery because they're doing the work. I think you pull more students to mastery through discovery rather than dictating content to them.” His thoughts are directly connected to Moje's (2015) suggestion that we need to make inquiry within a community of practice and discourse central to the learning of the literacy practices of a discipline (p. 255). Moje's (2015) 4E model (Engage, Elicit/Engineer, Examine, Evaluate) is essentially embedded within the Amplify Science program, so students engage in scientific inquiry using disciplinary literacy practices. Daily, students use reading, writing, speaking, and listening to engage with science concepts, elicit and engineer new learning, examine evidence, and evaluate claims. This model allows students to deeply learn science concepts, therefore increasing their overall performance in science.

Students also provided evidence that they were performing higher in science when I interviewed them. The increase in specificity to science skills and content between the fall and spring interviews was astounding. Students were able to verbalize specific content and skills that they did not understand by saying things like:

- I struggle with how energy transfers from ocean currents to the air and land.
- I'm struggling with the energy and latitude and longitude stuff on the globe.
- It's hard finding the evidence and proving that it's true.
- The reasoning is hard to connect to the evidence.

Their increase in metacognition is evidence that students engaged with science in the same way that scientists would, instead of learning discrete science concepts. Amplify Science allows students to do what Shanahan & Shanahan (2012) consider disciplinary literacy because the program emphasizes the knowledge and abilities that scientists use to create, communicate, and use knowledge within their field.

Prior to seeing Amplify Science, and the impact it can have on students, I was not completely sure that inquiry was necessary for science. I had always thought that students needed to "know" science concepts to investigate them. I did not really think that inquiry could be used as a vehicle to learning science concepts. This project has led me to the conclusion that not only can inquiry be effective in learning science concepts, it should be used with regularity. Students will learn science concepts on a much deeper level if they engage in inquiry, especially through reading and writing.

Impact on Students' Abilities to Read and Write in Science

The largest impact of Amplify Science was on students' abilities to read and write in science. Evidence that students greatly improved their abilities to read and write in science include students' scores on the Amplify and non-Amplify arguments, annotations, and the student and collaborating teacher interviews. Student proficiency on the Amplify arguments increased by 27%, while the proficiency on the non-Amplify arguments increased by 20%. The increase in the usage of the annotation strategies was also drastic, indicating that students now understand how to annotate science texts. Again, students also demonstrated a large increase in their metacognition related to their reading and writing abilities when interviewed. Students said things like:

- When I highlight and re-read text I really understand.
- I feel like I have strategies to help me learn when I read now.
- I am a much better reader because I know how to annotate text correctly now.
- I feel like the writing is helping me learn the concepts better.
- My writing is getting better because I reason it better.
- When I'm writing about my evidence I know how to add reasoning a lot better now.

The high amount of embedded reading and writing within Amplify Science could be a large part of the reason that students are much better readers and writers. Richard Allington (2011) recommends that students need a minimum of 60 minutes of reading and 40 minutes of writing every day, across the curriculum. The collaborating teacher estimated that students are writing about 15-20 minutes and reading 10-15 minutes per day; half of Allington's recommended 20 minutes of writing and a quarter of

his recommendation for reading. Not only are the students frequently reading and writing, but they are also participating in discussions and seminars that are purposeful and grounded in the reading and writing that they are doing. Mike Schmoker (2018) argues that students engaging in purposeful reading, writing, and discussion will significantly increase students' abilities to read and write.

As a literacy coach, I frequently encounter the phrases, "learning to write," "writing to learn," "learning to read," and "reading to learn." These phrases essentially mean that students first need to learn to read and write and then they can use reading and writing as vehicles to learn content. Shanahan and Shanahan (2008) explain this phase of instruction as transitioning from intermediate literacy to disciplinary literacy, and that it usually occurs in middle school. Amplify Science capitalizes on this research, as it uses disciplinary literacy, especially reading and writing, as a vehicle to help students learn content. Prior to becoming a literacy coach, I was guilty of doing all the reading for students to create the notes. I also didn't have students writing about the concepts enough. Amplify Science made me recognize the high impact that reading and writing can have on students' learning of science skills and concepts. I have seen firsthand why Richard Allington (2011) recommends 60 minutes of reading and 40 minutes of writing daily; it can significantly impact student learning.

Impact on Students' Confidence in Science and Literacy

Amplify Science has also had a large impact on students' confidence in reading, writing, and in science in general. Because the program naturally allows the science teacher to do what Grant, Fisher, and Lapp (2015) recommend, providing students opportunities to use language to learn science, students have become more confident. As

Grant, et al., suggested, this group of students have a deeper understanding of science from being actively immersed in using the language of science so they have begun to think, read, and write like scientists (p. 18). This deeper understanding of science has led them to become more confident in all aspects of what scientists do daily: reading, writing, speaking, and listening about science concepts. Evidence of this confidence is seen in the Student Confidence Survey (Appendix B) results and in the final student and collaborating teacher interviews. Again, the level of specificity with which students spoke about their learning of science concepts and skills demonstrates a much higher level of confidence. To talk about your strengths and weaknesses, you must have confidence. Both the students and teacher expressed increases in confidence as well. The teacher felt that their confidence in writing was what had increased the most. Students expressed an increase in confidence about reading, writing, and science as a whole.

When I began this project, I was not very concerned with how Amplify Science might impact students' confidence in science and their confidence reading and writing within science. Working closely with this group of 6th grade students and the collaborating teacher has given me a much greater understanding of how confidence impacts learning. Amplify Science encourages students to investigate phenomena, while using reading, writing and discussion to explore and evaluate evidence. By constantly investigating and figuring out whether they are on the right track, students naturally become more confident in their abilities to learn science. They also become much more comfortable with being wrong and a lot less concerned with finding the "right" answer. Becoming more confident with reading and writing is just an added bonus. Because students use reading and writing as a vehicle for learning, they do it a lot and with a very

specific purpose in mind. This consistency of amount and purpose naturally increases students' confidence in their abilities to read and write.

In order to teach science in a way that will allow students to learn science concepts deeply, the scientific practices that scientists engage in, and the communication strategies that scientists must use, teachers must use inquiry with a focus on disciplinary literacy.

VALUE

This Capstone Project has led me to the conclusion that quality science instruction needs to include inquiry and disciplinary literacy woven together. When students use disciplinary literacy skills to drive the inquiry process, they make significant growth in their science content knowledge, their ability to read and write scientifically, and their overall confidence with science.

The students at C.R. Anderson Middle School come from six different elementary schools, so their abilities when they walk into their 6th grade science class are extremely diverse. Teaching with Amplify Science will ensure that teachers can help all students make significant growth in science. Amplify Science provides teachers the appropriate tools to ensure that students will leave middle school with a deep understanding of content and strong disciplinary literacy skills, such as reading science text and writing scientific arguments. Students who have a deep understanding of science disciplinary skills and content knowledge will also be more confident in science. This should lead to more success in their high school courses and will hopefully contribute to students taking more than the two science credits required for graduation. If we can increase the number

of students who take additional science courses, we will be increasing the scientific skills and knowledge of our Helena community.

This Capstone Project has forever changed my view on science pedagogy. I have completely shifted from thinking that teaching science concepts is best done independent of scientific practices, to thinking that inquiry with disciplinary literacy is paramount to science teaching. I have learned that science education is significantly more than just STEM (science, technology, engineering, and math). We need to ensure that students can individually read, write, and communicate within these fields. If we want a society with a deep understanding of science, we must begin teaching science with the same methodology as Amplify Science. If we want students to be able to be scientists, then we must teach them like scientists. This project has given me the knowledge and confidence to begin working more closely with all teachers on incorporating daily, purposeful reading and writing in their classrooms.

Finishing this project amidst a global pandemic has been surreal. Supporting teachers and students through our current educational environment of online instruction has further iterated the importance of teaching students to how to independently construct science knowledge and skills. Amplify Science allows teachers to seamlessly use inquiry and embedded disciplinary literacy to help students gain this independence. The rug has been pulled out from under us and shifts in our teaching methods and educational philosophies must be expedited if we are going to continue to prepare students for high school and beyond. Authentic learning of science knowledge and skills in an online environment must include purposeful reading, writing, and communicating.

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APPENDICES

APPENDIX A
UNIT CONCEPT MAP

APPENDIX B
STUDENT CONFIDENCE SURVEY

Student Confidence Survey/Interview

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

1. I enjoy science.

- ☐ Strongly Disagree
- ☐ Disagree
- ☐ Neutral
- ☐ Agree
- ☐ Strongly agree

2. What do you like/not like about science?

Enter your answer

3. I find science difficult.

- ☐ Strongly Disagree
- ☐ Disagree
- ☐ Neutral
- ☐ Agree
- ☐ Strongly agree

4. What about science do you find difficult?

Enter your answer

5. I feel confident in my ability to learn science.

- ☐ Strongly Disagree
- ☐ Disagree
- ☐ Neutral
- ☐ Agree
- ☐ Strongly agree

6. Why do you feel confident/not confident in science?

Enter your answer

Submit

Never give out your password. [Report abuse](#)

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APPENDIX C
COLLABORATING TEACHER
INTERVIEW QUESTIONS

Final Interview Questions for Collaborating Teacher:

Impact on science performance and confidence:

1. What has been the impact of Amplify on students' performance in science thus far?
 - a. What are some skills that students have developed in science this year that you did not observe last year?
 - b. Are there specific SEP's you're observing on a regular basis?
 - c. What do you think the impact has been on students' content knowledge?
 - i. Are they learning content on a deeper level?
 - ii. Do they understand the CCC's on a deeper level?
 - d. Are there sub-groups (females, students with IEP's, etc.) that have been impacted most?
2. What has been the impact of Amplify on students' confidence in science this year?
 - a. Evidence?
 - b. What about the program helps students' build confidence in science?
3. Students made significantly more growth on the Rock Transformations and Plate Motions Unit than the E/S/M unit, why do you think that is?

Impact on confidence in reading/writing in science:

1. What has been the impact of Amplify on student confidence reading in science?
 - a. Evidence?
 - b. What reading strategies do you see students using on a regular basis?
 - c. In your opinion, are students better at comprehending what they're reading, how do you know?
2. What has been the impact of Amplify on students' confidence in writing in science?
 - a. Evidence?
 - b. What writing strategies are students utilizing?
 - c. In your opinion, are students becoming better writers?

Impact on students' abilities to write scientific arguments:

1. What has been the impact of Amplify on students' ability to write scientific arguments?
 - a. Evidence?
 - b. What are they doing well? What do they still struggle with?

APPENDIX D

VOYAGE TO PLUTO

COMMONLIT ARTICLE

Name: _____ Class: _____

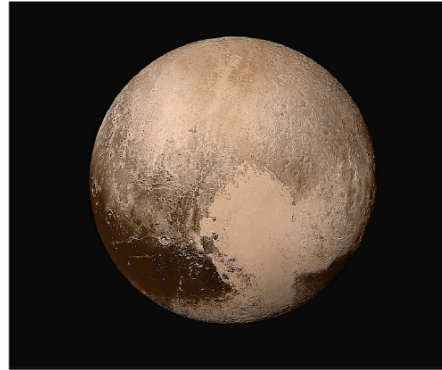
Voyage to Pluto

 By Ken Croswell, Ph.D.
2016

In this informational text, Ken Croswell discusses the New Horizons spacecraft's voyage to Pluto. The spacecraft was launched in 2006 and arrived at Pluto's system in 2015. Pluto was considered a planet until 2006, but then scientists decided it should not be counted as a planet. This announcement led to new interest in Pluto. As you read take notes on what the New Horizons spacecraft observed about Pluto.

- [1] In July 2015, a spacecraft named New Horizons sped past Pluto, the farthest world NASA has ever visited. The spacecraft found tall mountains on Pluto and deep canyons on its largest moon. "I think the solar system saved the best for last," said Pluto scientist Dr. Alan Stern.

Pluto is billions of miles from the Sun and Earth. It is so far away that our telescopes can't see it well. So no one knew what the spacecraft would see.



"Pluto's 'heart' is bigger than Texas!" by NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute is used with permission.

Pluto vs. Eris

Pluto belongs to a belt of objects beyond the orbit of the distant planet Neptune. If Pluto were as big as a basketball, the typical object in this belt would be smaller than a marble.

But in 2005, astronomers found a similar world, Eris, which is much farther than Pluto. "If it's not larger than Pluto, then I'll eat my telescope," the discoverer claimed. In 2010, Eris passed in front of a star and blocked its light. How long this event lasted revealed how big Eris is: 1,445 miles across.

- [5] The New Horizons spacecraft measured Pluto's size: 1,477 miles across. So Pluto is bigger than Eris. In fact, Pluto is the largest object in the solar system beyond Neptune.

A Cold World with a Heart

Pluto is so far from the Sun that sunlight there is weak. So Pluto is cold. The coldest temperature ever observed on Earth, near the South Pole, is -129 degrees F. But the spacecraft measured Pluto at -397 degrees F. Pluto is the coldest world a spacecraft has ever visited.

The New Horizons spacecraft surprised and delighted everyone by finding a huge white "heart" on Pluto. This heart-shaped region is a thousand miles across, bigger than Texas. Scientists named this heart Tombaugh Regio, after Clyde Tombaugh, who discovered Pluto in 1930.



Pluto's "heart" may be white because of frozen nitrogen and carbon monoxide. Nitrogen gas makes up most of the air on both Earth and Pluto. But Pluto is so cold that most of its nitrogen freezes and turns into ice. Carbon monoxide is a poison gas on Earth, but Pluto is so cold that this gas also turns to ice. Maybe geysers¹ or volcanoes in Tombaugh Regio erupt nitrogen and carbon monoxide gas that freezes, coloring this area white.

Pluto's heart has immense² mountains two miles high. That's as tall as the Rocky Mountains. But Pluto's mountains aren't made of rock. Instead, they're made of water ice! Pluto is so cold that its water ice is as hard as rock. Glaciers³ made of nitrogen ice flow across parts of Pluto.

Mysterious Moons

- [10] The spacecraft also looked at Pluto's five moons. The largest is Charon (pronounced "Karen" or "Sharon"). Spanning 753 miles, Charon is about half Pluto's diameter.

While Pluto is orange, Charon is gray, and it has a polar cap. The polar caps on Earth and Mars are bright white. Charon's polar cap is dark.

Charon has canyons that dwarf⁴ the Grand Canyon in Arizona. The Grand Canyon is about a mile deep; it formed when a river cut through rock. Charon's canyons are hundreds of miles long and up to four miles deep. They probably formed when Charon's crust tore apart.

Charon has craters that scientists have named for characters on the TV series Star Trek: Kirk, Spock, Sulu, and Uhura.

Like Earth, Pluto and Charon are round because they have enough mass that their gravity squeezes them into spheres. But Pluto's other moons are so small that their gravity isn't strong enough to force them into round shapes.

- [15] Styx is egg-shaped. Another moon, named Nix, is shaped like a jelly bean. The next moon out, Kerberos, looks like two small moons stuck together. And Pluto's outermost moon, Hydra, is shaped like Michigan's lower peninsula.⁵

The New Horizons spacecraft looked for more moons around Pluto but did not find any. That disappointed scientists.

But the mission was a big success. Someday another spacecraft may visit, one that will circle Pluto again and again. Then we can study Pluto and its moons for years, discovering even more about these distant and mysterious worlds.

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1. a hole in the ground that shoots out hot water and steam
2. **Immense (adjective):** extremely large, especially in scale
3. an unchanging form of dense ice that constantly moves under the pressure of its own weight
4. **Dwarf (verb):** to cause to seem small or insignificant in comparison
5. a piece of land surrounded by water on the majority of its border, while connecting to a mainland from which it extends

Voyage to Pluto Text-Dependent Questions

Directions: Answer the two multiple-choice questions by circling the letter of the correct answer.

1. Which statement best expresses the central idea of the text?
 - a. Pluto is likely the furthest point any spacecraft will travel in the universe, due to the length of the journey and temperature in space.
 - b. Scientists are now planning on sending a person to Pluto to further study the world and its moons.
 - c. After New Horizons spacecraft's trip to Pluto, scientists are ready to reclassify it as a planet due to its size and moons.
 - d. The New Horizons spacecraft was able to learn important details about Pluto's surface, landscape, and its moons.
2. Which detail from the text best supports the answer to Question 1?
 - a. "The spacecraft found tall mountains on Pluto and deep canyons on its largest moon. 'I think the solar system saved the best for last'" (Paragraph 1)
 - b. "But in 2005, astronomers found a similar world, Eris, which is much further than Pluto. 'If it's not larger than Pluto, then I'll eat my telescope'" (Paragraph 4)
 - c. "But the spacecraft measured Pluto at -397 degrees F. Pluto is the coldest world a spacecraft has ever visited." (Paragraph 6)
 - d. "But the mission was a big success. Someday another spacecraft may visit, one that will circle Pluto again and again." (Paragraph 6)

Directions: Write your response to Short Answer Question 3 below on the lines provided.

3. You have been studying the features of the biosphere, hydrosphere, atmosphere, and geosphere of different planets in our solar system. In this article, the author described many features of Pluto. Could humans live on Pluto? Cite evidence from the text to support your answer.

APPENDIX E

WHAT IS EARTH?

COMMONLIT ARTICLE

Name: _____ Class: _____

What Is Earth?

 By NASA
2015

This informational text explores what makes up the planet Earth, how it supports life, and its movement within the solar system. As you read, take notes on what Earth is made of and how scientists are able to study it.

- [1] Earth is our home planet. Scientists believe Earth and its moon formed around the same time as the rest of the solar system. They think that was about 4.5 billion years ago. Earth is the fifth-largest planet in the solar system. Its diameter is about 8,000 miles. And Earth is the third-closest planet to the sun. Its average distance from the sun is about 93 million miles. Only Mercury and Venus are closer.

Earth has been called the "Goldilocks planet." In the story of "Goldilocks and the Three Bears," a little girl named Goldilocks liked everything just right. Her porridge couldn't be too hot or too cold. And her bed couldn't be too hard or too soft. On Earth, everything is just right for life to exist. It's warm, but not too warm. And it has water, but not too much water.



"This picture of Earth is sometimes called the blue marble" by NASA is in the public domain.

Earth is the only planet known to have large amounts of liquid water. Liquid water is essential for life. Earth is the only planet where life is known to exist.

What Does Earth Look Like?

From space, Earth looks like a blue marble with white swirls and areas of brown, yellow, green and white. The blue is water, which covers about 71 percent of Earth's surface. The white swirls are clouds. The areas of brown, yellow and green are land. And the areas of white are ice and snow.

- [5] The equator is an imaginary circle that divides Earth into two halves. The northern half is called the Northern Hemisphere. The southern half is called the Southern Hemisphere. The northernmost point on Earth is called the North Pole. The southernmost point on Earth is called the South Pole.

How Does Earth Move?

Earth orbits the sun once every 365 days, or one year. The shape of its orbit is not quite a perfect circle. It's more like an oval, which causes Earth's distance from the sun to vary during the year. Earth is nearest the sun, or at "perihelion," in January when it's about 91 million miles away. Earth is farthest from the sun, or at "aphelion," in July when it's about 95 million miles away.

At the equator, Earth spins at just over 1,000 miles per hour. Earth makes a full spin around its axis once every 24 hours, or one day. The axis is an imaginary line through the center of the planet from the North Pole to the South Pole. Rather than straight up and down, Earth's axis is tilted at an angle of 23.5 degrees.

Why Do We Have Day and Night?

At all times, half of Earth is lighted by the sun and half is in darkness. Areas facing toward the sun experience daytime. Areas facing away from the sun experience nighttime. As the planet spins, most places on Earth cycle through day and night once every 24 hours. The North Pole and South Pole have continuous¹ daylight or darkness depending on the time of year.

Why Does Earth Have Seasons?

Earth has seasons because its axis² is tilted. Thus, the sun's rays hit different parts of the planet more directly depending on the time of year.

- [10] From June to August, the sun's rays hit the Northern Hemisphere more directly than the Southern Hemisphere. The result is warm (summer) weather in the Northern Hemisphere and cold (winter) weather in the Southern Hemisphere.

From December to February, the sun's rays hit the Northern Hemisphere less directly than the Southern Hemisphere. The result is cold (winter) weather in the Northern Hemisphere and warm (summer) weather in the Southern Hemisphere.

From September to November, the sun shines equally on both hemispheres. The result is fall in the Northern Hemisphere and spring in the Southern Hemisphere.

The sun also shines equally on both hemispheres from March to May. The result is spring in the Northern Hemisphere and fall in the Southern Hemisphere.

What Are Earth's Different Parts?

Earth consists of land, air, water and life. The land contains mountains, valleys, and flat areas. The air is made up of different gases, mainly nitrogen and oxygen. The water includes oceans, lakes, rivers, streams, rain, snow and ice. Life consists of people, animals and plants. There are millions of species, or kinds of life, on Earth. Their sizes range from very tiny to very large.

-
1. **Continuous** (*adjective*): continuing without being stopped or interrupted
 2. the imaginary straight line that something (such as the Earth) turns around

- [15] Below Earth's surface are layers of rock and metal. Temperatures increase with depth, all the way to about 12,000 degrees Fahrenheit at Earth's inner core.

Earth's parts once were seen as largely separate from each other. But now they are viewed together as the "Earth system." Each part connects to and affects each of the other parts. For example:

- Clouds in the air drop rain and snow on land.
- Water gives life to plants and animals.
- Volcanoes on land send gas and dust into the air.
- People breathe air and drink water.

Earth system science is the study of interactions between and among Earth's different parts.

Why and How Does NASA Study Earth?

NASA studies Earth to learn about how the planet changes. Earth's parts — land, air, water and life — are always changing. Some of the changes are natural and some are caused by humans. Scientists want to understand how Earth has changed in the past and how it is changing now. This information helps them predict how Earth might change in the future.

NASA studies Earth using satellites.³ Satellites look toward Earth from space. They take pictures of, and collect information about, all of Earth's parts. NASA satellites are especially good for observing clouds, oceans, land and ice. They also measure gases in the atmosphere, such as ozone and carbon dioxide. They measure how much energy enters and leaves Earth's atmosphere. And they monitor wildfires, volcanoes and their smoke.

- [20] Information gathered by NASA satellites helps scientists predict weather and climate. It also helps public health officials track disease and famine⁴. It helps farmers decide when to plant crops and what kinds to plant. And it helps emergency workers respond to natural disasters.

The more people know about Earth and its current and predicted changes, the better decisions they can make.

"What Is Earth" from NASA Knows (2015) is in the public domain.

3. an object placed in orbit around the Earth, moon, or other planet that collects information or is used for communication
 4. extreme lack of food

Name: _____

Date: _____

Period: _____

What is Earth? Text-Dependent Questions**Directions:** Answer the two multiple-choice questions by circling the letter of the correct answer.

1. Which statement best identifies one of the central ideas of the text?
 - a. The Earth's natural elements and distance from the sun allow humans and animals to live successfully on Earth.
 - b. Scientists' observations of Earth show that the planet may be habitable for humans in the future.
 - c. The Earth's placement in the universe guarantees that humans will always be able to live comfortably there.
 - d. Scientists' understanding of Earth's makeup and movement is still limited, but it is becoming more advanced through satellites.
2. Which detail from the text best supports the answer to Question 1?
 - a. "Earth is the only planet known to have large amounts of liquid water. Liquid water is essential for life. Earth is the only planet where life is known to exist." (Paragraph 3)
 - b. "Earth has seasons because its axis is tilted. Thus, the sun's rays hit different parts of the planet more directly depending on the time of year." (Paragraph 9)
 - c. "Earth's parts once were seen as largely separate from each other. But now they are viewed together as the 'Earth System.'" (Paragraph 16)
 - d. "NASA studies Earth to learn about how the planet changes. Earth's parts – land, air, water and life – are always changing. Some of the changes are natural and some are caused by humans." (Paragraph 18)

Directions: Write your response to Short Answer Question 3 below on the lines provided.

3. In this article, the author describes Earth's characteristics and movement within the solar system. List at least two ways that Earth's characteristics or movement impact humans. Cite evidence from the text to support your answer.

APPENDIX F
COMMONLIT ARTICLE STUDENT
ANNOTATION TRACKER

Active Reading Strategy	Used?			
	Yes		No	
	#	%	#	%
1. Highlighting challenging words/phrases				
2. Annotations to record thinking				
3. Questions				
4. Connections to own experiences				

APPENDIX G
SCIENTIFIC ARGUMENT SCORING RUBRIC

4 Exemplary	An exemplary response: • Gives sufficient claim that answers the question • Includes two or more pieces of specific evidence from the text/unit that supports the claim • Has detailed, scientific reasoning of how each piece of evidence supports the claim • Writing is organized, with the claim listed first, followed by evidence 1 and then reasoning 1, etc.
3 Adequate	An adequate response: • Gives sufficient claim that answers the question • Includes one specific piece of evidence from the text/unit that supports the claim • Gives adequate scientific reasoning of how the piece of evidence supports the claim • Writing is organized, with the claim listed first, followed by evidence 1 and then reasoning 1, etc.
2 Partial	A partial response: • Claim insufficiently answers the question • Includes general or not specific evidence from the text/unit • Does not provide adequate scientific explanation of the evidence • Writing is unorganized
1 Minimal	A minimal response: • No claim or claim doesn't answer the question • Lacks evidence or evidence doesn't support the claim • Lacks scientific explanation of evidence • Writing is unorganized
0 No credit	A response gets no credit if it provides no evidence of the ability to answer the prompt, answers without relevant information.

APPENDIX H
STUDENT SELF-ASSESSMENT
READING SURVEY

Student Reading Survey

Participation in this research is voluntary and participation or non-participation will not affect your grade in this class in any way.

1. Read each sentence and decide whether it describes a person who is like you or different from you. There are no right or wrong answers.

	Very different from me	A little different from me	A little like me	A lot like me
When I read I think about if I'm understanding what I'm reading.	☐	☐	☐	☐
When I read I make connections to my own experiences and/or knowledge.	☐	☐	☐	☐
When I read I take notes (annotate) about what I'm thinking.	☐	☐	☐	☐
When I read I highlight challenging words or phrases.	☐	☐	☐	☐
When I read I add my own notes and/or record any questions I have.	☐	☐	☐	☐
When I read I look carefully at the visual representations (graphs, pictures, charts, diagrams, etc.).	☐	☐	☐	☐
After reading, I discuss what I read with someone else to check own understanding.	☐	☐	☐	☐

Submit

APPENDIX I
STUDENT INTERVIEW QUESTIONS

Final Interview Questions for Students

1. How do you feel about reading science articles now?
 - a. Are there certain strategies you use to help yourself understand what you're reading in science?
 - b. Do you feel more confident in your ability to read in science? Why or why not?
2. How do you feel about writing scientific arguments now? (CER)
 - a. Are there certain strategies you use to help yourself write these?
 - b. Are there parts that are still difficult?
 - c. What do you find the easiest?
 - d. Overall, do you feel more confident in your ability to write in science? Why or why not?