

INVESTIGATING READING STRATEGIES IN A
HIGH SCHOOL EARTH SCIENCE CLASSROOM

by

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of

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DEDICATION

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ABSTRACT

The majority of science teachers consider reading to be an important skill for students to master yet most teachers agree that their understanding of how to teach the cognitive and metacognitive processes to increase student comprehension of scientific text is lacking (Yore, 1991). My goal was to address this gap in my pedagogy, by integrating four different reading strategies into my Earth Science curriculum. The primary purpose was to measure the students' comprehension of scientific text using four reading strategies. The secondary research questions investigated the change in student attitudes and self-confidence when using reading strategies, how choice impacted student comprehension, attitudes and self-confidence, and finally how including reading strategies impact my teaching practice. To answer these questions, students completed a Likert survey measuring student attitudes, self-confidence and beliefs towards reading. Then each reading strategy was taught, first by modeling for the entire group, then with small groups and finally each strategy was completed independently. Students completed assessments using word associations to measure student comprehension using each reading strategy. After students mastered each strategy, they began to choose which strategy to use when reading. The same Likert survey was administered at the conclusion of the study. The results showed that implementing a reading strategy increased student comprehension of scientific text to a statistically significant margin. However, there was no statistical significance when comparing student comprehension rates between each reading strategy. The scores between Likert surveys did increase significantly, however there was not a significant difference in student self-confidence when reading using a reading strategy. According to student interviews, choice was the largest factor to impact student behavior towards reading. The implications of the action research project finds that reading can be integrated into the inquiry process to create a more student centered approach to teaching.

INTRODUCTION AND BACKGROUND

“The quality of our reading is not only an index of the quality of our thought, it is our best known path to developing whole new pathways in the cerebral evolution of our species” (Wolff, 2018, p.8).

Context of the Study

An educator’s hope is to instill a love of learning and academic independence in students. While there are many methods in which to do so, reading remains the primary skill to uncover new worlds of thought. As a student, reading allowed me to follow my interests in science past the textbook, to classic nature writing, which inspired me to major in Environmental Science and English. When training to become a science teacher, I did not realize that I was missing a vital aspect of my education – teaching students to read scientific text. I thought of science reading as vibrant and multifaceted, yet my teaching was dry and methodical.

This result is not uncommon. While science teachers consider reading to be an important skill to include in science education, their understanding of the cognitive and metacognitive skills needed to teach science literacy are fragmented (Yore, 1991, p. 55). The lack of specific teaching strategies in content-based classes could be a result of a lack of reading instruction in educational programs (Hall, 2005, p. 411). However, this phenomenon could also result from assumptive teaching, or the tendency for teachers to unconsciously take for granted that students know how to read and that other instructors will teach the students specific reading strategies (Herber, 1970). I have to admit, that my

lack of teaching reading in the science classroom stemmed from both of these factors, but also from my students clear dislike of reading.

In a digital culture, our brains are adapting to reading by leaping from one topic to another, which Maryanne Wolf (2018) compares to a grasshopper leaping across a field. These short moments of attention result in a decreased ability to closely analyze a text, especially with children, since when we are distracted by stimuli, we will not be able to consolidate “reservoirs of knowledge” and therefore, have less capacity to “draw analogies and inferences when read(ing)” (p. 9). Yet administrators argue that literacy is the main way to increase student achievement, especially in “under resourced, and low income” schools (McDaniel and Riddile, 2015, p. 58). This is applicable to the school where I teach, since the economically disadvantaged population is 40.8 percent (OPI GEMS, 2020). The school’s ACT Reading score is a 19.7 in comparison to the state’s average of 20.2 (ACT, Inc. 2019) indicating that my students have room to grow in comprehending academic text.

Reading can do much to influence academics overall since the emotions that result from reading can change our students’ culture. One example is a study of 13,737 college students that found a 40 percent decline in empathy over the past twenty years, with a sharpest decline over the past decade (Konrath, O’Brien, Hsing, 2011). Multiple studies state that empathy is partially a learned trait; one that Wolf (2018) argues is best taught through deep reading (Reiss, 2010, Carr, Dubeau, Mazzoita, Lenzi 2003). With a decline in empathy, Konrath et al. (2011) cite an increase in narcissism, violence and bullying. Perhaps by including more deep reading in my classroom, I could encourage my students to understand the other’s perspectives, an essential skill to employ when navigating a world of

divergent cultures. Reading with empathy is especially essential when students engage in controversial text on Earth Science topics, such as energy use, climate change and geological time.

Focus Questions

In order to fulfill the purpose of this classroom research topic, I gathered data to answer the following questions. The overarching question that guided the entire project was, “How does the integration of specific reading strategies impact students’ comprehension of scientific text?” To relate the effect of these reading strategies to the purpose of this project, I answered the following sub questions.

- How does including specific reading strategies in my practice impact my teaching?
- How do student attitudes and self-confidence regarding scientific text change when using reading strategies?
- If students are given the choice of reading strategy, how does this impact their reading comprehension, attitudes, and self-confidence?

CONCEPTUAL FRAMEWORK

Introduction

Within science education, there is minimal teaching of intentional communication skills. This seems to be resulting in students who are not scientifically literate and who cannot critically analyze scientific findings. Science literacy and evaluating scientific findings is especially important in Earth Science, so that a student can evaluate the accuracy of articles that relates to current societal issues, such as climate change (Rupley, 2010, p. 203). In a study of 36 geoscientists and educators, the most valued role of Earth Science was to educate the public before decision making, especially as a response to disaster planning, weather and climate events, and economic impacts related to Earth Science concepts, such as resource extraction (LaDue & Clark, 2012, p. 375). A student's ability to use their knowledge to "participate in decision making that ... affects others in the global community" is a key component of science literacy, according to the National Science Education Standards (as cited in Krajcik, Sutherland, 2010, p. 456).

A student's scientific literacy, or ability to think "critically and creatively about the natural world" using the scientific method, is what is measured in science specific standardized tests (Maienschein, 1998, p. 917). The Trends in International Mathematics and Science Study (TIMSS) is the international standardized test that measures scientific literacy. Of forty-seven countries that participated in the study, the United States ranked tenth, behind countries with fewer resources, such as Poland and Kazakhstan (TIMSS, 2015). While the purpose of the standardized test is to measure students' science knowledge, researchers argue that student reading ability erodes the validity of the TIMSS

and other science standardized tests (Visone, 2010, p. 96). In a study of 135 eleventh grade students who had taken the Connecticut standardized test in science, researchers found that good readers are able to “allocate time more efficiently and persist longer with difficult text during standardized tests, while poor readers are more likely to waste time and quit with difficult material” (Visone, 2010 p. 98). Students who were able to read for detail, ignore irrelevant information, retain information, reread difficult text, and use content clues were more successful on science specific standardized tests (Visone, 2010).

The instruments we use to measure science mastery also measure reading, yet science teachers have mixed attitudes regarding the importance of teaching reading in their classrooms. Nineteen studies found that teacher attitudes ranged from the opinion that content area teachers cannot or should not teach reading; that teaching reading is the responsibility of others; to the idea that teaching reading in the content area is important, but the teacher does not know how to teach reading (Hall, 2005, p. 406). When these teachers taught reading, vocabulary instruction dominated the lesson, and there was little instruction on “effective strategies for increasing comprehension within their own subject area” (Hall, 2005, pp. 410- 411).

For science teachers specifically, teachers lack the skills to teach the skills required to learn from scientific texts (Yore, 1991, p. 55). Since the 1960s, science teachers have identified comprehension as the skill in which students were least competent. Yet there is push back increasing the amount of reading instruction because of increased content required by standards and reduced instructional time (Yore, 1991, p. 56). Time spent reading in the science classroom may be well spent, since recent studies have found that

combining reading with hands-on inquiry approaches leads to better learning than singular inquiry activities or simply reading about science (Rupley, 2010, p. 203).

Information Processing Theory

The information processing theory is based on the idea that humans want to make sense of their surroundings, then process that information using their memory before structuring and organizing the information into their mental schema (Tadlock, 1978). The organization is done in the most meaningful way to interrelate the idea with other categories that are similar in the person's existing schema so that the information is available for future recall. Information processing is necessary because an individual's brain cannot process all the stimuli from the surrounding environment, since their own cognitive load limits each individual (Tadlock, 1978). Kintsch and Van Dijk (1983) suggest the information processing theory helps the reader create three different mental representations of the text. First the reader establishes a literal idea using the exact wording of the text, then a semantic concept that describes the meaning of the text, and finally a situational idea, which connects the meanings of the text. Each step in a strategic reading strategy aims to move information from a text to a student's long-term memory by first preparing the reader with pre-reading questions or with surveying the text to determine an essential question for the reading. To process the information in the reading, students need to develop questions to tie the new information to existing cognitive categories. Then the reader needs to apply the information in some way to move the information into the long-term memory (Tadlock, 1978, p. 111). An effective reading strategy slows down the

processing of information in the text to allow for comprehension and integration into the reader's mental schema (Tadlock, 1978, p. 112).

Reading Strategies

The two following reading strategies apply the Information Processing Theory and have been used in formal studies to observe how the reading strategy has impacted student comprehension of text. In order to measure student comprehension of text, researchers suggest using student understanding between connections of key terms.

Concept Mapping. Utilized in Magnet Summaries using PLAN

To increase reading comprehension, it has been recommended that students be taught multiple methods that incorporate predicting, summarizing, questioning and graphic organizers (Burdumy et. al, 2006; Zmach et al., 2007). These methods require students to connect the information in the reading to their prior knowledge, which applies the Information Processing Theory. One common graphic organizer is a concept map, which allows the instructor to view how well a student comprehends specific structures in a text (Oliver, 2009 p. 403). Schmid and Telaro (1990) completed a study comparing student relational thinking with a group of high school biology students that used concept maps for one month versus comparison groups of students who did not complete the mapping. Students who were considered to have low reading ability outcompeted their comparison group of low ability readers and matched the ability of the high ability students in the comparison group. A study by Oliver (2009) of 74 sixth grade science students found that

students were able to classify sequencing and explanatory statements using concept mapping, but have more difficulty identifying cause and effect statements (p. 408). The study did not find major differences in success between reading ability, but did find that students struggle to detail specific relationships between terms (p. 410).

KWHHL: A modified Know-Want-Learn Strategy. KWHHL is a modification of the Know-Want-Learn (KWL) strategy devised by Susan Szabo, a reading intervention teacher, who applied the strategy in an eighth grade classroom. Szabo observed that the structure of KWL using questions before, during and after reading was effective for students to monitor their own comprehension (Szabo, 2006, p. 59). However, the KWL strategy did not encourage students to reflect if their prior knowledge was correct, did not encourage students to formulate questions when reading the text, and did not increase vocabulary development. To address the limitations of KWL, Szabo added positive, and negative column to the “know” section of the strategy to help students establish their initial beliefs about the topic (Szabo, 2006, p. 61). From a science teacher’s perspective, this is where to include an inquiry activity for students to develop initial thoughts about the topic, before researching initial ideas using text.

The second section of the strategy, “What do I want to find out” was adapted to encourage more student questioning while reading by dividing the initial table into a “before reading” and “while reading” question section. In order to develop student vocabulary knowledge, Szabo added two vocabulary sections – the “head” and the “heart.” Vocabulary development allowed for differentiation, and allowed students to focus on two to three words per category.

In the “head” category, students define both content specific words and non-specific words (Szabo, 2006, p. 62). In the “heart” section, students identified words or phrases that created an emotional response (Szabo, 2006, p. 63). While this section created mixed responses, with time Szabo’s students began to create responses that showed how linking prior experiences to the reading increased comprehension. Using these words, the students created a word wall using the three to five words students selected from each text.

The final section, or the L, for What did I learn? section, required students to reflect on their comprehension by summarizing and evaluating the text. Through the study, Szabo saw students increase their skills in summarizing a text, but students continued to have difficulty connecting what they had learned to their prior knowledge. To adapt to this limitation in the strategy, students looked back at the information in the K column to determine if their knowledge on these ideas “stayed the same,” was “correct, but added to” or if the student “adjusted (the knowledge because) it was flawed” (p. 64). This strategy is concrete, is clear on how to implement, and builds on the understanding of cognition as outlined in the Information Processing Theory.

Study Methodology in the Literature

Measuring reading comprehension can be difficult to assess. Kintsch & Kintsch (2005) found that multiple-choice assessments use only short texts and a few questions, which limits the assessment of longer texts (as cited by Davis & Guthrie, 2015, p. 150). According to Goldsmith et al. (1991) using an essay assessment limits the amount of measurement of structured comprehension, since counting the number of ideas presented in the essay results in imprecise data (as cited by Davis & Guthrie, 2015, p. 150). Proximity

data, where students rank the similarities between two concepts can be used to quantitatively determine not only the understanding of individual concepts, but also the individual's hierarchical organization of these concepts (Davis & Guthrie, 2015, p. 150).

Davis and Guthrie created three studies, one of 168 students in third grade classrooms, the second of another 168 students in third grade the following year and a third of 160 ninth grade students (Davis & Guthrie, 2015, p. 151, 154, 158). The studies measured the comprehension scores using proximity data in comparison to traditional free-recall essay assessments, measurement of prior knowledge and questioning strategies and text signals (Davis & Guthrie, 2015, p. 148). This assessment strategy is consistent with the student responses to free responses, and distinguishes students who are able to determine the structure of the text, as well as create inferences between concepts in the text (Davis & Guthrie, 2015, p. 161). The assessment was designed in the following manner.

The first step in designing the assessment is to determine the key words of the text, some of which represent the conceptual knowledge of the reading, one word symbolizing the main theme, and two words symbolizing the main concepts, and finally six words that symbolizes supporting details. Students responded to word relationships by ranking the pair as a 9, if the words were highly related, and 1 to word pairs that were not related. To evaluate the student's response a Pearson correlation was calculated comparing a student's rankings to an expert's rankings. This was determined by subtracting the ranking by the student from the ranking from the expert. The word relationships were divided into hierarchical relationships by relating a theme word to a concept word, concept words to other concept words and concept words to "supporting phenomenon" such as move – swim

(Davis & Guthrie, 2015, p. 151). The second relationship measured student ability to create inferences from the text, by using groups of three words by relating two words through a third word. Davis and Guthrie (2015) explain the process with the following example, “if a reader understands that *paddle* and *webbed* are both related to *move* the reader should also understand the *paddle* and *webbed* should be related as well” (p. 152). The correlation between a traditional free response showed a high correlation between student comprehension with the hierarchical relationships, but showed less correlation between inference questions and traditional response for lower level readers (Davis & Guthrie, 2015, p. 154). This study provides evidence to support assessing student comprehension using proximity data of keywords.

Hart (2012) implemented a similar action research project measuring the effectiveness of reading strategies with a freshman science course in a school that was identified as “low achieving” in reading (p. 3, 1). Prior to the study, Hart identified where each strategy would relate to the content being taught, and implemented each strategy three times. She modified the strategy throughout the study if it was not effective. To scaffold the instruction of the strategy, Hart demonstrated the strategy, then students implemented the strategy using teaching prompts with a partner before using the strategy independently (Hart, 2012, p. 9). To gather data on the effectiveness of each strategy, Hart gathered a Student Confidence and Attitude Survey using a Likert scale and a few qualitative questions, an instrument to measure student comprehension when using the reading strategy, a student evaluation of the effectiveness of the strategy, and she conducted focus group interviews. As I planned my own action research, I decided to use proximity data

using word relationships, coupled with a diversity of instruments and flexible methodology, allowing me to gather enough valid and reliable data to analyze the effectiveness of each reading strategy.

METHODOLOGY

Demographics

This study was conducted at Columbia Falls High School, in Columbia Falls Montana. Columbia Falls High School is a public high school with an enrollment of 643 students. Of these students, 31 percent are eligible for free and reduced lunch. Of these students 40-44 percent are proficient in reading and language arts, compared to the state average of 51 percent (Public School Review, 2019). I chose to analyze my class with the greatest diversity in grades, with four students earning an A, nine students earning a B, seven students earning a C and three students earning a D. At the time the study was implemented, no student earned a failing grade. Of the twenty-two students in the class, there were thirteen males and nine females. One student is identified as gifted, and one student receives services in a 504 plan to accommodate for attention deficit disorder.

Treatment

When teaching specific reading strategies, I organized the treatment into an introduction, in depth implementation, and then a comparison phase. All students used the same reading strategy to complete each reading during the initial phase of the study. First, I modeled how to employ each strategy, including modeling my metacognition while reading out loud. Students followed along, then read the last paragraphs with a group and completed the reading strategy with support from this small group. As the week progressed, I removed the scaffolds, by decreasing the group size until students were using the strategy independently.

I implemented the reading strategies in order of increasing complexity. While all strategies apply the Information Processing Theory, each strategy requires the student to create more connections within the content in the text as well as with their own background knowledge. During the final week of the study, students chose which strategy they preferred to use when reading. During this time students completed a word association assessment and survey to measure how choice impacts student comprehension and attitudes towards reading. The reading strategies implemented are listed in Table 1 below. These strategies can work with a variety of texts to create the metacognitive questioning strategies that are used by master readers. The study began in October and concluded in February. These strategies have also been studied in a variety of educational studies (Szabo, 2006; Barton & Jordan, 2001). (To view a consolidated version of each of these strategies, see Appendix A.)

Table 1. Reading strategies.

Anticipation Guide	The Anticipation Guide is the most simplistic reading strategy, so I implemented this first. The strategy requires the teacher to develop four to six questions that prompt the students to assess prior knowledge and promote interest in the concept. Before reading, students will mark a check box next to each statement they agree with. Then students will explain why they marked their responses. Then students will read looking for evidence for each statement. If a student agrees with a statement, and finds evidence to support this fact, they will record this evidence. If their initial choice was incorrect, the student will record the evidence from the reading that disagrees with the statement. After completing the activity, students will discuss what they have learned (Barton & Jordan, 2001, p. 73).
Magnet Summary using PLAN	A magnet summary is a summary written from a concept map created when reading a text. From my experience, students struggle prioritizing which information should be included in a concept map. The PLAN strategy requires students to first <i>predict</i> the text structure and content, which become the main circled terms in the concept map. Then students <i>locate</i> their prior knowledge, by writing

	a checkmark next to the terms they are familiar with, and write a question mark next to unknown terms. In the third step students <i>add</i> information about each concept, to add new knowledge if the concept had a question mark, or clarify existing knowledge, if the concept had a checkmark. Finally, students make <i>note</i> of what they have learned by writing a summary of the reading, only using the information in the concept map. (Barton & Jordan, 2001, p. 95).
LAPS for science – a protocol for critical reading of texts	Using this method, students build their ability to think beyond the literal meaning of the text into analysis and evaluation of evidence. The first step, students Look! to determine the literal meaning of the text. Second, students Analyze! To determine how the author communicates this information. Third, the students Prove it! using evidence from the text. Finally, students relate the text to other learning, to themselves, or to what they consider to be important through the So What? process.
KWHHL (Modified Know-What-Learn)	The know-what-learn strategy creates a structure for students to develop questions before, during and after reading to allow students to monitor their own comprehension (Szabo, 2006, p. 59). In the initial know category, students could observe a demonstration or conduct an inquiry activity to establish prior knowledge before reading. The next step, “what I want to find out,” students develop before reading questions, by looking through the structure of the reading and diagrams. Students answered these questions while reading and developed new questions while reading. The next section “head and the heart” requires students to define content related words, and words that elicited emotion while reading (Szabo, 2006, p. 62). The final section, “what did I learn?” students summarize the text, then look back at the first section of the strategy to see if their knowledge stayed the same, if their knowledge was added to by the reading, or if their knowledge changed due to an initial misconception (Szabo, 2006, p. 64).

Data Collection and Analysis Strategies

Prior to beginning the study, I measured student comprehension of a National Geographic Encyclopedic Entry on erosion without directing students to use a specific reading strategy (“Erosion,” 2018). After students completed the comprehension pre-assessment, students responded to the Student Beliefs, Attitudes and Self-Confidence

Survey (See Appendix B). After this initial baseline was established, students began to use the reading strategies. When teaching each strategy, I reflected on my experiences, and recorded student reactions using a journal template. (See Appendix C). Student samples were also collected during this time to evaluate. After a week of implementing the reading strategy, students completed a reading comprehension assessment (see Appendix D) using the proximity data through word associations method. After students completed the assessment, four students responded to focus group interviews. All students responded to a survey to monitor their attitudes regarding the reading strategy (see Appendix E). This instrumentation was followed for each reading strategy, until all four strategies were implemented. At this time, students completed the Student Believes, Attitudes and Self-Confidence Survey they responded to in the beginning of the study. During the final week of the classroom research project, the students chose the reading strategy they preferred. I monitored the reading strategy students chose, as well as any change in student attitudes and self-confidence in reading as measured by student surveys, focus group interviews and observations.

These methods were chosen to provide multiple methods to address each research question using different techniques. The diversity of instrumentation also provides both qualitative and quantitative data using an explanatory mixed methods design for each research question. The survey students completed before and after the study includes questions from the Adolescent Motivation to Read questions, and questions from a survey on middle school students' awareness of strategies for resolving comprehension difficulties in reading (Pitcher, Albright, DeLaney, et. al, 2007, p. 378; Craig and Yore, 1996). A

Classroom Assessment Technique by Angelo and Cross (1993) was used to develop self-confidence questions for the survey. The Lexile level of all readings were recorded and all comprehension assessments used the same proximity data through word associations assessment. The following matrix depicts the data collection and research methods used to answer the research questions. In sum, validity of this study was founded in using instruments and strategies from peer reviewed educational literature, as well as feedback from colleagues, professors and reading experts in the community.

Table 2. Research questions, data collection and research methods.

Initial and Final Self Confidence, Attitudes, Beliefs Survey	Reading Comprehension Pre-test (no strategy implementation)	Reading Comprehension Assessment (one per strategy, also after student choice)	Teaching Reflections Journal	Student work samples	Reading Strategy Effectiveness Survey	Focus group interviews (one conducted per strategy)	Focus group interview (overall changes in reading attitudes)
<i>Research question: How do specific reading strategies impact students' comprehension of scientific text?</i>							
	✓	✓	✓	✓	✓	✓	✓
<i>Sub-question: How does including specific reading strategies impact my teaching?</i>							
✓			✓		✓	✓	✓
<i>Sub-question: How do student attitudes and self-confidence regarding comprehending scientific text change when reading strategies?</i>							
✓						✓	✓
<i>Sub-question: How does student choice impact reading comprehension, attitudes and self-confidence?</i>							
✓			✓	✓	✓	✓	✓

The research methodology for this project received an exemption by Montana State University's Institutional Review Board (Appendix F) and compliance for working with human subjects was maintained throughout the course of the study.

DATA AND ANALYSIS

Results: Comprehension

Before the study began, students read the article *Erosion*, an entry in the National Geographic Resource Library (“Erosion,” 2018). Students read for fifteen minutes, using any reading strategy they knew prior to any instruction on reading strategies. Then students completed the reading comprehension assessment using word associations as designed by Davis and Guthrie (2015). Following the pre-assessment, students then read a sequence of articles by Tristin Scott for the Flathead Beacon on the Superfund site in Columbia Falls, Montana. While reading, students used the reading strategy of their choice. When done reading, post-intervention student comprehension was measured by the word association technique (See Appendix D). A t-test was used to compare student comprehension scores. The mean pre-test score of this pre-assessment was 6.28, and the posttest score was 12.78. The variance prior to the study was 1.60, and after the study the variance was 4.95. A two-tailed *p-value* was used to account for positive and negative differences from the mean. Using a two-tailed *p value*, the *p value* was less than 0.0001, signifying a statistical significance, rejecting the null hypothesis that reading strategies did not have an impact on student comprehension of scientific text. When including incomplete or students with a zero score on either assessment, the *p value* was also less than 0.0001, which rejects the null hypothesis.

However, when comparing the comprehension scores between reading strategies there was no statistical significance. Using an ANOVA test to analyze the variance

between students who completed all reading strategies ($n=15$), the p value was 0.19.

Therefore the p value accepted the null hypothesis that there was no significant difference between student comprehensions of the articles based on the reading strategy used. When expanding the sample size to include all students who participated in the study, including zeros and incomplete work, ($n=19$) the p value increased to 0.21, in part due to the large variance in the LAPS reading strategy. See Table 2 below. This result also supports the null hypothesis that there is no difference in student comprehension due to the type of reading strategy when reading.

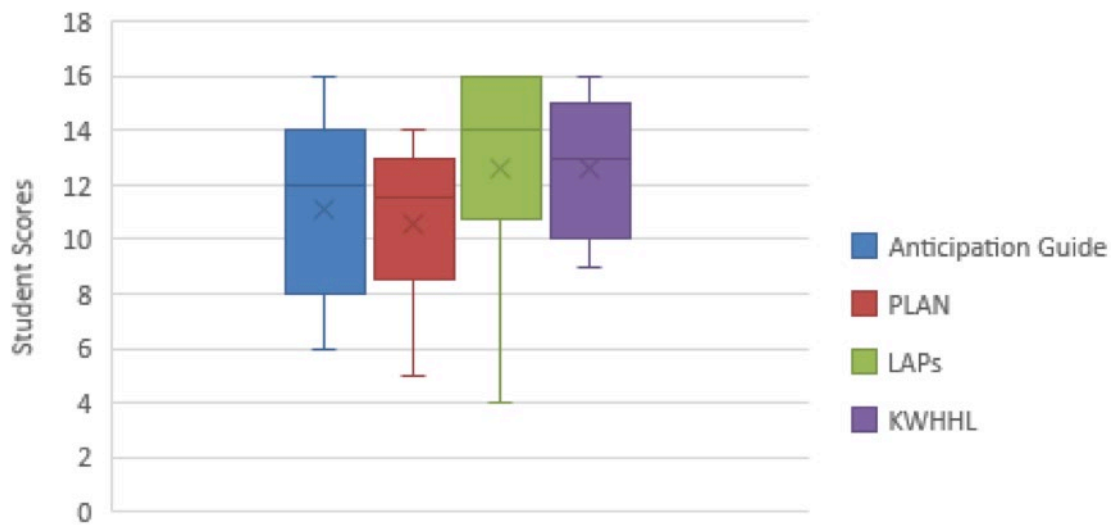


Figure 1: Reading Strategies Comprehension Scores: No Zeros ($N=15$)

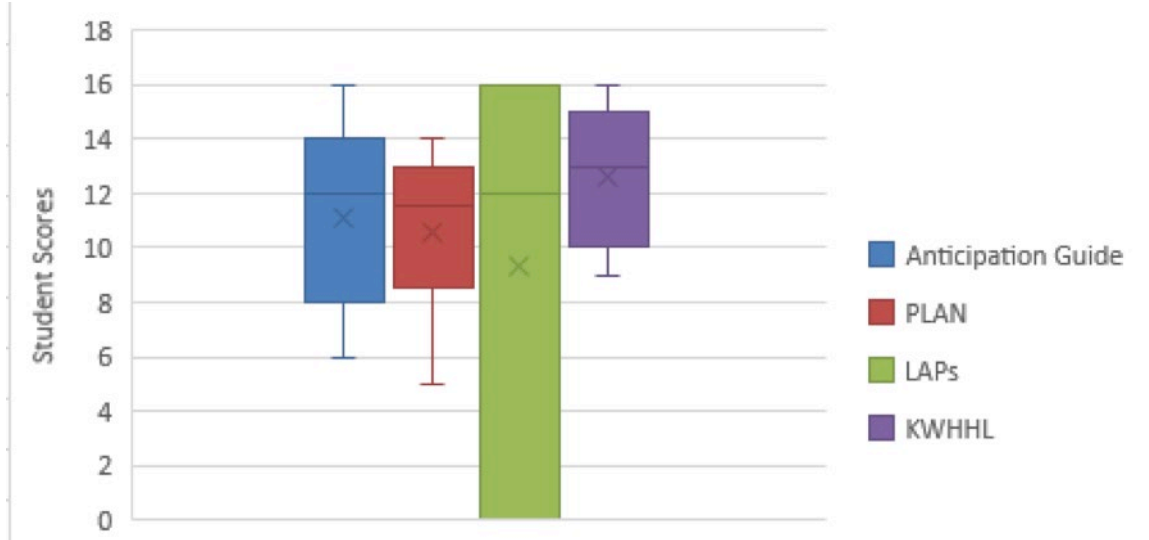


Figure 2: Reading Strategies Comprehension Scores: All Data ($N=19$)

Using this data analysis, it can be concluded that there is a statistically significant improvement in student comprehension of scientific articles using reading strategies; however, there is not a clear statistical significance to suggest that there is one reading strategy that is most beneficial to student comprehension. This conclusion was supported by student focus groups. Repeatedly students stated that reading helped to support their understanding of the scientific concepts taught in class. However, when asked specifically what aspects of the reading strategies increased their comprehension the answers varied widely. Of the seven students interviewed in the focus group, 42% ($n=3$) of the students preferred the anticipation guide. One student claimed this was because it helped “me look for the four main ideas” and then “actually have to use evidence to support my answers.” Another 28% ($n=2$) students in the focus group felt the anticipation guide caused the reader to “just focus on guessing and checking myself” and “just read to try and pin point things rather than reading the whole thing.”

From these interviews a clear pattern emerges: the thought processes of students and their motivation to read largely influenced their comprehension when using specific reading strategies. Students stated that interest in the article was a large factor in their understanding of the text. Students who focused on reading for “facts” felt they had increased comprehension with the “bubble map” (PLAN strategy) or students who preferred to generate summaries and applications of the information choose the KWHHL (Modified Know-What-Learn) and modified LAPs strategy. It can therefore be concluded that no one specific reading strategy increased student comprehension of scientific text more than other specific reading strategies.

Student responses to surveys for each strategy also support these conclusions. When explaining the benefits of the PLAN strategy, a student wrote, “this strategy makes you use the knowledge and better process the information and the headers and reviewing the details are helpful.” Another student repeated the idea that the bubble map allowed the student to organize the facts by “helping me understand key ideas and show how things are connected.” Students who chose KWHHL liked to generate their own questions about the topic before reading to motivate their own learning rather than having the teacher generate the purpose for the reading. The LAPS strategy was the most complex, and students repeatedly told me they “hated” the strategy both as off hand comments in class and in written surveys. Students told me that their hatred of strategy was the reason why 25 percent ($n=5$) of students did not complete the strategy responses and assessments (see Figure 2). They found the amount of information required in the strategy to be “crowded” and “distracting.” However when students began to choose a strategy to apply, 38% ($n=6$)

of students chose the adapted version of the strategy. Students wrote that this strategy “helped me focus on the evidence and I found it helpful to write, as I remembered it better. It is helpful that it is broken down into so many steps, which made it slightly more understandable. It is hard to re-word what you read and have it make sense. It was boring and really hard to find the questions it was asking.” The variety in student responses in the interview and survey data supports the ANOVA statistical conclusion that suggests one specific reading strategy did not result in significant difference in reading comprehension in comparison to the others.

As Maryanne Wolff (2018) writes, each individual reacts to reading differently based on how his or her brain organizes language. Therefore the influence of the reading strategy on his or her comprehension of text will be variable based on the neurological pathways of the individual’s brain. There was no correlation between the student’s preferred reading strategy and student’s comprehension in this study, or between the reading strategy used and the student’s standardized STAR reading assessment score.

The diversity of topics and article types assigned with each reading strategy may have influenced the study’s findings. Articles came from various news outlets and authors, and one section was assigned from the textbook. As students reported in the surveys and interviews, interest in the topic influenced student comprehension of the text. Also, the PLAN reading strategy assessment required more lateral thinking (such as analyzing the connection between deforestation in Haiti and corruption in the government) in comparison to more linear connections (exfoliation and temperature change) in other assessments.

From this study it is clear that students must interact with the text in some way to increase the comprehension of the text. This aligns with the information processing theory (Tadlock, 1978). While there was not one specific strategy that impacted students' comprehension relative to others, a specific reading strategy was needed for students to interrelate the information with their initial understanding of the scientific information. In all strategies students had to apply the information to move it into their working memory.

Results: Attitudes and Self-Confidence

To determine a change in student attitudes and self-confidence regarding reading, students completed a Likert survey before and after the study. To analyze these results a Wilcoxon's Signed Rank Test was used, since the assessments were matched and the sample size was below thirty, with a sample size of 16 students. The null hypothesis was that there would be no difference between the student surveys before and after the study.

Table 3. Wilcoxon's Signed Rank Test for Prior-to-Study and Post-Study Total Scores.

#	Student	Prior-to-Study	Post Study	Post-Prior	Post-Prior	Student Sorted	Sorted	Rank	Mean	Mean Signed	W+	W-
		Total Score	Total Score			by Post-Prior	Post-Prior		Tied Ranks	Tied Ranks		
1	A.L.	40	41	1	1	B.A.	0	0	-	-	-	-
2	B.A.	44	44	0	0	M.S.	0	0	-	-	-	-
3	B.L.	46	49	3	3	A.L.	1	1	2.5	2.5	2.5	0
4	B.R.	32	37	5	5	F.C.	1	1	2	2.5	2.5	0
5	C.GE.	29	37	8	8	J.D.	1	1	3	2.5	2.5	0
6	C.GO.	23	29	6	6	R.B.	1	-1	4	2.5	-2.5	-2.5
7	C.N.	37	43	6	6	R.A.	2	2	5	5.5	5.5	0
8	D.P	27	31	4	4	T.S.	2	2	6	5.5	5.5	0
9	E.B.	44	40	-4	4	B.L.	3	3	7	7.5	7.5	0
10	F.C.	34	35	1	1	G.C.	3	-3	8	7.5	-7.5	-7.5
11	G.C.	48	45	-3	3	D.P	4	4	9	9.5	9.5	0
12	J.D.	31	32	1	1	E.B.	4	-4	10	9.5	-9.5	-9.5
13	M.S.	29	29	0	0	B.R.	5	5	11	11.0	11.0	0
14	R.A.	34	36	2	2	C.GO.	6	6	12	12.5	12.5	0
15	R.B.	35	34	-1	1	C.N.	6	6	13	12.5	12.5	0
16	T.S.	40	42	2	2	C.GE.	8	8	14	14.0	14.0	0
Sum (check):							105	105	Sum: 85.5 -20			

Note: N=16

As seen in Table 3, students number 1 and 2 have no difference in the survey scores prior to and after the study, therefore the sample size is reduced from $n=16$ to $n=14$ (Lowry, 2020; Statistics Solutions 2019). As determined in Table 3, the $w^+ = 85.5$ and $|w^-| = 20$, thus $Max(w^+, |w^-|) = 85.5$. Thus the change in the attitudes, self-confidence and beliefs towards readings increased during the course of the study. Since the sample size was greater than 10, it is considered to be a large study for this statistical test, and was assumed to be a normal distribution. Therefore the following was calculated to determine the z value: $\mu_w = \frac{n(n+1)}{4}$, $\sigma_w = \sqrt{\frac{n(n+1)(2n+1)}{24}}$. Due to tied mean ranks there were five compensation terms as shown in table 2.

Table 4: Wilcoxon's Signed Rank Test Prior-to-Study and Post-Study Compensation.

Mean Rank	How many tied t	$\frac{t^3 - t}{48}$
2.5	4	1.25
5.5	2	0.125
7.5	2	0.125
9.5	2	0.125
12.5	2	0.125
		1.75

When accounting for this compensation, the z value was calculated.

$$z = \frac{85.5 - \frac{14(14+1)}{4}}{\sqrt{\frac{14(14+1)(2 \times 14+1)}{24} - 1.75}} = 2.0788 \dots \approx 2.08$$

In order to reject the null hypothesis at 95% confidence with a two-tailed test, with the null hypothesis being no difference in the score before and after the study, the $z \geq 1.960$ while a one-tailed test (null hypothesis being no increase in score) would require $z \geq 1.645$. Since the $z=2.08$, the null hypothesis is rejected in both tests. The Wilcoxon test assumes continuous data, and therefore a continuity correction must be applied. With this correction, the z score is 2.05, thus the null hypothesis is rejected based on the criteria listed above.

$$z = \frac{85.5 - \frac{14(14 + 1)}{4} - 0.5}{\sqrt{\frac{14(14 + 1)(2 \times 14 + 1)}{24} - 1.75}} = 2.0473 \dots \approx 2.05$$

The Wilcoxon's Signed Rank test shows a significant increase in student survey scores after the study. When evaluating student responses, a change can be observed in the specificity of student responses. Prior to the study students were lacking the metacognition to explain strategies used when reading or how to address challenges when reading. Prior to the study 83% of students ($n=15$) were unable to describe the strategy used to comprehend the text. After the study, only 16% ($n=3$) did not describe the strategies used in detail. While the shift in metacognition is evident, the largest change observed in the study is student attitudes towards reading.

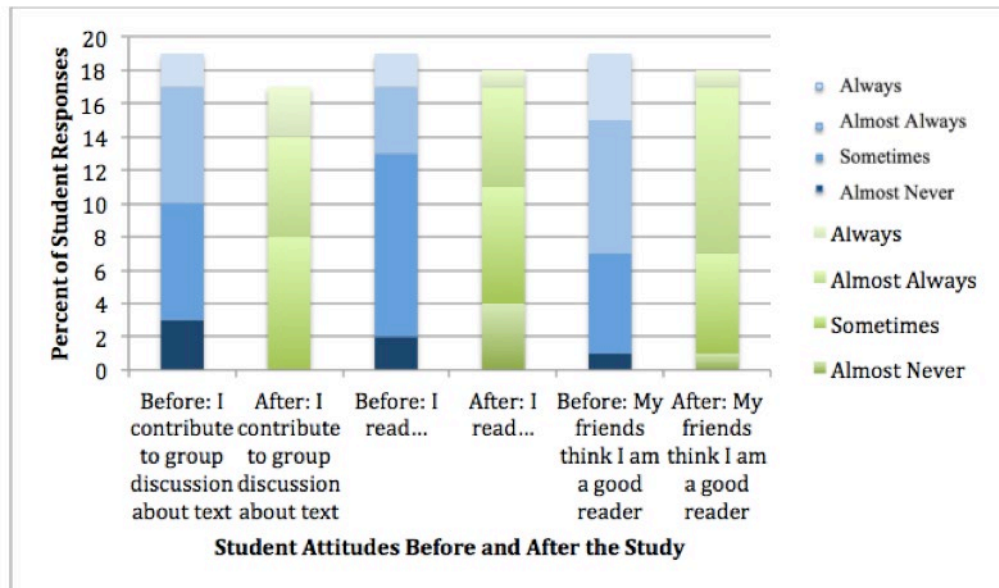


Figure 3: Student Attitudes Before and After the Study (N=16)

When analyzing a shift in student attitudes, the two largest changes were in the frequency that students read, and in the belief that knowing how to read is important. In a focus group interview, a student said, “Reading isn’t too hard, but it makes you understand it (science concepts) more.” This quotation encapsulates the change of attitude in students. At the end of the study a student told me, “all I read are instruction manuals, and I still throw them away” yet there was a change in attitude in the room as students read throughout the study. In the early stages of the study, students were disengaged and would often complain about how boring the readings were. However, as the study progressed, 7 students in focus groups told me that while “lecture is better, reading has improved the academics” in the class. The student with the lowest grade in the class, (64 percent) stated that reading “helps with retention” and he “liked learning about interesting places and how to apply information” learned in class while reading. Students understood the value of

reading strategies since they “actually have to read the thing and use evidence to support my answers.” Twenty one percent ($n=4$) of students preferred to learn via reading than lecture. Students who prefer to learn via lecture said they “learn better from videos or direct explanations” or “I learn better when I say the information, not just reading it off the piece of paper.” Students, who prefer to read, also preferred to learn independently. All students in focus groups ($n=27$) said that reading has improved the academics of the class. These students demonstrated an interesting conflict between admitting that reading has academic importance yet exhibited a reluctance to read because “it is boring.” However, there was a marked transition in attitudes towards reading when the articles were focused on local current events, especially with articles that showed the relevance of the scientific concepts in the curriculum.

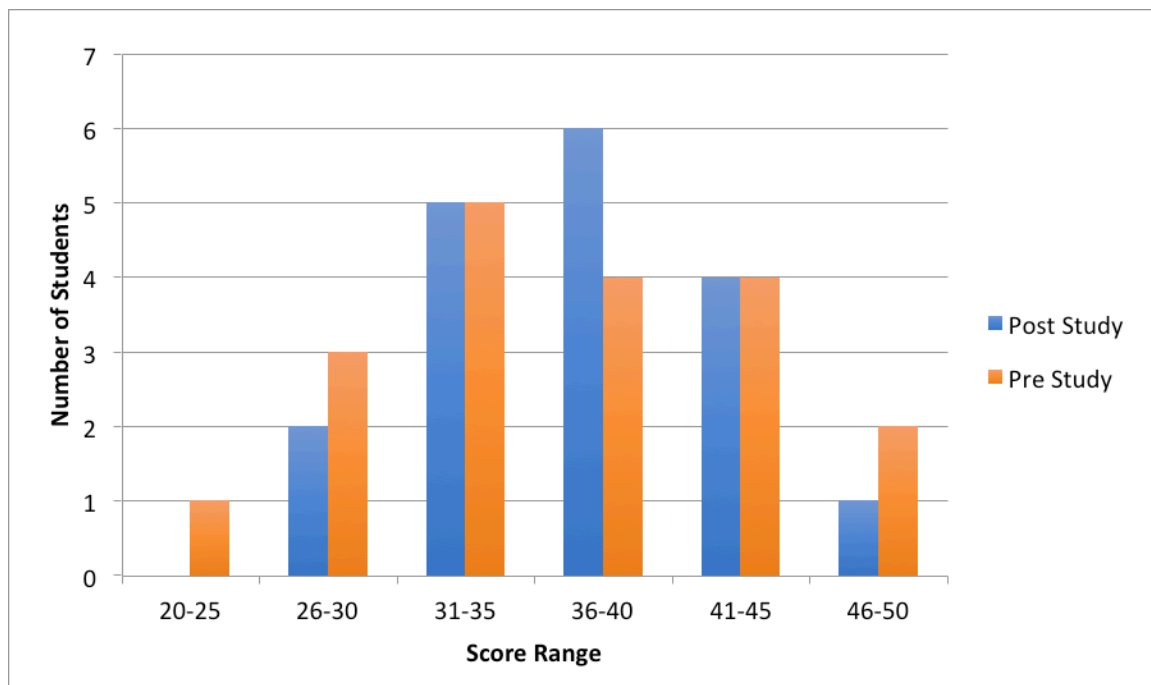


Figure 4: Total Scores on the Survey Before and After the Study ($N=17$)

Findings suggest that, prior to the study, students struggled with reading strategies and comprehension. Two of these students reported finding reading difficult since elementary school, and relied on asking for help and re-reading as the best way to comprehend scientific text. The one student, who scored a 23 on the initial survey, wrote that reading “doesn’t keep my interest.” His definition of comprehension is directly related to vocabulary. For example, when asked, “How do you know if you’ve really understood a reading assignment for science class?” he responded, (when) “it doesn't sound like the teacher is speaking a different language.” This student is successful in science class, earning an 83 percent. However, after looking at his English grade, I was surprised to learn he had earned a 31% in English. After the study this student’s raw score rose from 23 to 29 due to a change in confidence in reading. Prior to the study he responded, “my friends think I am a poor reader.” After the study he responded to same prompt with, “my friends think I am a good reader.” He summarized the change with this quotation, “I [sic] honestly just plain hate trying to read in general, although i'm [sic] a pretty good reader.” The responses from this student show a change in confidence, but no change in attitudes or beliefs in reading.

Three students’ total scores on the survey decreased. This was a reflection of how students thought others judged their reading. The overall perception of their reading abilities did not change, and some responded with an increase in their confidence in understanding and summarizing scientific text. However, these students reported more worry about their peers perception of their reading and reported being at about the same reading level as their friends, while two of these three individuals showed higher

comprehension on the reading assessment than the average score. This indicates a gap between self-confidence and ability.

Based on the student scores, I predicted that the largest increase would have been in student confidence, since students now had specific strategies to use when reading. To determine if this change had occurred, I conducted another Wilcoxon's Signed Rank Test. Four students showed zero difference on the confidence questions before and after the study, which was double the number of students who showed zero difference on the study overall. Based on the Wilcoxon's Signed Rank Test criteria, this decreased the sample size to 12.

Table 5: Wilcoxon's Signed Rank Test for Student Confidence Before and After the Study

#	Student	Prior-to-Study Confidence	Post Study Confidence	Post-Prior	Post-Prior	Student Sorted by Post-Prior	Sorted Post-Prior	Rank	Mean Tied Ranks	Mean Signed Tied Ranks	W+	W-
1	A.L.	13	12	-1	1	B.A.	0	0	-	-	-	-
2	B.A.	13	13	0	0	J.D.	0	0	-	-	-	-
3	B.L.	15	14	-1	1	R.A.	0	0	-	-	-	-
4	B.R.	11	10	-1	1	T.S.	0	0	-	-	-	-
5	C.GE.	9	10	1	1	A.L.	1	-1	1	-2.0	0	-2
6	C.GO.	8	11	3	3	B.L.	1	-1	2	-2.0	0	-2
7	C.N.	11	13	2	2	B.R.	1	-1	3	-2.0	0	-2
8	D.P.	9	10	1	1	C.GE.	1	1	4	5.5	5.5	0
9	E.B.	12	13	1	1	D.P.	1	1	5	5.5	5.5	0
10	F.C.	9	10	1	1	E.B.	1	1	6	5.5	5.5	0
11	G.C.	14	13	-1	1	F.C.	1	1	7	5.5	5.5	0
12	J.D.	12	12	0	0	G.C.	1	-1	8	8.5	-8.5	0
13	M.S.	8	7	-1	1	M.S.	1	-1	9	8.5	-8.5	0
14	R.A.	13	13	0	0	R.B.	1	1	10	10	10.0	0
15	R.B.	9	10	1	1	C.N.	2	2	11	11	11.0	0
16	T.S.	14	14	0	0	C.GO.	3	3	12	12	12.0	0
Sum (check):							78	78		Sum:	55	-23

The same process was used in analysis, assuming a normal distribution since the

same size was greater than ten. Therefore, $\mu_w = \frac{n(n+1)}{4}$, $\sigma_w = \sqrt{\frac{n(n+1)(2n+1)}{24}}$ and

compensation was determined using $\frac{t^3-t}{48}$ for each tied rank.

Table 6: Tied rank for confidence scores

Mean Rank	How many tied t	$\frac{t^3 - t}{48}$
2	3	0.5
5.5	4	1.25
8.5	2	0.125
		1.875

Using these compensation terms, $z = \frac{55 - \frac{12(12+1)}{4}}{\sqrt{\frac{12(12+1)(2 \times 12 + 1)}{24} - 1.875}} = 1.262447 \dots \approx 1.26$

The z value of 1.26 does not reject the null hypothesis, in a one tailed test ($z \geq 1.960$) or a two-tailed test ($z \geq 1.645$) at 95% confidence. After adjusting for the continuity

correction, $z = \frac{55 - \frac{12(12+1)}{4} - 0.5}{\sqrt{\frac{12(12+1)(2 \times 12 + 1)}{24} - 1.875}} = 1.2229 \dots \approx 1.22$ which again rejects the null

hypothesis in both cases. This shows that there is no significant difference between student self-confidence before and after the study.

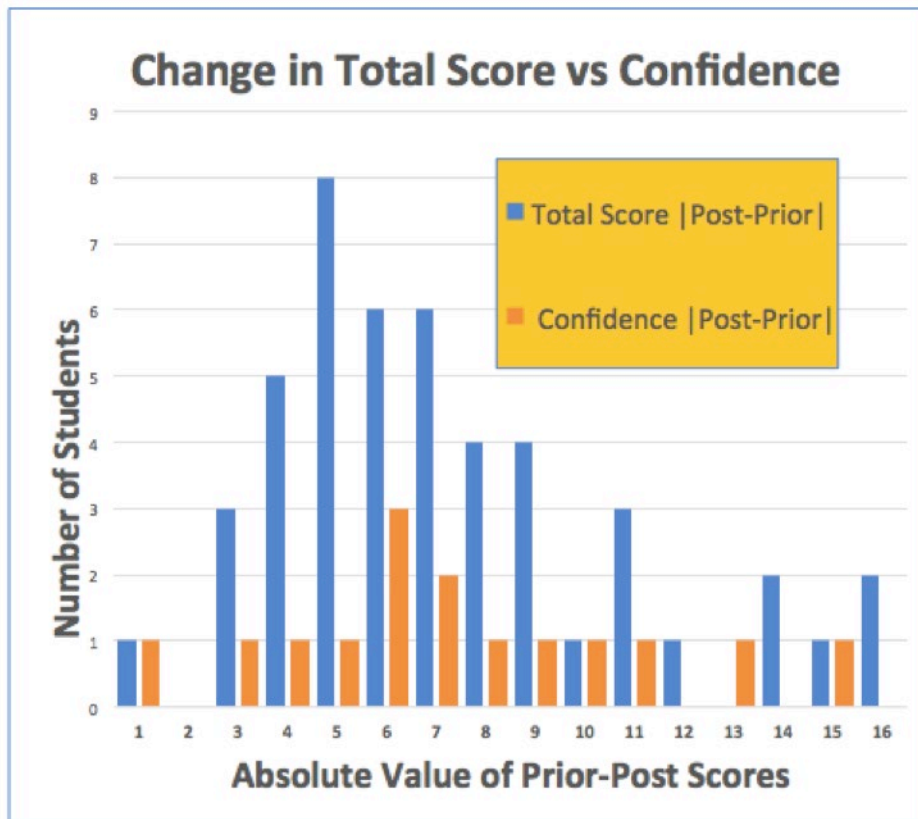


Figure 5. Change in Total Score vs. Confidence ($N=16$)

To analyze the patterns of student confidence scores I compared the absolute value of the difference between total scores and confidence scores on the pre-study and post-study survey. In the total scores, there were a larger number of students that demonstrated a four to nine point difference between the surveys. With the confidence scores, there was a much larger distribution of the difference between surveys. A large distribution shows that applying reading strategies does not result in clear patterns of student confidence. However, should there have been a larger sample size, using a study over a longer time period, the results may differ. Therefore I focused on individual questions in the study to notice any patterns that may emerge.

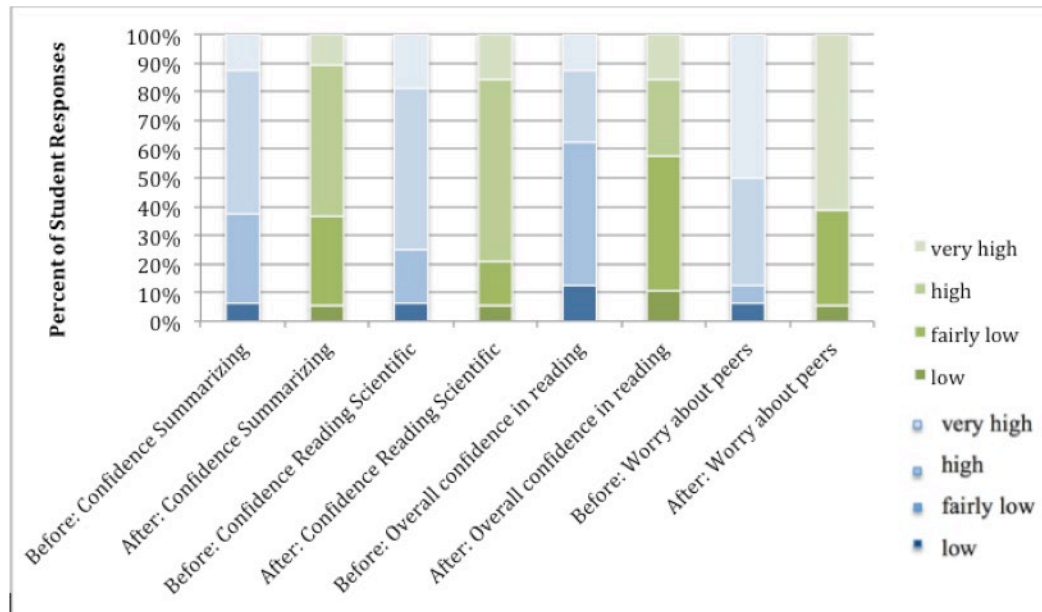


Figure 6. Student Response to Confidence Questions ($N=16$)

When analyzing individual student responses, slight differences between student responses before and after the study emerge. The number of students who had high confidence summarizing scientific text increased. The number of students who had fairly low confidence reading scientific text decreased and the number of students with high confidence in this category increased. The overall confidence in reading increased, with fewer students ranking their confidence as “fairly low” and more students ranking their confidence as “very high.” Based on this data it can be concluded that reading strategies slightly increase student confidence, but not to significant degree. The surveys also show student worry about their peers’ perceptions of their reading becoming polarized. Students either had “low” or “fairly low” worry or had “very high” worry about their peer perceptions. One clear pattern that emerges from this analysis is that students who responded with low confidence before the study also had low confidence after the study.

There was a slight movement of students from “fairly low” confidence to “high” and fewer students who moved from “high” confidence to “very high.” This opinion was supported by data from the focus group interviews. Four students said reading strategies increased their confidence, while the remaining 15 students said the strategies did not impact their self-confidence towards reading.

Results: Choice

The final aspect of this study is the impact of student choice on reading comprehension, attitudes and self-confidence. When given the choice of reading strategy, seven students chose the anticipation guide, one student chose KWHHL, five students chose the PLAN concept map, and three students chose the LAPS strategy. This frequency changed depending on the article assigned. Based on focus group responses, students would decide which strategy would be the best match for the article, depending on the topic. For instance, since KWHHL focused on the students’ prior knowledge and new perspectives, students chose this when reading more political articles, such as the articles on the Superfund Site in town. When analyzing scientific articles on specific experiments students explained that LAPS was a better fit, since the focus was more on evidence. No specific pattern emerged for the PLAN and Anticipation Guide. This could be because these reading strategies are more generic, and focus more on student understanding of the concepts in the article.

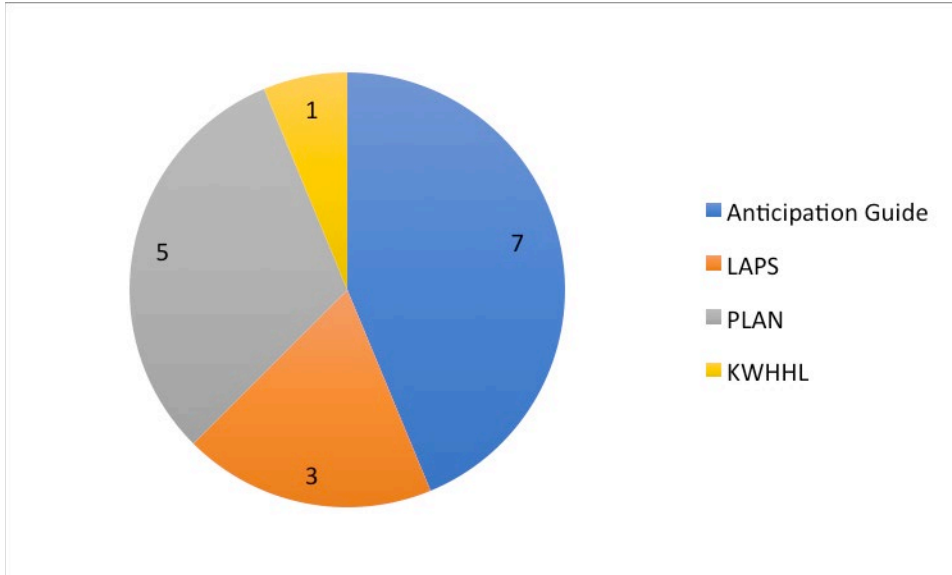


Figure 7: Student Choice of Strategy (N=16)

When students chose the strategy to use when reading, there was no significant difference in the comprehension score when assigned to use the strategy compared to students choosing to complete the strategy. The two tailed *p value* of 0.216 when using a t-test does not reject the null hypothesis. In a sample size of sixteen, four (25 percent) students had an increase of comprehension scores. Six of the students had a two-point difference between scores, which signifies the validity of the assessments. Four of the students did not complete the assessment on the strategy when it was assigned. Surprisingly, two of the students who refused to complete the LAPS strategy when assigned chose the strategy later in the study. This pattern was also seen with KWHHL, where two other students did not complete the KWHHL assessment, but used the strategy by choice. Since there is no statistical difference between student comprehension scores shows that in this case there is little impact of student choice on reading comprehension.

Students still face the same challenges of vocabulary and scientific concepts, and the same rigor is required in the assessments.

Table 7: Student comprehension scores when implemented by choice vs. assigned

Reading Strategy	Reading Comprehension Score (Student's Choice)	Reading Comprehension Score (Strategy Assigned)
LAPS	11	0
LAPS	9	16
LAPS	16	16
LAPS	16	15
LAPS	14	0
LAPS	14	16
KWHHL	0	0
KWHHL	11	16
KWHHL	13	0
PLAN	13	12
PLAN	16	14
PLAN	12	12
PLAN	2	13
PLAN	12	13
PLAN	11	5
PLAN	10	10

Note. N=17

Allowing students to choose the strategy to use when reading made a huge difference in the student's attitude. When assigning students the reading strategy to apply, one could sense the cloud of dread in the room. Suddenly when students were choosing the strategy to use, this cloud lifted. To identify a change in attitude, I compared student responses in surveys when the assignment was assigned and when the strategy was chosen. This comparison did not lead to any patterns, except for two students who did not answer the question, "What components of the reading strategy did you find helpful when reading the text?" then would respond to the question when the strategy was chosen. (These students responded that the LAPS strategy was helpful to find evidence and the KWHHL strategy's reflection questions were useful.) When I first gave students the choice of reading strategy, one student said, "Now I get the point of this project." The biggest consensus in all focus group interviews was the impact of choice on student attitudes. One student said, "If you were to give me the one I like most, I would have said, 'No I don't like it.' But when I choose it, I like it." When asked if choice impacted his attitude, another student said, "100 percent. Because even if you would have said, here you have to do the bubble map, I would have complained. But when I chose it I didn't." To show the change in attitude quantitatively, students would need to take the post study survey after the last strategy was taught and again after the students began to choose the strategy to implement. Therefore, statistical significance could be determined between attitude scores. With this study design, it is difficult to determine if the change in student scores on the survey is due to the impact of choice or the impact of the reading strategies themselves.

I was also interested in the change of student self-confidence when using this strategy when assigned versus when students chose to implement the strategy. I analyzed the difference between self-confidence scores using a t-test. A one tailed *p value* of 0.1198 does not refute the null hypothesis that there is no increase in student confidence when choosing the reading strategy. A two-tailed test resulted in a *p value* of 0.239 supported the null hypothesis (no difference between confidence scores). Therefore, student choice did not impact student comprehension of scientific text or increase student self-confidence, but did increase student attitudes towards implementing reading strategies.

CLAIM, EVIDENCE AND REASONING

Claims From The Study

At the heart of this project is the question of how specific reading strategies impact student comprehension of scientific text. Simply put, the use of reading strategies significantly increases student comprehension of scientific text. When comparing reading strategies, however, there was no statistical difference in the student comprehension rates. Therefore, this study suggests that while reading strategies positively impact student comprehension in general, there is not one specific strategy that produces a higher rate of comprehension than any other. This claim is supported by a variety of evidence including quantitative data from assessments, student responses to focus group interviews, and survey responses. A similar result was found in a similar action research project (Hart, 2012). As long as the reading strategy applies information processing theory as Tadlock (1978) describes, the reader will have deeper comprehension of the text. Each reading strategy used in this study did so. All strategies required students to develop questions that connect new information to existing categories in the individual's mental schema, and then applied this information in some way to move it into a student's long-term memory (Tadlock, 1978). This action research project suggests student application of any strategy that includes these components will increase student comprehension of academic text. The reasoning for these results demonstrates how this project is truly a microcosm for the complexity of teaching. Each student comprehends a reading differently due to their unique schema and the neurological pathways used to read.

How do student attitudes and self-confidence regarding scientific text change when using reading strategies?

The first sub-question in this study is, “How does student attitudes and self-confidence regarding scientific text change when using reading strategies?” As students repeatedly used the same reading strategies and reading became a regular component of the science class, student attitudes and self-confidence began to change. This was especially noticeable when students began to choose their own strategies to apply and began reading articles they were inherently interested in. This was observed primarily by student discussion regarding the text. Instead of discussing the mechanics of how to complete the strategy or simple recall questions, students began to ask their classmate’s opinions and would repeatedly use evidence from the text to support their statements.

Using a Wilcoxon’s Signed Rank test, there was a significant increase in student survey scores when comparing the post study data to the data collected before the study began. The biggest difference was in the number of students who had an increase in their self-confidence summarizing scientific text—the number of students who stated they had low confidence in summarizing scientific text decreased, while the number of students who stated they had high confidence summarizing scientific text increased. The two strategies applied in the study, PLAN and KWHHL, required students to develop a paragraph summary of the reading. In these summaries, student personal connections to the text were observed, as Szabo (2006) also observed in development of the KWHHL strategy.

A second Wilcoxon’s Signed Rank test was used to analyze a change in student confidence toward reading during the study. The test found fewer students ranking their

confidence when reading as “fairly low” and more students ranking their confidence as “very high.” This change could be due to students knowing a variety of strategies to apply when reading. However, when asked “What can you do if you are reading and don’t understand what a sentence is about?” the number of students who described using context clues, or “writing about” the information decreased. Instead more students relied on asking a partner or teacher for help by the end of the study. This suggests the strategies did not increase student independence when reading, perhaps due to the large amount of instructional time working with partners or small groups when applying the reading strategies. This finding is problematic as Visone (2010) observed a large number of students would quit when reading independently if they do not have the skills for comprehension. In addition, this finding suggests that students could benefit from a longer-term exposure to reading strategies, perhaps using the same strategy across different grade levels.

The results of the Wilcoxon’s Signed Rank test did not correspond to student responses in focus group interviews. In these interviews, twenty percent ($n=4$) stated that their self-confidence towards reading increased. In the student survey, those who described their self-confidence towards reading as low remained low. This could be due to the emotional connection students build towards reading from a young age as suggested by Wolff (2018). These attitudes towards reading often begin with visceral reactions. When asked, “When did you first realize that you were or weren’t a strong reader? What happened?” Thirty percent ($n=6$) referred to an incident that occurred in elementary school. In comparison, two students responded with a situation that occurred in high school. This

finding suggests the confidence and attitudes towards reading are formed at an early age and are often resistant to change.

If students are given the choice of reading strategy, how does this impact their reading comprehension, attitudes, and self-confidence?

When answering this sub-question using statistical analysis, there was no correlation between the student's preferred reading strategy and the student's reading comprehension abilities as measured in students' standardized STAR test scores. There was also no statistical difference between student comprehension scores when choosing the reading strategy and when assigned the strategy. This action research project did not measure attitudes towards the reading strategy when assigned versus chosen in surveys, however the results of the interviews were very clear on this topic. All students in the sample responded in focus group interviews that stated that choice positively impacted their attitudes towards reading. Since students chose the strategy they used for reading prior to the post study survey, it is impossible to determine to what extent the students' attitudes and self-confidence increase were due to choice or implementing reading strategies.

I predicted that students would choose either the PLAN or Anticipation Guide based on student focus group interviews. When first choosing which strategy to use, these were the most popular, with fewer students choosing the LAPS or KWHHL strategy. However, this frequency changed overtime. At the end of the study, I developed a handout of strategy "bookmarks" for students to refer to when reading. (See Appendix A.) Before reading the articles in detail, students would pre-read by referring to the headings, pictures,

and titles before deciding on the strategy to apply while reading. For instance, if an article required students to analyze an argument, they would be more likely to choose the LAPS strategy, since this strategy evaluated the author's use of evidence. If a student would be asked to develop their own opinion, they were more likely to use the KWHHL strategy, since this strategy required students to reflect on their own perspectives. Students who did not shift between strategies had lower comprehension scores. Perhaps this could be a result of lacking confidence in applying the reading strategies, or due to a lack of comprehending the purpose of the articles. Some students simply chose a strategy because they described the strategy as the "easiest" to use, but students disagreed amongst themselves in focus groups about which strategy was the easiest. This disagreement was especially apparent between a group of six male students. One said the PLAN concept map "was scary" due to the disorganization of the map. Another student in the group agreed and said that the LAPS plan was easiest, the rest of the group agreed with these opinions except for one student who maintained that the PLAN strategy was the easiest. This conversation escalated into an argument, with the students in the majority opinion claiming that their friend was "wrong" – the PLAN strategy was "really confusing." These opinions were surprising, since the LAPS strategy includes analyzing evidence from the article to prove the validity of the author's conclusion and which is arguably more complex. This conversation demonstrates how a person's mental schema and neurological pathways will impact attitudes. I observed that students who preferred linear thinking avoided the PLAN strategy, while students who often use creative problem solving in inquiry projects were more likely to gravitate towards the concept map in the PLAN strategy.

Values Of The Study And Considerations for Future Research

LaDue and Clark (2010) consider the most valuable role of earth science to be educating the public before decision making, specifically regarding natural resources, disaster and climate change. In order to do so, students must be scientifically literate. Through teaching reading strategies, especially the LAPS strategy, students have a concrete procedure to evaluate the accuracy of articles that relate to current scientific and societal issues. Evaluating the validity of evidence is the main goal of our school district this year. If all teachers across a school or grade level were to teach the same reading strategy, students could experience consistency between classes and increase the amount of reading they complete each day. Including reading strategies in the curriculum does not require much preparation or funding and is accessible to all.

The value of including reading strategies is not limited to earth science. McDaniel and Riddle (2015) maintain that literacy is the single most effective factor that will increase student achievement. Since science standardized tests often include large reading sections, student achievement in science is often impacted by the students ability to decode scientific text (Visbone, 2010). By combining reading and inquiry approaches Rupley (2010) found that students learn the material better than if they were to experience either reading strategy separately.

Prior to the study, I found that on average my students experienced reading fatigue at nine minutes. Student neurological pathways are altered by digital devices and are increasingly unable to immerse themselves in literature for a significant period of time (Wolff, 2018). However, college courses continue to include reading assignments as the

primary method for students to acquire new information. Therefore, high school instructors need to prepare students for the inevitability that they will have to read for information, not simply for entertainment. English curriculum primarily focuses on fiction (Hypes, Vestal) and therefore reading strategies must be included in more classes. There is hope that this may change as the Common Core standards are implemented, since nonfiction reading strategies standards begin in first grade. Hall (2005) states that in many educational programs, there is a lack of reading instruction in content-based classes. Therefore this gap needs to be filled through professional development.

In August, I will be presenting the findings of this study at the Northwest Montana Reading Council Back-to-School Literacy Conference. The purpose for presenting at this conference is to share the reading strategies with other local content area teachers. As Yore (1991) writes, teachers understand that reading is an important skill to include in their teaching, yet they have a lack of knowledge of how to teach the metacognitive skills needed to be a fluent reader. These strategies represent four methods to increase the reading comprehension for students.

If I were to extend the scope of this project, I would measure how reading impacts student engagement with content covered in the curriculum. Student interest in current events and case studies was a side effect of the treatment I had not anticipated. Over the course of the study, I found students were more engaged with the curriculum in my class. Since I did not anticipate this, I did not measure student interest or opinions regarding the importance of earth science curriculum in my pre-assessment. After including current events and news articles where landslides and other mass movements impacted

communities, students saw why understanding weathering was important. Through reading, I have expanded the scope of my class from being focused primarily on the scientific concepts to including human interactions with Earth systems, which I infer has increased student engagement in the class. Adding these articles allowed me to seamlessly integrate NGSS standards on human interactions with earth systems (such as HS-ESS3-1).

I had hoped to integrate these reading strategies within the student driven inquiry process, however this exceeded the scope of the treatment. In future years it would be interesting to see how increased reading integration in inquiry approaches impacts student writing through the Claim, Evidence and Reasoning framework. Monitoring students' change in comprehension using these reading strategies while differentiating by offering various articles with varying Lexile levels would be another clear progression of this study.

Impact of Action Research on the Author

When designing this action research project, I envisioned the student's need for lecture to diminish, to replace this process with reading and inquiry. I imagined this process to create a student centered instructional model. This vision did not become a reality. During the first week of the study, I reflected, "This was my hardest day teaching this year. I was in tears multiple times and feel very discouraged, mostly due to the lack of student interest and lack of metacognition." That first week I learned that students could not focus on reading for more than 8 minutes, and had surprising low comprehension of the article's content. Therefore, my hopes to replace my lecture with reading began to seem impossible.

Instead I began to include shorter articles of current events or application of the information content taught through lecture or inquiry activities. Therefore instead of

replacing activities in my curriculum, I was adding activities. This had large ramifications for my scope and sequence. This supports Yore's (1991) conclusion that the time science teachers spend on literacy is due to the increased number of required standards. I began to shorten inquiry activities and project based learning units to be able to include enough articles to complete my treatment. The time needed to find articles and adjust the strategies did not allow me enough time to trim information from lectures or link the information to other lessons I had planned. I was worried that the readings had become busy work, rather than the essential component of my class I was hoping it would become.

In focus group interviews and in surveys, 79% of students stated that they learned better from lecture than reading. Yet these students also said that including more reading in the class "improved the academics" of the course. Student responses reveal an interesting conflict between admitting that reading has academic importance yet they continue to be reluctant to read because "it is boring." As the action research progressed, and I altered the tone of the articles from being purely factual to more current event based, students became more interested in the curriculum and I observed fewer off task behaviors.

I had hoped that with more analysis of how authors used evidence in their arguments, I would be able to instruct students on how to include more evidence in their own writing using the claim, evidence, reasoning framework. This is my third year teaching, and I continue to have difficulty modeling effective scientific writing. While I was now including articles, my practice still lacks using student examples of how to apply the data gathered through inquiry activities. However, when analyzing a sample essay,

students were able to identify the use of evidence in the essay with more accuracy than students have in the past.

When analyzing student responses to the question, “What would you change about how we do reading in class?” the most common answer was more class discussion of the text. As Hall (2005) writes, I had no training in how to conduct discussion on texts from my educational program, however, I now have enough experience to use successfully use reading comprehension strategies in my class. At this point in my practice, I have yet to find the balance between providing direct instruction, modeling, and “giving the answers away.” I constantly worry that more instruction disengages students, since they think they will be given the answers later. However, I know that most students need additional modeling and reaffirmation that their ideas are correct. While this study increased my confidence in teaching the skills required to learn from scientific text, it did not increase my confidence in leading class discussion of the text.

I did observe social studies teachers leading close reading discussions in the past, yet when recreating these methods in the science classroom, I felt the energy drain from the room. I had hoped that this treatment would aim me towards more student-centered instruction, yet as it progressed, my teaching became more focused on the teacher. What I learned through this process was that while reading can enrich the curriculum and show students the connections between earth systems and humans, the articles must be short, and the strategy must be simple. That will keep the energy and focus on the practice of science and ensure that the science classroom remains an exciting place revolving around student driven inquiry. As my practice develops, I hope that my initial vision will come true.

Lecture will continue to be part of my teaching, but I hope this aspect will be integrated as a natural response to a student led discussion about a text, with both acting as background for an inquiry project. Overall, this action research project has allowed me to develop the skills to integrate scientific reading into my teaching practice and has given me goals to work towards in the future.

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APPENDICES

APPENDIX A

READING STRATEGY “BOOKMARKS”

LAPS

Look

- A. What is the general topic?
B. What is the source? Do you think this source is credible?

Analyze

What is the author's conclusion? (Use evidence and reasoning here.)

Prove it!

What facts or data back up the author's conclusion?

So what?

Do you think the author provided enough evidence to prove the conclusion? If so, explain how.

If not, what evidence do you think is missing?

Bubble Map

Predict

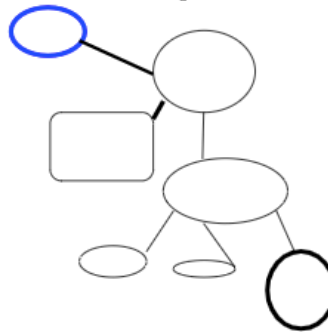
Skim through the reading. What are the main ideas covered in this reading?

Draw a map with space for these ideas.

Fill in map with evidence from the reading under each main idea in the map.

Add new categories if needed.

Write a summary paragraph about the main ideas of the reading.



K-W-H-H-L

Before Reading

What do you already **know** from experience about this topic?

What **questions** do you have about the topic?

After Reading

What **new things** did you learn while reading?

New Perspectives

Explain at least one way this reading or topic changed your perspective of science.

Final summary.

Begin with a topic sentence, then summarize the evidence in three to four sentences.

APPENDIX B

STUDENT BELIEFS, ATTITUDES AND SELF-CONFIDENCE SURVEY ON
READING AND READING STRATEGIES

1. Explain the process you used to read this text. Why did you use that process?
2. In other classes or grades, have you ever been taught reading strategies? What grade or class, and what are your thoughts about how helpful that was to you?
3. What makes you realize that a reading is becoming more difficult?
3. What can you do if you are reading and don't understand what a sentence is about?
4. How would you decide if you don't understand a sentence?
5. How is reading in science class different from reading in language arts?
6. How do you know if you've really understood a reading assignment for science class?
7. What do you do when you come to a big word in your science text that you don't know?
8. Do you agree or disagree with this statement:
I already know specific reading strategies that will help me have a better understanding of scientific text.
Strongly agree
Agree
Disagree
Strongly disagree
Did not score this question – just to collaborate with description of reading strategies used when reading text.⁴
9. My friends think I am _____.
1-a poor reader
2-an OK reader
3-a good reader

4-a very good reader

10. Reading a book is something I like to do.

1-Never

2-Not very often

3-Sometimes

4-Often

11. I read

1-not as well as my friends

2-about the same as my friends

3-a little better than my friends

4-a lot better than my friends

12. I am confident reading scientific text.

1-Never

2-Not very often

3-Sometimes

4-Often

13. What do you find challenging about reading science text?

14. I am confident summarizing scientific text.

1-Never

2-Not very often

3-Sometimes

4-Often

15. When I come to a word I don't know I can

1-never figure it out

2-almost never figure it out

3-sometimes figure it out

4-almost always figure it out

16. People who read a lot are _____.

1-boring

2-not very interesting

3-interesting

4-very interesting

17. I am

1-a poor reader

2-an OK reader

3-a good reader

4-a very good reader

18. When did you first realize that you were or weren't a strong reader? What happened?

19. I worry about what other students think about my reading _____.

1-everyday

2-almost everyday

3-once in a while

4-never

20. Knowing how to read well is _____.

1-Not very important

2-Sort of important

3-Important

4-Very important

21. When my teacher asks me a question about what I have read, I _____.

1-Can never think of an answer

2-Have trouble thinking of an answer

3-Sometimes think of an answer

4-Always think of an answer

22. As an adult, I will spend _____.

1-none of my time reading

2-very little time reading

3-some of my time reading

4-a lot of my time reading

23. When I am in a group talking about what are reading, I _____.

1-Almost never talk about my ideas

2-Sometimes talk about my ideas

3-Almost always talk about my ideas

4-Always talk about my ideas

APPENDIX C

TEACHING JOURNAL TEMPLATE

Component of capstone:	Rating (1-5)	Date:
Statement	5=Strongly agree 1=Strongly disagree	Explanation, Student quotes
Students are independently applying the strategy		
Students are working together to apply the strategy		
Students apply information from the reading in their hypothesis.		
Students apply information in the reading in their conclusions.		
Students do not need additional direct instruction to apply this information.		
Students use evidence from the text in discussion.		
Students are motivated to apply the strategy: there is little frustration; students are on task.		

APPENDIX D

READING COMPREHENSION ASSESSMENTS

Erosion Reading Comprehension (pre-study)

Complete practice ranking:

Are the terms **ice** and **cold**...

Highly related in the reading

A little bit related in the reading

Not at all related in the reading

Explain why you choose your answer, including a definition of the words in your answer.

1. Are the terms **topography** and **factors impacting erosion** ...

Highly related in the reading

A little bit related in the reading

Not at all related in the reading

Explain why you choose your answer, including a definition of the words in your answer.

2. Are the terms **factors impacting erosion** and **Dust bowl**...

Highly related in the reading

A little bit related in the reading

Not at all related in the reading

Explain why you choose your answer, including a definition of the words in your answer.

3. Are the terms **glaciers** and **mechanisms of erosion**...

Highly related in the reading

A little bit related in the reading

Not at all related in the reading

Explain why you choose your answer, including a definition of the words in your answer.

4. Are the terms **river deltas** and **factors impacting erosion**...

Highly related in the reading

A little bit related in the reading

Not at all related in the reading

Explain why you choose your answer, including a definition of the words in your answer.

5. Are the terms **mechanisms of erosion** and **mass wasting**...

Highly related in the reading

A little bit related in the reading

Not at all related in the reading

Explain why you choose your answer, including a definition of the words in your answer.

6. What is the central idea, thesis or theme of this reading?

7. What evidence is presented to support the author's conclusions (claims)?

8. What is the biggest human factor contributing to erosion?

9. What is the major agent of erosion on Earth?

1. Are the terms **fungi** and **soil**...

Highly related

A little bit related

Not at all related

Explain why you chose your answer, using **evidence/facts** from the reading.

2. Are the terms **aggregates** and **microbes** ...

Highly related

A little bit related

Not at all related

Explain why you chose your answer, using **evidence/facts** from the reading.

3. Are the terms **impermeable** and **floods** ...

Highly related

A little bit related

Not at all related

Explain why you chose your answer, using **evidence/facts** from the reading.

4. Are the terms organic and **soil** ...

Highly related

A little bit related

Not at all related

Explain why you chose your answer, using **evidence/facts** from the reading.

Name:

Period:

After completing the reading strategy, decide on the relationship between concepts in the reading. Then explain why you choose your answer, including a definition of words in your answer.

5. Are the terms **deforestation** and **erosion**...

Highly related

A little bit related

Not at all related

Explain why you chose your answer, using **evidence** from the reading that you included in your bubble map or paragraph.

6. Are the terms **erosion** and **poverty**...

Highly related

A little bit related

Not at all related

Explain why you chose your answer, using **evidence** from the reading that you included in your bubble map or paragraph.

7. Are the terms **erosion** and **disease**...

Highly related

A little bit related

Not at all related

Explain why you chose your answer, using **evidence** from the reading that you included in your bubble map or paragraph.

8. Are the terms **erosion** and **corruption**...

Highly related

A little bit related

Not at all related

Explain why you chose your answer, using **evidence** from the reading that you included in your bubble map or paragraph.

Name:

Period:

After completing the reading strategy, decide on the relationship between concepts in the reading. Then explain why you choose your answer, including a definition of words in your answer.

9. Are the terms **earthquakes** and **Yellowstone volcano**...

Highly related

A little bit related

Not at all related

Explain why you chose your answer, using **evidence** from the reading that you included in your bubble map or paragraph.

10. Are the terms **fire** and **earthquakes**...

Highly related

A little bit related

Not at all related

Explain why you chose your answer, using **evidence** from the reading that you included in your bubble map or paragraph.

11. Are the terms **strike-slip fault** and **transform plate boundaries**...

Highly related

A little bit related

Not at all related

Explain why you chose your answer, using **evidence** from the reading that you included in your bubble map or paragraph.

12. Are the terms **intermountain seismic belt** and **focus**...

Highly related

A little bit related

Not at all related

Explain why you chose your answer, using **evidence** from the reading that you included in your bubble map or paragraph.

Name:

Period:

After completing the reading strategy of your choice, decide on the relationship between concepts in the reading. Then explain why you choose your answer, including evidence from the article.

13. Are the terms **Superfund** and **contamination**...

Highly related

A little bit related

Not at all related

Explain why you chose your answer, using **evidence** from one of the readings.

14. Are the terms **potliner material** and **cyanide**...

Highly related

A little bit related

Not at all related

Explain why you chose your answer, using **evidence** from one of the readings.

15. Are the terms **Superfund listing** and **economy...**

Highly related

A little bit related

Not at all related

Explain why you chose your answer, using **evidence** from one of the readings.

16. Are the terms **drinking water** and **landfills ...**

Highly related

A little bit related

Not at all related

Explain why you chose your answer, using **evidence** from one of the readings.

APPENDIX E

SURVEYS COMPLETED THROUGHOUT THE STUDY, ONCE PER STRATEGY

Think back to the reading we did this week. Answer the question completely for full credit.

1. Which reading strategy did you use when reading the article(s)?
2. How did completing the reading strategy impact your understanding of what we read?
3. What components of the reading strategy did you find helpful when reading the text?
3. What components of this strategy were distracting or not helpful when reading the text?
4. Rank your confidence when reading using this strategy.

1 very confident 2 3 4 not confident
5. What would you change about how we do reading in class?

APPENDIX F

IRB EXEMPTION



**INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165**

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MEMORANDUM

TO: Mary Kohnstamm Webb and Walter Woolbaugh
FROM: Mark Quinn *Mark Quinn CJ*
Chair, Institutional Review Board for the Protection of Human Subjects
DATE: October 21, 2019
RE: "Reading Strategies Effect on Student Science Literacy" [MKW102119-EX]

The above research, described in your submission of October 21, 2019, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- ☒ (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- ☒ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation; and (iii) the information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by section 16.111(a)(7).
- ☐ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- ☐ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- ☐ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- ☐ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX G

FOCUS GROUP INTERVIEW QUESTIONS

Focus Group Interview Questions – During Study

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

Name of reading strategy implemented: _____

1. What parts of this reading strategy did you find helpful when reading scientific text?
2. What was your favorite reading this week? What was your overall impression (attitude) towards this text?
3. Did using this reading strategy impact your overall understanding of the text? Explain why or why not.
4. Did you prefer to use this strategy in a group of four, with a partner, or individually? Explain your answer.
5. How did you use the information you learned from the reading in your lab?
6. Would you prefer to learn from reading or from lecture? Explain your answer.
7. Do you think that reading increases the quality of instruction (teaching) in our class? Explain your answer.
8. Did using this strategy impact your self-confidence when reading science text?
9. Do you think you will choose to use this strategy in the future? Explain why or why not.
10. Do you think you could use this strategy when reading for other classes or when reading for fun?
11. Is there anything else I should know?

Focus Group Interviews – After the study

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

1. What strategy did you choose this week?
2. Why did you choose to use this strategy?
3. What strategy lead to the best understanding of text you read?
4. What strategy did you dislike the most? Why did you dislike it?
5. Do you prefer to learn via reading or lecture? Explain why.
6. How do you implement information you learned via reading in your labs?
7. Think about your self-confidence toward reading prior to this study. Do you think your confidence has changed by implementing reading strategies? Explain why or why not.
8. Did your attitude towards reading in science change when using reading strategies? Explain why or why not.
9. Did your interest in the topic impact your understanding of the reading? Explain why or why not.
10. Do you read outside of class? Can you see yourself reading a book about science for fun?
11. Do you prefer to read articles or the textbook? Explain your answer.
12. Is there anything else you think I should know?

APPENDIX H

FIGURES ON STUDENT ATTITUDES AND SELF-CONFIDENCE IN READING
PRIOR TO STUDY

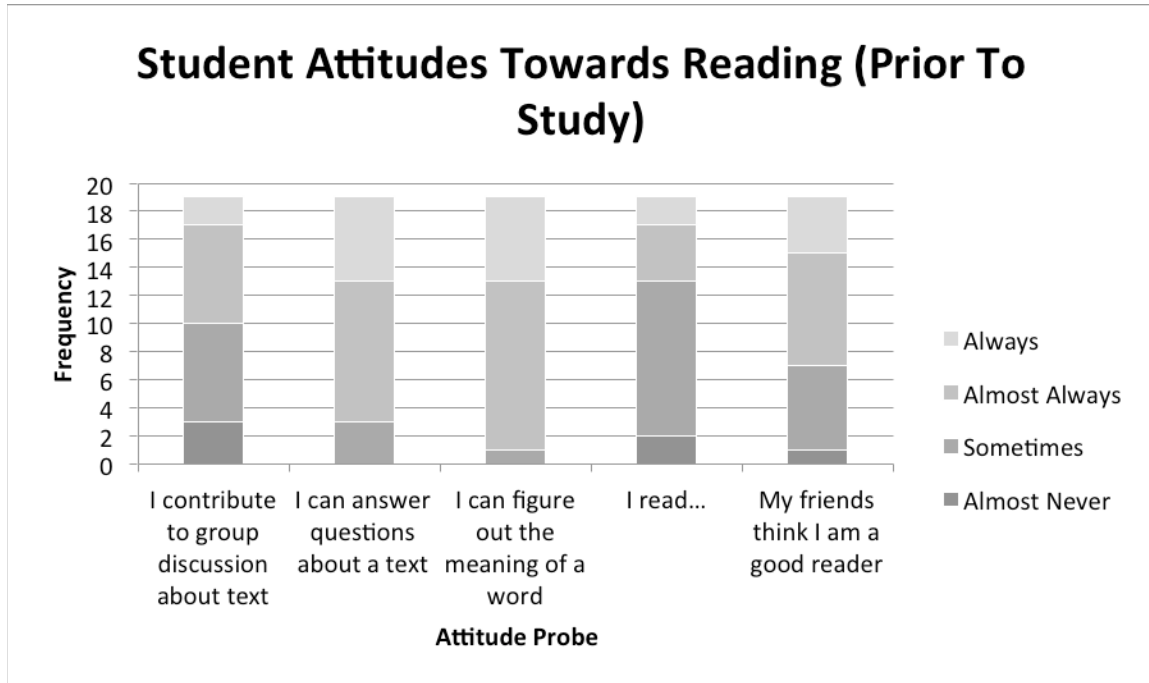


Figure 1. Student attitudes towards reading prior to the study. ($N=19$)

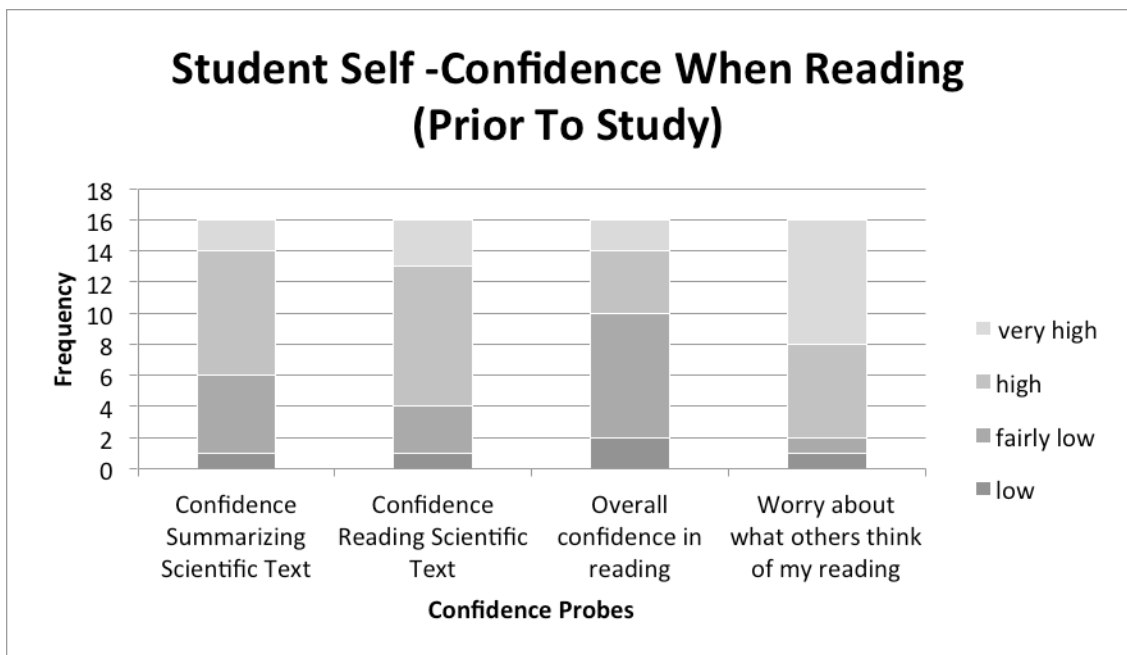


Figure 2. Student self-confidence when reading prior to the study. $N=19$.